VBM FUSION REACTOR D-D CYCLE

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Verdict :-

1.Formation of compound nucleus :-

Various charged particles fuse to form a homogeneous compound nucleus. The homogeneous compound nucleus is unstable. So, the central group of quarks [that which with gluons and other groups of quarks compose the homogeneous compound nucleus] with its surrounding gluons to become a stable and the just lower nucleus [a nucleus having lesser number of groups of quarks and lesser mass (or gluons) than the homogeneous nucleus] than the homogeneous one, includes the other nearby located groups of quarks with their surrounding gluons and rearrange to form the 'A' lobe of the heterogeneous compound nucleus. While the remaining groups of quarks [the groups of quarks that are not involved in the formation of the lobe 'A'] to become a stable nucleus includes their surrounding gluons (or mass) [out of the available mass (or gluons) that is not involved in the formation of the lobe 'A'] and rearrange to form the 'B' lobe of the heterogeneous compound nucleus. The remaining gluons [the gluons (or the mass) that are not involved in the formation of any lobe] keeps both the lobes joined them together. Thus , due to formation of two lobes within into the homogeneous compound nucleus, the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

2.Splitting of the compound nucleus :-

The heterogeneous compound nucleus, due to its instability, splits according to the lines perpendicular to the direction of the velocity of the compound nucleus ($\overrightarrow{Vcn}$) into three lobes. Where the each separated lobe represent a separated particle. So, the two particles that represent the lobes 'A' and 'B' are stable while the third particle that represent the remaining gluons (or the reduced mass) is unstable . each particle that is produced due to splitting ofthe compound nucleus has an inherited velocity $(\underset{Vinh}{\longrightarrow})$equal to the velocity of thecompound nucleus ($\overrightarrow{Vcn}$) .

3.Propulsion of the produced particles :- The reduced mass converts into energy and propell both the particles with equal and opposite momentum .

Verdict :-

Various charged particles with different momentum by charge ratio when injected to a point 'F' where two uniform magnetic fields perpendicular the charged particles follow the confined circular paths of different radii passing though the common tangential magnetic field point 'F' (point of injection) by time and again.

Where ,

$r \; \alpha \; \frac{mv}{q}$

Where ,radius of the circular path followed by the charged particle is directly proportional to the momentum by charge .

Or

$r = \frac{2E_K}{Fr}$

Where ,

E_K = Kinetic energy of the confined particle.
F_r = Resultant force (net force) acting on the charged particle due to the magnetic fields.

By how we can apply the principle : -

Injection ofbunches of charged particle :-
if the bunches of charged particles of same species (deuterons) are injected to a point 'F' where the two magnetic fields are applied , the charged particles (deuterons) of the first bunch will undergo to a confined circular path and will pass through this point 'F' [point of injection] by time and again and thus will be available for the deuterons of the later bunch(es) to be fused with at point 'F' .

2Occurrence of fusion at point 'F' : -

As the deuterons of the n^{th} injected bunch reaches at point 'F' , it fuses with the deuterons of the first injected bunch passing throughthe point 'F' .

3. Confinement of the injected deuteron and Exhaustment of the produced charged and uncharged nuclei :-

1.confinementof injected deuteron

Conclusion :-

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the deuteron are along **+x , -y and -z** axes respectively .So, by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed bythe deuteron lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis where the magnetic fields areapplied.

The resultant force($\underset{Fr}{\rightarrow}$) tends thedeuteron to undergo to a circular orbit of radiusof 0.7160 m. It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.1092 m ,-0.6403 m,-0.6406 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak. And uninterruptedly goes on completing its circle until it fuses with the deuteron of later injected bunch (that reaches at point "F") at point "F

2.Fusion reactions and the confinement or exhaustment of the produced charged and uncharged particles :-

1.^2_1H + $^2_1$ H $\rightarrow$ $^3_2$ He + $^1_0$n

[injected] [confined][not confined]

€ Conclusionforthe produced helium -3 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the helium-3 nucleus are along **-x , +y and +z** axes respectively .So,by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the helium-3 nucleus to undergo to a circular orbit of radius 0.4842 m.

It starts itscircular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-0.7501 m, 0.4329 m,0.4331m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circularpath (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is not confined.

€ Conclusion for the produced neutron :- The produced neutron strike to the wall of the tokamak.

2.^2_1H +$^2_1H \rightarrow ^3_1$ H +^1_1H

[injected] [confined] [not confined] [not confined]

Conclusion for the produced proton :-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the proton are along **+x , -yand -z** axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axiswhere the magnetic fields are applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the protonto undergo to a circular orbit of radius 2.5977 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.0238 m,- 2.3233 m ,-2.3239m). intrying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.

Conclusion for the produced triton :-

Thedirections components[$\underset{Fx}{\rightarrow}$, $\underset{Fy}{\rightarrow}$,and $\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that are acting on thetritonare along **-x , +y and +z** axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the triton lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the triton to undergo to a circular orbit of radius 1.1918m . It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-1.8463 m, 1.0659 m,1.0661 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the tirton gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward andstrike to the roof wall of the tokamak.

Hence thetriton is not confined.

3. $^2{}_1H$ + $^2{}_1$ H $\rightarrow_2{}^4$ He + y says

[injected] [confined] [confined]

€ Conclusion for the produced helium -4 nucleus :-

The directionscomponents[$\underset{Fx}{\rightarrow}$, $\underset{Fy}{\rightarrow}$,and $\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the helium-4 nucleusare along **+x , -y and -z** axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negativez-axis where the magnetic fields are applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the helium-4 nucleus to undergo to a circular orbitof radius of 0.6997 m. It starts its circular motion from point P_1(0,0,0) andreaches at point P_2 (1.0838 m, -0.6258 m,-0.6259 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circleuntil it fuses with the confined deuteron or deuteronof later injected bunch (that reaches at point "F") atpoint "F"

€ Conclusion for the produced gamma rays :- The gamma rays strike to the wall of the tokamak.

4. $^{2}_{1}H$ + $^{4}_{2}He$ → $^{6}_{3}Li$ + γ says

[injected][confined][confined]

€ Conclusionfor the produced lithium -6 nucleus :-

Thedirections components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the lithium-6 nucleusare along **+x , -y and -z** axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the lithium-6 nucleus lies in the plane made up of positive x- axis, negative y-axisand negative z-axiswhere the magnetic fields are applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the lithium-6 nucleusto undergo to a circular orbit of radius of 0.6557 m. It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.0158 m,-0.5863 m, -0.5865m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circle until it fuses with the confined deuteron or deuteron of later injected bunch (that reaches at point "F")at point "F"

€ Conclusion for the produced gamma rays :-The produced gamma rays strike to the wall of the tokamak.

5. $^{2}_{1}H$+$^{6}_{3}Li$→[$^{8}_{4}Be$]→$^{7}_{3}Li$ + $^{1}_{1}H$

[injected] [confined] [not confined] [not confined]

€ Conclusionfor the produced lithium -7 nucleus :-

Thedirections components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that are acting on the lithium-7 nucleus are along **-x , +y and +z** axes respectively.So ,by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know thatthe circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the lithium-7 nucleus to undergo to a circular orbit of radius 0.2645 m. Itstarts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.4098m,0.2364m,0.2365 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid ofthe region covered-up by the applied magnetic fields. so as the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion .so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

So the lithium-7 nucleus is not confined.

€ Conclusion for the produced proton :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that are acting on the protonare along **+x , -y and -z**axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negativey-axis andnegative z-axis

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the proton to undergo to a circular orbit of radius2.9812m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.6178 m,- 2.6657 m ,-2.6669 m). in trying to complete its circle, due to lack of space ,it strike to the base wallof the tokamak.

Hence the protonis not confined.

6.$^2{}_1H+^6{}_3Li\rightarrow [_4{}^8 Be]\rightarrow{}_4{}^7Be +^1{}_0 n$

[injected] [confined] [not confined]

€ Conclusionfor the produced beryllium -7 nucleus :-

Thedirections components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the beryllium-7 nucleusare along **-x , +y and +z** axes respectively .So ,by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positivez-axis wherethe magnetic fields are not applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the beryllium-7 nucleus to undergo to a circular orbit of radius 0.0773 m.

It starts its circular motion from point P_1 (0,0,0) and tries toreach at point P_2 (-0.1198 m,0.0690 m, 0.0690m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1(0,0,0) andas it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circularmotion, starts its linear motion . so , inspite ofcompleting its circle , ittravel upward and strike to the roof wall of thetokamak.

Hencethe beryllium-7 nucleusisnotconfined.

€ Conclusion for the produced neutron :-The produced neutron strike to the wall of the tokamak.

7.$^2{}_1H.$ + $^6{}_3LI$ $\rightarrow[_4{}^8 Be]\rightarrow{}_2{}^4 He+ {}_2{}^4 He$

[injected] [confined][not confined][not confined]

€ Conclusionforthe produced right hand side propelled helium -4 nucleus :-

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that areacting on theright hand side propelled hellion-4are along**+x , -y and -z** axes respectively .

So by seeing the direction ofthe resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed bythe right hand side propelled hellion-4 lies in the plane made up of positivex- axis, negative y-axis and negative z-axis where the magnetic fields are applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the right hand side propelled hellion-4 to undergo to acircularorbit of radius 4.8509 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (7.5140 m,- 4.3376 m ,-4.3396 m). in trying to complete its circle , due to lack of space ,it striketo the base wallof the tokamak.

Hencethe right hand side propelled hellion-4 is not confined.

€ Conclusionfor the produced left hand side propelled helium -4 nucleus :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force$(\underset{Fr}{\rightarrow}$)thatare acting on the left hand side propelled helium-4 nucleusare along **-x , +y and +z**axes respectively .So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the left hand side propelled helium-4 nucleus. lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow}$) tends the left hand side propelled helium-4 nucleus to undergo to a circular orbit of radius 3.7601m

It starts its circular motion frompoint P_1 (0,0,0) and tries to reach at point P_2 (-5.8243 m , 3.3630 m, 3.3637 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the left hand side propelled helium-4 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completingits circle ,it travel upward and strike to the roof wall of thetokamak.

So theleft hand side propelled helium-4 nucleusis not confined

8.$^2{}_1H + {}^6{}_3 Li \rightarrow [{}_4{}^8Be] \rightarrow {}_2{}^3 He + {}_2{}^4He + {}^1{}_0 n$

[injected] [confined][not confined] [not confined]

€ Conclusion forthe produced helium -3 nucleus :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force$(\underset{Fr}{\rightarrow}$)that are acting on the helium-3 nucleus are along **-x , +y and +z**axes respectively .Soby seeing the direction ofthe resultant force$(\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axiswhere the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow}$) tends the helium-3 nucleus to undergo to a circular orbit of radius 0.3899 m.

Itstarts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.6039 m, 0.3487 m,0.3488 m) where the magnetic fields are not applied

So , It starts its circular motion from point P_1 (0,0,0) and as ittravel along anegligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is not confined.

€ Conclusion for the produced helium -4 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the helium-4 nucleusare along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields areapplied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the helium-4 nucleus to undergo to a circular orbit of radius of 0.7980 m.

It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.2362 m ,-0.7135 m,-0.7137m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circleuntil it fuses with theconfined deuteronor deuteron of later injected bunch (thatreaches at point "F")atpoint "F"

€ Conclusion for the produced neutron :- The neutron strike to the wall of the tokamak.

9.$^2{}_1H + {}^6{}_3 Li + {}^2{}_1H \rightarrow [{}_5{}^{10}B] \rightarrow {}_3{}^7 Li + {}^3{}_2 He$

[injected] [confined] [confined] [not confined] [not confined]

Conclusion for the produced lithium -7 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that areacting on the lithium-7 nucleus are along **-x , +y and +z** axes respectively .So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the lithium-7 nucleus to undergo to a circular orbit ofradius 1.4805 m. It starts its circular motion from point P_1(0,0,0) and tries to reach atpoint P_2 (-2.2935 m,1.3238 m,1.3241 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so ,inspite of completing itscircle , ittravel upward and strike to the roof wall of the tokamak.

The lithium-7 nucleus is not confined withininto the tokamak.

Conclusion for the produced helium -3 nucleus :-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the helium-3 nucleusare along**+x , -y and -z** axes respectively .So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium-3 nucleus lies in the plane made up of positive x- axis, negative y-axis and negativez-axis

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the helium-3 nucleus to undergo to a circular orbit of radius 3.3766 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (5.2303 m,- 3.0200 m,-3.0207 m). in trying to completeits circle , due to lack of space,it strike to the base wall of the tokamak.

Hence the helium-3 nucleusisnot confined.

10.$^2{}_1H + {}^6{}_3 Li + {}^2{}_1H \rightarrow [{}_5{}^{10}B] \rightarrow {}_4{}^7 Be + {}^3{}_1 T$

[injected] [confined] [confined] [not confined] [not confined]

Conclusionfor the produced beryllium -7 nucleus :-

The directionscomponents$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are actingon theberyllium-7 nucleus are along **-x, +y and +z** axes respectively .So, by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the beryllium-7 nucleus to undergo to a circular orbit of radius 1.0458 m . It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2(-1.6201 m,0.9351 m,0.9353 m) where the magneticfields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligiblecircular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts itslinear motion .so , inspite of completing its circle , it travel upwardand strike to the roof wall of the tokamak.

Theberyllium-7 nucleus is notconfined within into the tokamak.

Conclusion for the produced triton :-

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ ofthe resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the tritonare along **+x , -y and -z** axes respectively .So, by seeing the direction ofthe resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed by the triton liesin the plane made up of positive x- axis, negative y-axis andnegative z-axis where the magnetic fields are applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the triton to undergo to a circular orbit of radius 6.4952 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (10.0610 m,- 5.8093 m ,-5.8106 m). in trying tocomplete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence thetritonisnot confined.

11.$^2{}_1H + {}^6{}_3 Li + {}^2{}_1H \rightarrow [{}_5{}^{10}B] \rightarrow {}_4{}^9 Be + {}^1{}_1 P$

[injected][confined] [confined] [not confined] [not confined]

Conclusionfor the produced beryllium -9 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on theberyllium-9 nucleus are along **-x , +y and +z** axes respectively .So, by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the beryllium-9 nucleus to undergo to a circular orbit of radius 0.9078 m . It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2(-1.4061 m,0.8117 m,0.8121 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-9 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upwardand strike to the roof wall of the tokamak.

The beryllium-9 nucleus is not confined within into the tokamak.

Conclusion for the produced proton :-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the proton are along **+x , -y and -z** axes respectively .So ,by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis .

The resultant force($\underset{Fr}{\rightarrow}$) tends the proton to undergo to a circular orbit of radius 5.9402 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (9.2013 m,- 5.3117 m ,- 5.3141 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.

4. production of power:-

(i) The non-useful charged nuclei (he-4) produced due to fusion reactions [D-T and D-$^{3}_{2}$ He] also undergo to a confined circular path but in trying to complete one round, the he-4 nucleus strike to the wall of the tokamak and thus be exhausted out of the tokamak with the help of vacuum pumps.

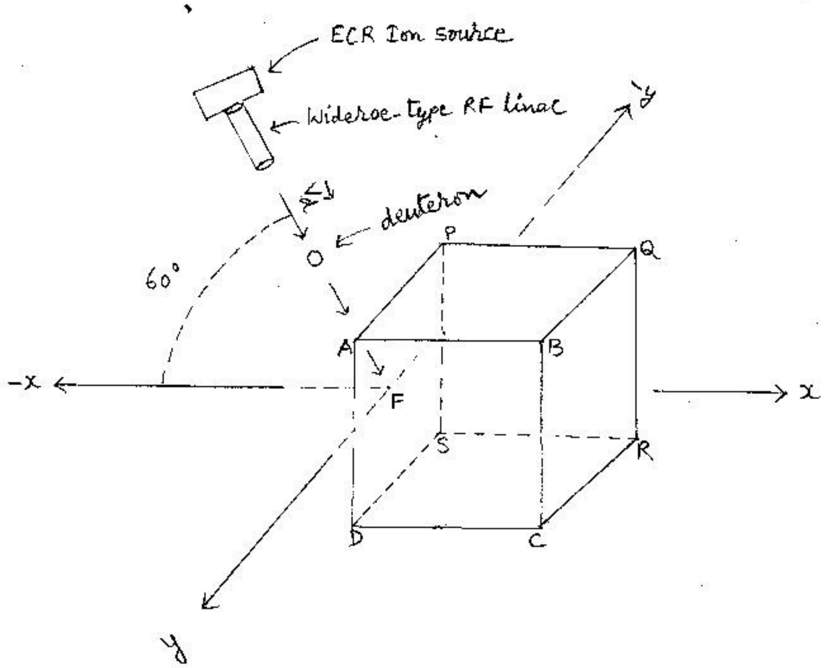
(ii) The produced uncharged nuclei (neutrons) have no effects of magnetic fileds and so follow an irratical straight path and strike to the wall of the tokamak and thus the neutrons are abrorbed by the boron (the inner liner) of the tokamak.

(iii) The produced are absorbed by the inner liner (graphite) of the tokamak.

The heat is transferred by a water – cooling loop from the tokamak to a heat exchanger to make steam.
The steam will drive electrical turbines to produce electricity .
The steam will be condensed back into water to absorb more heat from tokamak.

Thus, we get a steady state VBM fusion reator based on D-D cycle.

Ion Source : Electron cyclotron resonance Ion source produce the 6 X 10^{19} deuterons per second. The produced bunches of deuterons enters into a wideroe-type RF linac



Where, the point's 'F' is a point of injection . The RF linac acclerate the deuterons. The acclerated deuterons enters into the main tokamak at point 'F' (or the point of injection) where the two magnetic fields perpendicular to each other are applied.

Minimum kinetic energy (E_m) required for fusion :
Tunneling – tunneling is a consequence of the Heisenberg uncertainty principle which states that the greater certainity we know the particle the less we know about its position in the space and vice versa
The uncertainty in the position is such that
when a proton collides with another proton , it may find itself on the other side of the coulomb barrier and in the attractive potential well of the strong force .
Work done to overcome the coulomb barriers

$$U = kz_1z_2q^2 / r_0$$

So, the kinetic energy of the particle should be equal to

$$E_m = ½\ mv^2 = kz_1z_2q^2 / r_0$$

Rewriting the kinetic energy of the particle in terms of momentum

$$½\ mv^2 = p^2 / 2m = (h/\lambda)^2 / 2m$$

If we require that the nuclei must be closer than the de-broglie wavelength for tunneling to take over nuclei to fuse . ($r_o = \lambda$)

$$kz_1z_2q^2 / r_0 = kz_1z_2q^2 / \lambda$$

where ,

$$½\ mv^2 = (h/\lambda)^2 / 2m = kz_1z_2q^2 / \lambda$$

So, $h^2/\lambda^2 2m = kz_1z_2q^2 / \lambda$

Or lambda (λ) = $½h^2/ kz_1z_2q^2m$

If we use this wavelength as the distance of closest approach , the kinetic energy required for fusion is –

$$E_m = ½\ mv^2 = kz_1z_2q^2 / r_0 = kz_1z_2q^2 / \lambda = kz_1z_2q^2 \times 2kz_1z_2q^2m / h^2$$

$E_m = 2k^2 z_1^2 z_2^2 q^4 m / h^2$

Where m is the mass of the penetrating (injected) nucleus .

Fusion velocity :- A particle having charge q and mass m should have a minimum velocity ( ) to overcome the electrostatic repulsive force exerted by the other charge to reach into a fusion well where the distance of closest approach r =

$E_m = ½ mv^2_{fusion} = 2k^2 z_1^2 z_2^2 q^4 m / h^2$

$v^2_{fusion} = 2 X 2k^2 z_1^2 z_2^2 q^4 / h^2$

$v_{fusion} = 2k z_1 z_2 q^2 / h$

Minimum kinetic energy required for D – D fusion :

$E_m = ½ mv^2_{fusion} = ½ m_d(2k z_1 z_2 q^2 / h)^2$

$$E_m = \frac{2 K^2 Z_1^2 Z_2^2 q^4 m}{h^2}$$

For D-D fusion

$Z_1 = Z_2 = 1$
$q = 1.6 x 10^{-19}$ c
$m=3.3434x10^{-27}$ kg
$h=6.62x10^{-34}$ J-S
$k=9x10^9$ Nm/C^2

$$E_{D-D} = \frac{2 X (9X10^9)^2 X 1^2 X 1^2 X (1.6 X 10^{-19})^4 X 3.3434 X 10^{-27}}{(6.62 X 10^{-34})^2} \quad J$$

$$= \frac{3549.63161088 X 10^{18} X 10^{-76} X 10^{-27}}{43.8244 X 10^{-68}} \quad J$$

$= 80.9966961528 X 10^{-17}$ J

$= 50.6229350955 X 10^2$ ev

$E_{D\text{-}D}$= 5.0622 kev

= 0.0050622 Mev

Minimum kinetic energy required by a deuteron for D-Helium -4 fusion :

$E_m = E_{D\text{-}D} \times Z_2^2$ [$Z_2 = 1$]

=0.0050622 x4 Mev

=0.0202488 Mev

=20.2488 Mev

Minimum kinetic energy required by a helium -4 nucleus to take part in D – He-4 fusion :

$E_m = ½ mv^2_{fusion} = ½ m_{he\text{-}4} (2k z_1 z_2 q^2 / h)^2$

$$E_m = \frac{2 K^2 Z_1^2 Z_2^2 q^4 m_{he\text{-}4}}{h^2}$$

$$E_m = \frac{2 K^2 Z_1^2 Z_2^2 q^4 m}{h^2}$$

Z_1 =2 , Z_2 = 1
q = 1.6 x 10^{-19} c
m=6.64449x10^{-27} kg
h=6.62x10^{-34} J-S
k=9x10^9 Nm/C^2

$$E_{he\text{-}D} = \frac{2 \times (9\times10^9)^2 \times 2^2 \times 1^2 \times (1.6 \times 10^{-19})^4 \times 6.64449 \times 10^{-27}}{(6.62 \times 10^{-34})^2} \text{ J}$$

$$= \frac{28217.3736222 \times 10^{18} \times 10^{-76} \times 10^{-27}}{43.8244 \times 10^{-68}} \text{ J}$$

$= 643.87358691 \times 10^{-17}$ J

$= 402.420991818 \times 10^2$ ev

$E_{\text{-he-D}} = 40.242$ kev

$= 0.040242$ Mev

Minimum kinetic energy required by alithium-6 nucleus for D –lithium-6 fusion :

$E_m = ½ mv^2_{fusion} = ½ mLi_{-6}(2k z_1 z_2 q^2 / h)^2$

$$E_m = \frac{2 K^2 Z_1^2 Z_2^2 q^4 m_{Li\text{-}6}}{h^2}$$

$Z_1 = 3, Z_2 = 1$
$q = 1.6 \times 10^{-19}$ c
$m = 9.9853 \times 10^{-27}$ kg
$h = 6.62 \times 10^{-34}$ J-S
$k = 9 \times 10^9$ Nm/C^2

$$E_{Li\text{-}D} = \frac{2 \times (9 \times 10^9)^2 \times 3^2 \times 1^2 \times (1.6 \times 10^{-19})^4 \times 9.9853 \times 10^{-27}}{(6.62 \times 10^{-34})^2} \text{ J}$$

$$= \frac{95411.0273126 \times 10^{18} \times 10^{-76} \times 10^{-27}}{43.8244 \times 10^{-68}} \text{ J}$$

$= 2177.12113143 \times 10^{-17}$ J

$= 1360.70070714 \times 10^2$ ev

$E_{Li\text{-}D} = 136.0700$ kev

$= 0.13607$ Mev

Particle acclerator :

with the help of a wideroe- type linac we acclerate the deuterons up to 102.4 Kev .

A wideroe type linear acclerator

$K_n = n\ q\ v_o\ T_{tr}$

where, $v_o = v_{max} = 40$ KVand n=6

$\sin\psi_0 = T_{tr} = 0.64$ and q=1.6x10-19 c

$K_2 = 6 \times 1.6 \times 10^{-19} \times 40 \times 0.64$ KJ

$=245.76 \times 10^{-19}$ KJ

$= 153.6$ Kev[$1.6\text{x}10^{-19}$ J = 1ev]

1. length of the first drift tube

$L_1 = \frac{n^{1/2}}{f_{rf}} \times \sqrt{qv_{max}\sin\psi_0} / \sqrt{2m}$

Where , $f_{rf} = 7 \times 10^6 \text{Hz}$, $m = 3.3434\text{x}10^{-27}$kg

$L_1 = \frac{\sqrt{1}}{7X10^6} \text{x} \sqrt{1.6\ X\ 10^{-19} X\ 40\ X 10^3 X\ 0.64} / \sqrt{2 \text{ x } 3.3434 \text{ x } 10^{-27}}$ m

$= \frac{\sqrt{1}}{7X10^6} \text{x} \sqrt{409.6\ X 10^{10}} / \sqrt{6.6868}$ m

$= \frac{1}{7X10^6} X \sqrt{61.2550098701\ X 10^{10}}$ m

$= \frac{1}{7X10^6} \text{x} 7.8265\text{x}10^5$m

$= 1.11807\text{x}10^{-1}$ m

$= 11.1807\text{x}10^{-2}$ m

$l_2 = \sqrt{2} \times l_1$

$= 1.4142 \times 11.1807\text{x}10^{-2}$ m

$= 15.8117\text{x}10^{-2}$m

$l_3 = \sqrt{3}$ x l_1

=1.732 x 11.1807x10^{-2} m

= 19.3649x10^{-2} m

$L_4 = \sqrt{4}$ x l_1

= 2 x 11.1807x10^{-2}m

= 22.3614x10^{-2} m

l_5 =2.2360X11.1807X10^{-2} m

=25.0000X10^{-2}m

l_6 = 2.4494X11.1807X10^{-2} m

=27.3860 X10^{-2}m

Total lagth of the wideroe –type linac is -

$L = l_1 + l_2 + l_3 + l_4 + l_5 + l_6$

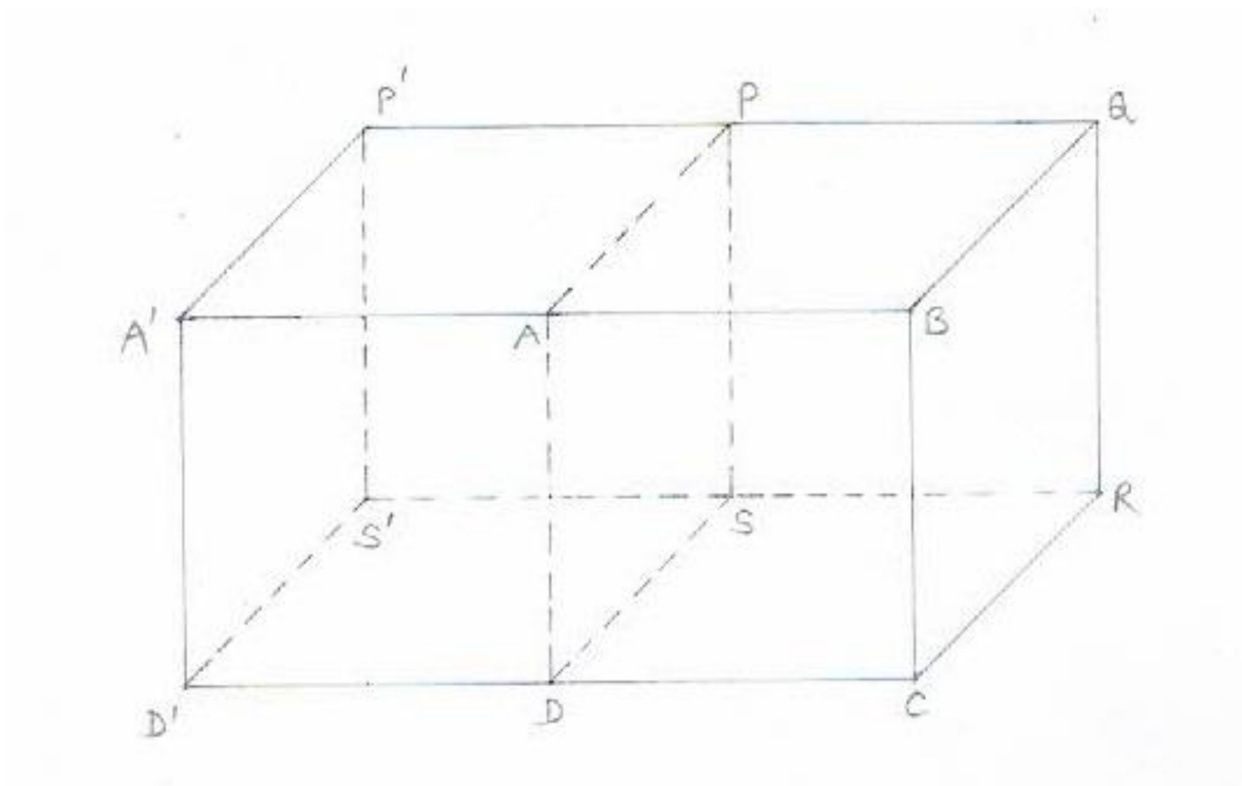
= [11.1807+15.8117+19.3649+22.3614 +25.0000 +27.3860]x10^{-2} m

=121.1047 x10^{-2} m

The tokamak

The takamak has two parts – one is the main tokamak and the another is the extended tokamak .
The points A, B , C , D , P , Q , R , and S represents the corners of the walls of the main tokamak while all the other remaining points represents the corners of the walls of the extended tokmak .
The tokmak is made up of steel .
The graphite or the boron is used as the inner liner of the tokamak to absorb the thermal neutrons .

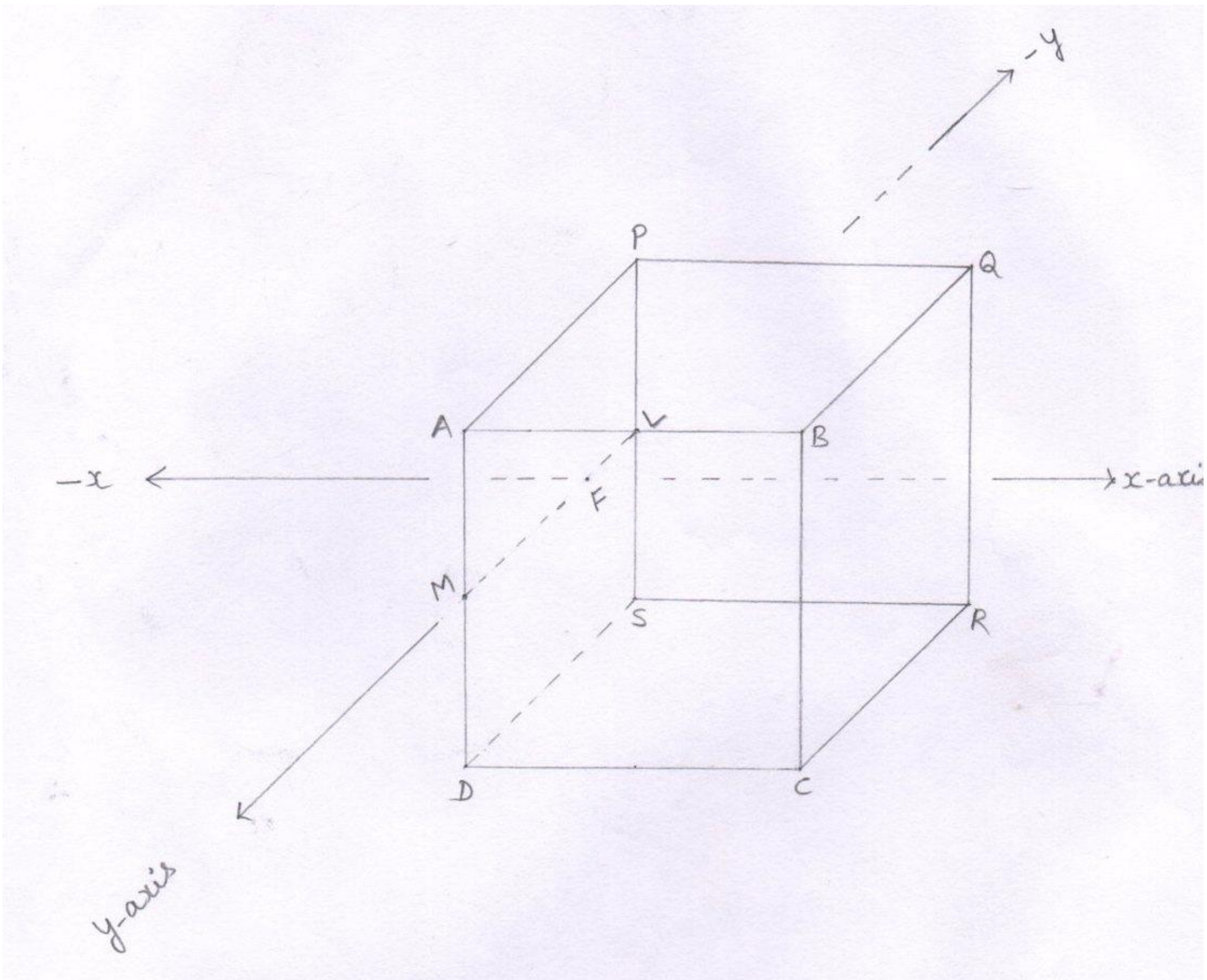
The main tokamak with its extensions



The location of the point of injection (F) of the charged particles (deuterons) or the location of the center of fusion (F) within - into the tokamak is -

Or

The location of the point ' F' [or the point of injection or the center of fusion]



where , MF=0.1m and LF = 1.40 m

AM = 0.1 m MD = 1.40 m

PL = 0.1 m LS = 1.40 m

AP = AD=DS= PS= ML = 1.5 m AB=DC= PQ=SR =2 m

BQ=CR=BC= RQ =1.5 m

Total surface area of the tokamak

Surface area of the walls of the main tokamak

I ABCD = length x breadth = 2m x 1.5m = 3 m^2

Ii PQRS = 2 m x 1.5m = 3 m^2

Iii APQB = 2m x 1.5m = 3 m^2

IV DSRC = 2m x 1.5m = 3 m^2

V BQRC = 1.5m x 1.5m = 2.25 m^2

So , the total surface area of the main tokamak = 14.25 m^2 eq.(9)
The points APSD do not represent a wall . it is a blank place that allows the injected protons to enter into the main tokamak . (or the region where the magnetic fields are applied .)

iiTotal Surface area of of the tokamak : -

surface area =2(lxb +bxh +hxl)

where, l = 4 m

b = 1.5 m

h = 1.5 m

S = 2(4x1.5 +1.5x1.5+ 1.5x4) m = 2x14.25 m = 28.50 m

Magnetic field coils

VBM fusion reactor has two pairs of semicircular magnetic field coils . out of them , one pair of semicircular magnetic field coils is vertically erected while another pair of semicircular magnetic field coils is horizontally lying .

1 Vertically erected magnetic field coils :

In a VBM fusion reactor , there are two vertically erected semicircular magnetic field coils that act as a helmholtz coil.

The distance between the two vertically erected semicircular coils is equal to the radius of any one of the semicircular magnetic field coil .

i.e. d = r = 2.5 m

The vertically erected semicircular magnetic field coils acting as a helmholtz coil produce a uniform magnetic field ($\underset{By}{\rightarrow}$) parallel to y – axis .

horizontally lying magnetic field coils :

in a VBM fusion reactor , there are two horizontally lying semicircular magnetic field cols that acts as a helmholtz coil .

the distance between the two horizontally lying semicircular magnetic field coils is equal to the radius of any one of the semicircular magnetic field coil .

i.e. d = r = 2.2 m

The horizontally lying semicircularmagnetic field coils acting as a helmholtz coil produce a uniform magnetic field($\underset{Bz}{\rightarrow}$) parallel to z –axis .

Magnetic field due to a semicircular coil at point x is –

$B_1 = \mu_o/4\pi \times \pi R^2 ni / (R^2 + x^2)^{3/2}$

Magnetic fields due toa semicircular coil at the x , If x = R/2

$B_1 = \mu_o/4\pi \times \pi R^2 ni / (R^2 + R^2/4)^{3/2}$ [$\therefore x = R/2$]

$= 8/5\sqrt{5} \times \mu_o ni / 4R$

So, the magnetic field in the mid plane of the two semicircular coils acting as a helmholtz coil is

$B_T = B_1 + B_2$

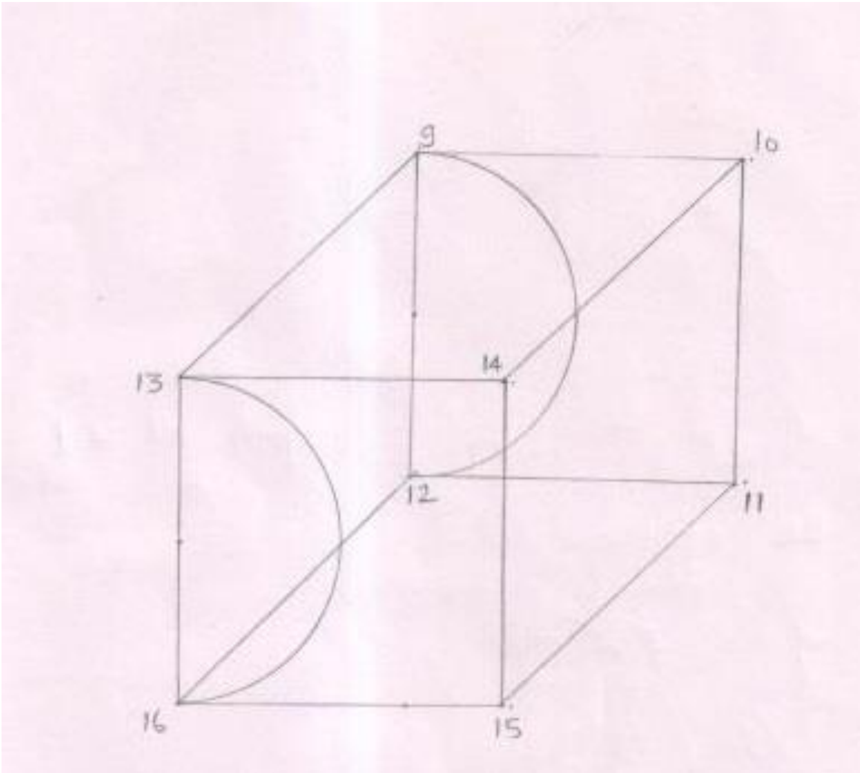
$= 2\,B$ $\quad [\therefore B_1 = B_2 = B]$

$= 16/5\sqrt{5} \times \mu_o\, ni / 4R$ from eq. (11)

$= 1.43 \times \mu_o\, ni / 4R$

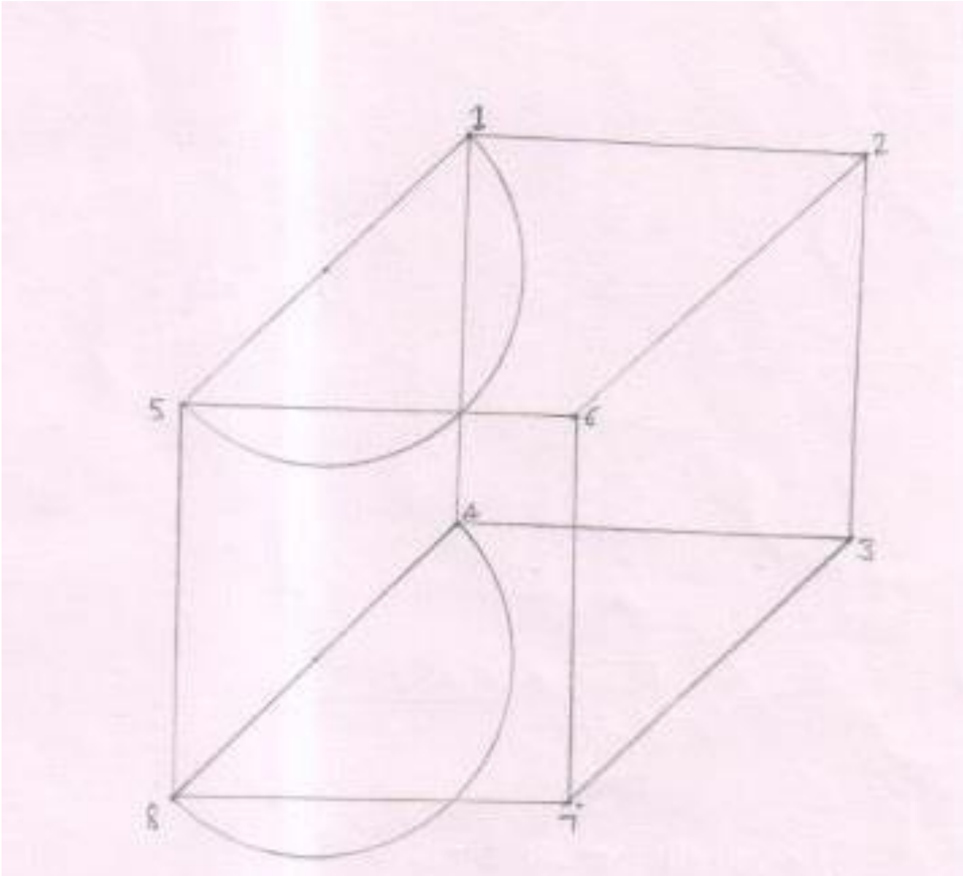
$= 1.43\, B_{center}$ $\quad [B_{center} = \mu_o\, ni / 4R]$ eq.(12)

The vertically erected magnetic field coils .



The vertically erected magnetic field coils are exterior to the horizontally lying magnetic field coils which in turn are exterior to the the main tokamak. so, the area covered up by the points9,10,11,12,13,14,15,16,is greater than the area covered up by the points1, 2, 3 ,4 , 5, 6, 7 and 8.The area covered up by the points 1,2,3,4,5,6,7,8is greater than the area covered up by the points P , Q , R ,S, A , B, C ,D of the main tokamak .

The horizontally lying semicircular magnetic field coils



The vertically erected semicircular coils are exterior to the main tokamak andalso exterior to the horizontally lying magnetic field coils. so, the area covered up by points 9, 10, 11 ,12 , 13, 14, 15, 16 is more than the area covered up by the points 1,2,3,4,5,6,7,8.The area covered up by the points A, B, C, D, P, Q, R, S is less than the area covered up by the points 1,2,3,4,5,6,7 and 8.

Magnetic field (By) in the mid plane of the two vertically exacted semicircular coils acting as a helmholtz coil is -

$B_y = 1.43 \quad B_{centre}$

$B_{centre} = \frac{\mu_0 \, ni}{4 R}$

Where ,

n = 5570 turns

i = 100 Amperes

R = 2.5 m

so, $B_{centre} = \frac{4 \times 22 \times 10^{-7} \times 5570 \times 100}{7 \times 4 \times 2.5}$ Tesla

$12254 \times 10^{-3}/175$ Tesla

$B_{centre} = 70.02285 \times 10^{-3}$ Tesla

$= 7.002285 \times 10^{-2}$ Tesla

$B_y = 1.43\ B_{centre}$

$B_y = 1.43 \times 7.002285 \times 10^{-2}$ Tesla

$= 10.0132 \times 10^{-2}$ Tesla

$= 1.0013 \times 10^{-1}$ Tesla

Magnetic field (B_z) in the mid plane of the two horizontally lying semicircular coils acting as a helmholtz coil is -

$B_y = 1.43\ B_{centre}$

$B_{centre} = \frac{\mu_0\, ni}{4R}$

Where ,

n = 4900 turns

i = 100 Amperes

R = 2.2

so, $B_{centre} = \frac{4 \times 22 \times 10^{-7} \times 4900 \times 100}{7 \times 4 \times 2.2}$ Tesla

$B_{centre} = 0.07$ Tesla

$B_z = 1.43 \times 0.07$ Tesla

$= 0.1001$ Tesla

$= 1.001 \times 10^{-1}$ Tesla

The directions of magnetic fields

The direction of flow of current in the horizontally lying semicircular coils is clockwise so that the direction of the produced magnetic field is according to negative z – axis (i. e. downward)

As $B_z = 1.001 \times 10^{-1}$ Tesla

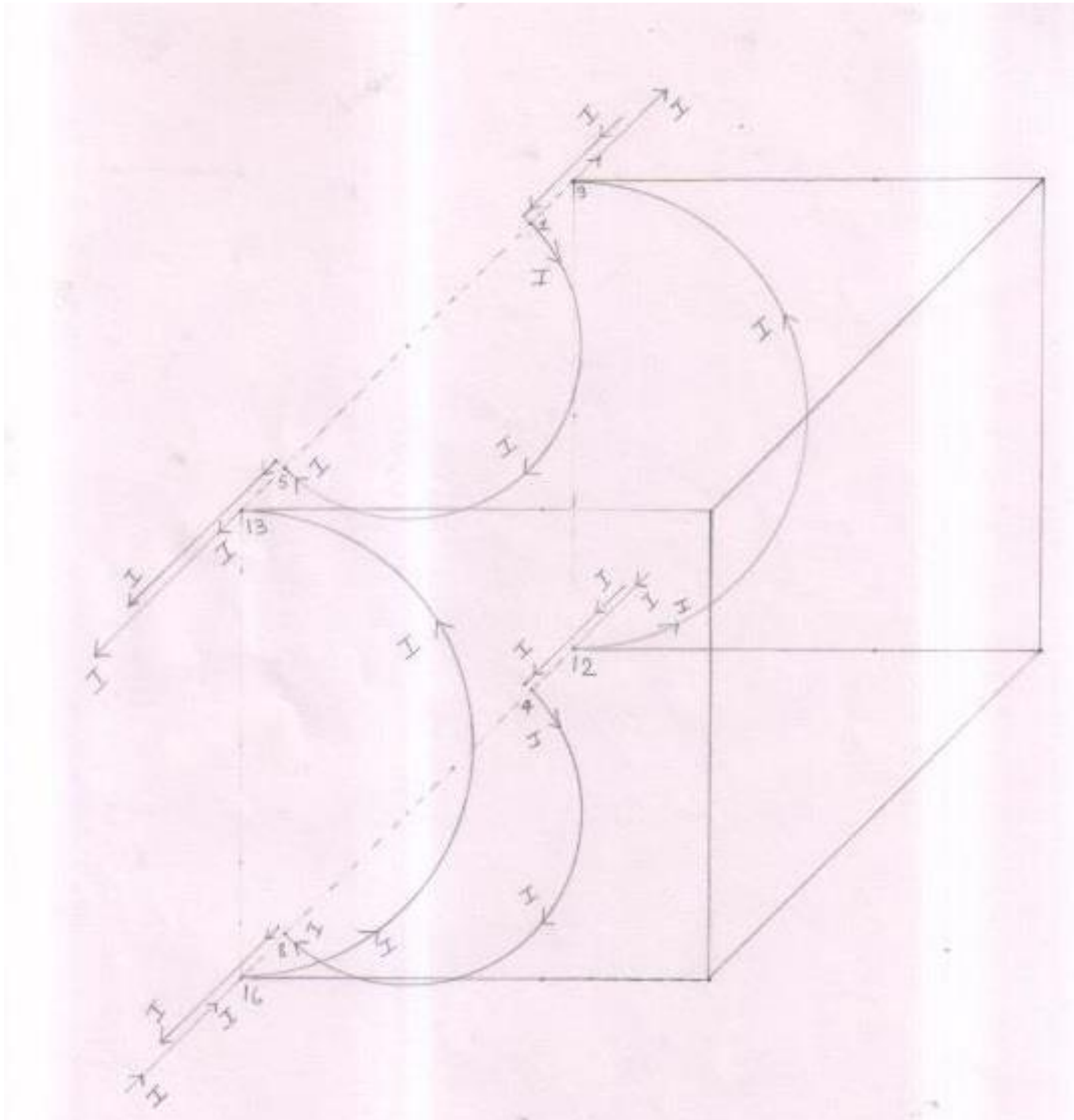
So $\underset{Bz}{\rightarrow} = -\,1.001 \times 10^{-1}$ Tesla

The direction of flow of current in the vertically erected magnetic coils is anticlockwise so that the direction of the produced magnetic field is according to positive y – axis .

As $B_y = 1.0013 \times 10^{-1}$ Tesla

So $\underset{By}{\rightarrow}$ = 1.0013X 10^{-1}Tesla

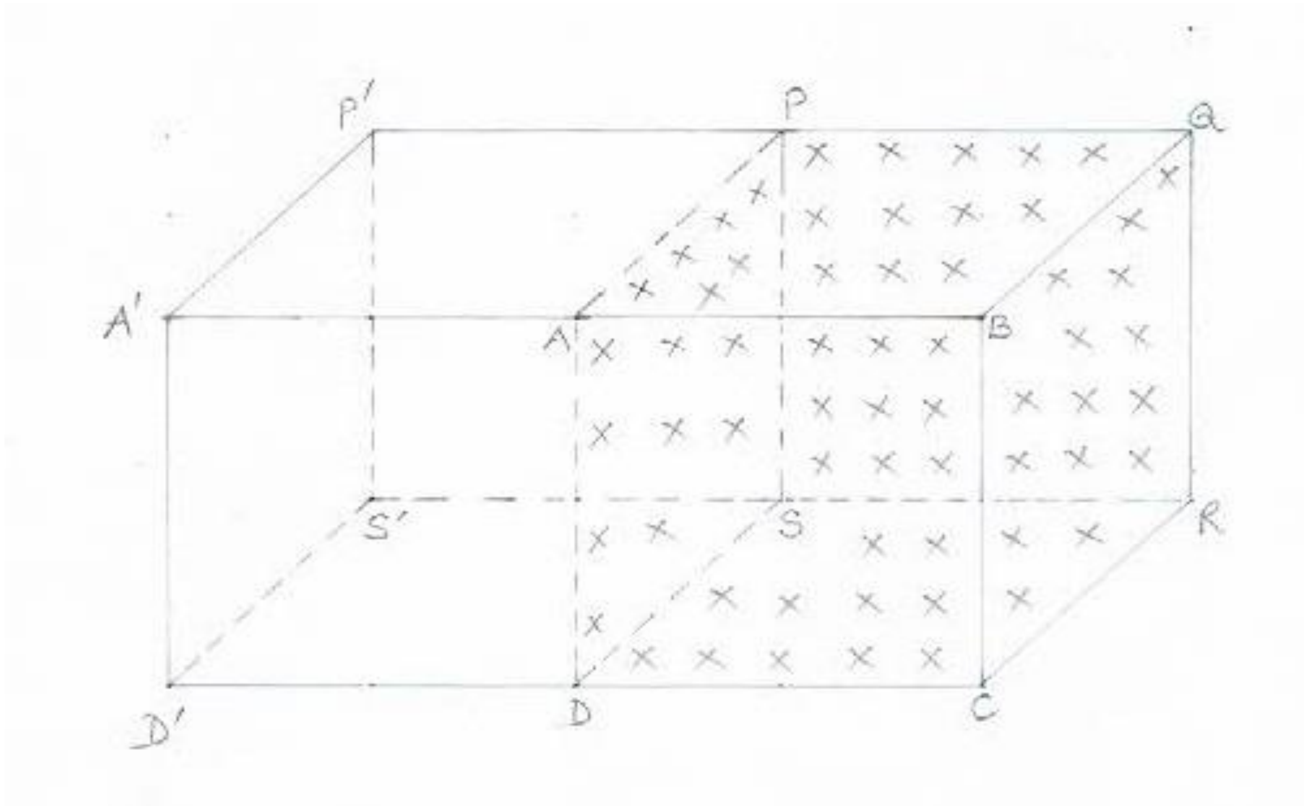
The direction of flow of current in the magnetic field coils.



In the horizontally lying semicircular coils the current (I) flows in the clockwise direction while in the vertically erected semicircular coils the current (I) flows in the anticlockwise direction.

The wire that supply the current (I) in the horizontally lying coils is above to the wire (&) that supply the current in vertically erected coils.

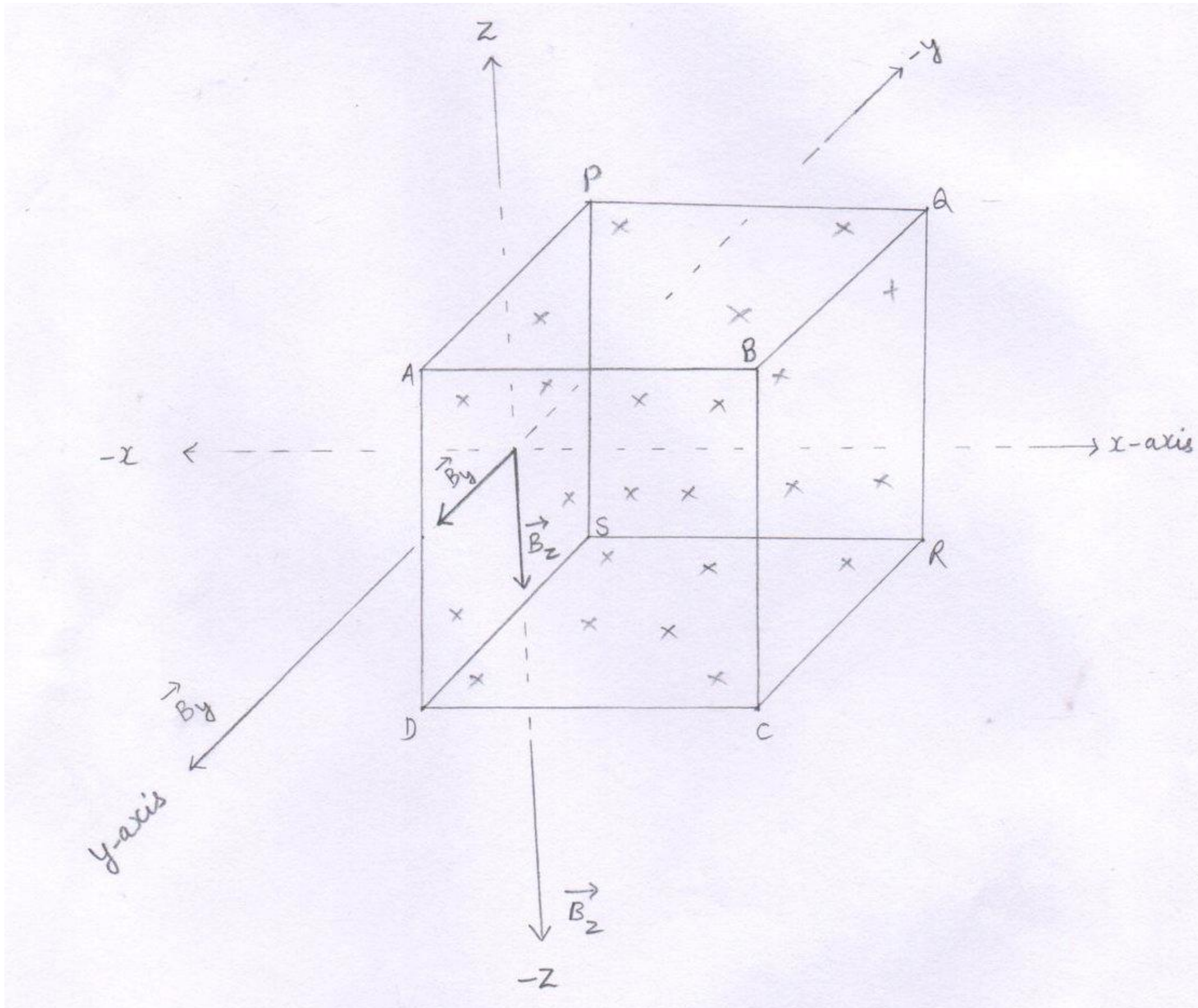
The uniform magnetic fields [B_y and B_z] are applied within into the main tokamak only.



we have denoted the presence of two uniform magnetic fields by the [x] sign.

Two uniform magnetic field are applied within into the main tokamak.

The direction of the uniform magnetic fields applied within into the main tokamak.



where

$\underset{By}{\rightarrow}$ = 1.0013 x 10^{-1} Tesla

$\underset{Bz}{\rightarrow}$ = - 1.001 x 10^{-1}Tesla

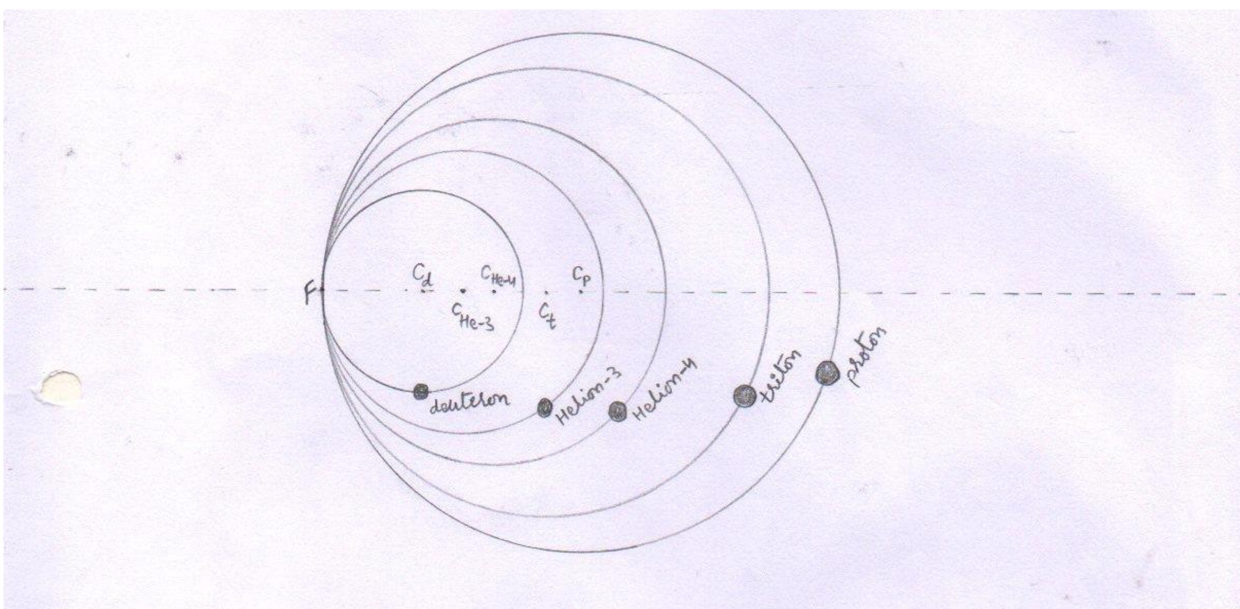
Center of fusion (F) : -center of fusion is actually a point where two charged particles fuse .

For the VBM fusion reactor –The center of fusion is a point from where a charged particle (either it is injected or produced) undergoes to a confined circular path and passes from this point by time and again and thus available for another injected particle (reaching at this point ' F ') for fusion

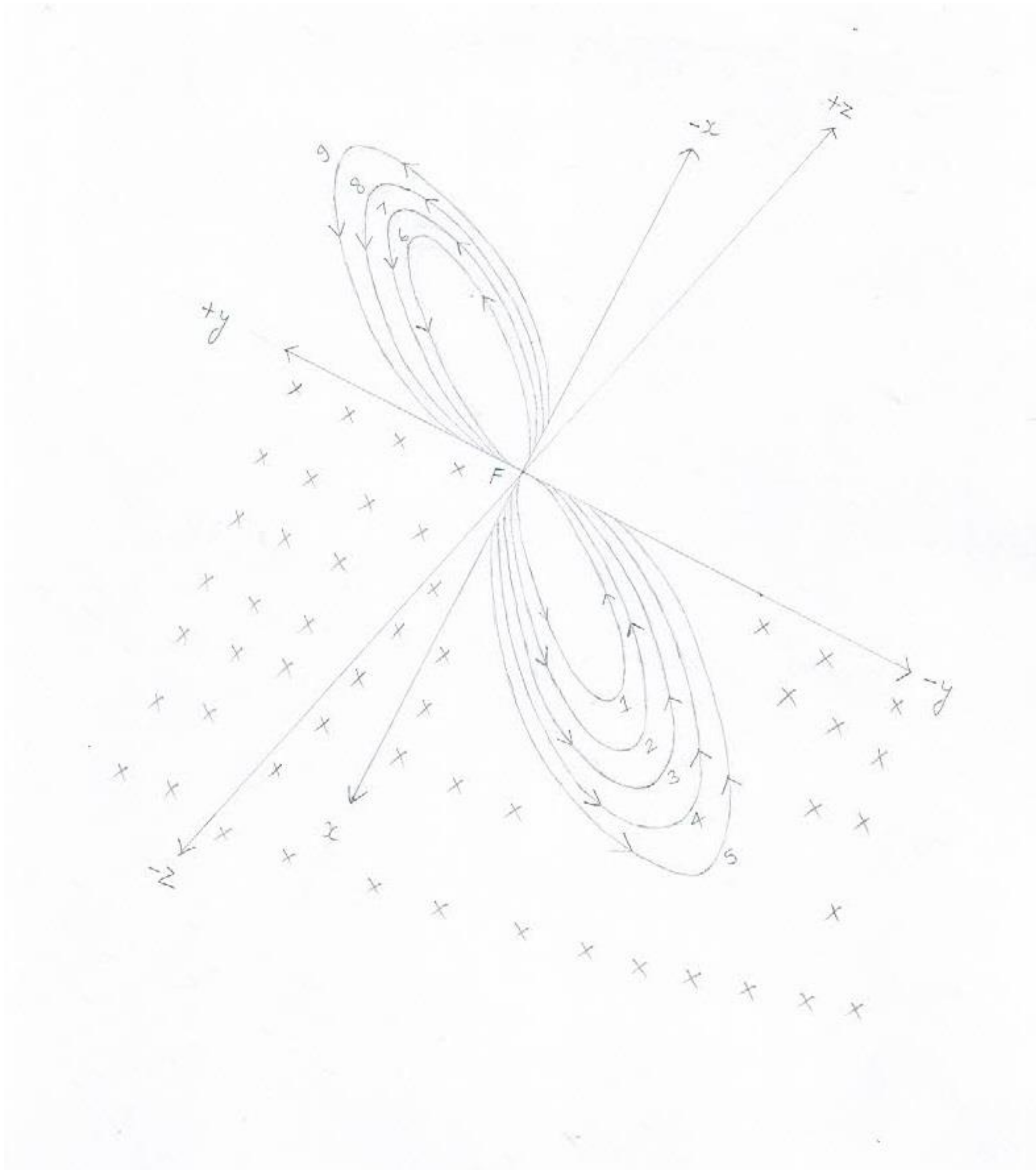
3. Number of ccenters of fusion (F) : As the point ‘F’ is acting as a center of fusion , the total no.of centers of fusion are equal to number of deuterons that an injected bunch contains.

4. Nature of center of fusion : Aa the magnetic field is tangential in nature so the pint F (the center of fusion) that is located within into the magnetic fields is a tangential point of a number of circular orbits (followed or to be followed by the charged particles of different radii.

The center of fusion (The point 'F') is the tangential point of all the circular orbits of different radii followed by the various charged particles.



If we denote the positive x,y and z-axes as shown blow then path of the confined and not confined particles will lie in the planes as shown below.



For +x, -y, -z axes

The denoted numbers represents the circular orbit of the particles described as below.

1st orbit represents the circular orbit of li-6(produced due to 4th fusion reaction) .

2nd orbit represents the circular orbit of helion -4(a by product of 3rd fusion reaction)

3rd orbit represents the circular orbit of injected deuteron.

4th orbit represents the circular orbit of helion -4(a by product of 8th fusion reaction) .

5th orbit represents the circular orbit of proton (a by product of 2nd fusion reaction).

Whereas, for -x, +y and -z axes

6th orbit represents the circular orbit of helion -3(a by product of first fusion reaction).

7th orbit represents the circular orbit of be-9 (a by product of 11th fusion reaction).

8th orbit represents the circular orbit of be -7(a by product of 10th fusion reaction).

9th orbit represents the circular orbit of triton (a by product of 2nd fusion reaction).

Here,

The radius of the circular orbit to be fololowed by the triton is more than the radius of the circular orbit to be followed by the helion -3.
'F' is the centre of fusion or the point of injection of deuteron (s).

Center of fusion (F) is a platform where the fusion is a certainty : -

Form the point ' F ' [The center of fusion] the deutoron of earlier bunch will undergo to confined circular path and will pass through this point by time and again until it fuses with the deuteron of later injected bunch .

Similarly , the point ' F ' also governs the produced charged particle togo through it and tends them to be fused with the injeted deuterons thus available us as a plateform where the fusion is a certainity .

Or , within into the tokamak , the point ' F ' [the center of fusion] is the only and only point where the fusion reactions occur .

Center of fusion in the view of magnetic fields : -

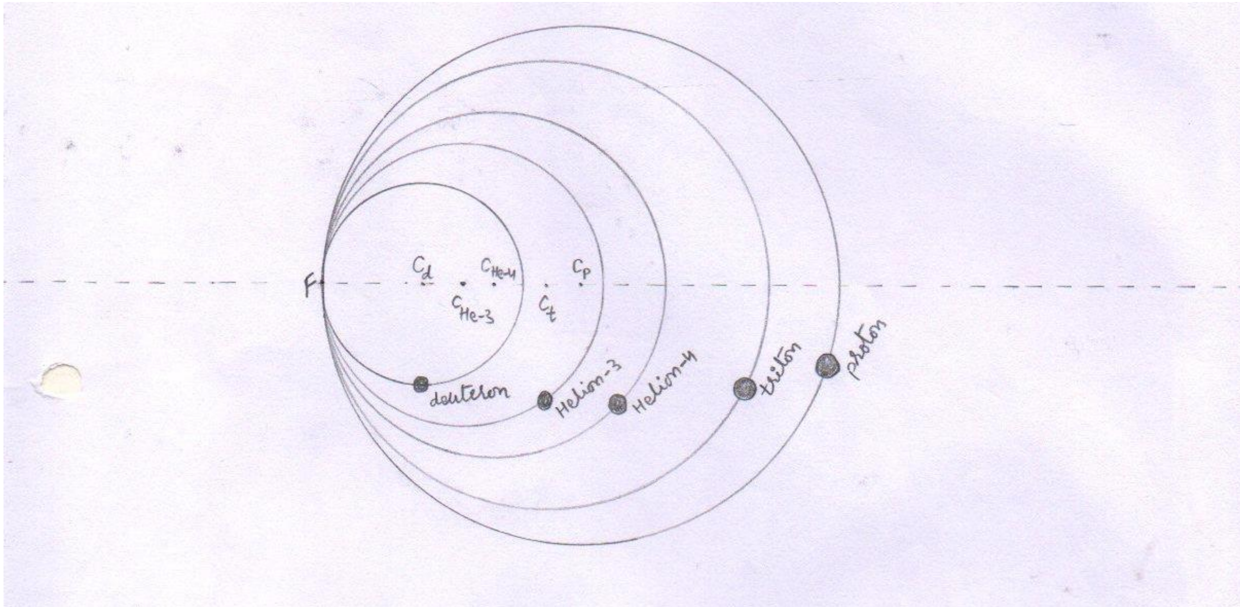
By the view of magnetic fields the center of fusion is a point where the two uniform magnetic fields are perpendicular . But within into the region covered – up by the main tokamak , at each and every point the ratio of two perpendicular magnetic fields [$\underset{Bx}{\rightarrow}$ and$\underset{Bz}{\rightarrow}$]is constant . so , the each and every point within into the region covered – up by the main tokamak can act as a center of fusion .

Note : that is why. if we use the lithiun blanket as an inner liner of the main tokamak then the triton produced due to lithum an netiron reaction will also undergo to a confined circular path and may interrupt the confined path (s) followed by the useful plasma and thus the produced triton may be an obstacle to the steady state VBM-fusion reactor.

7. Center of plasma :-

center of plasma is the center of the circular orbit followed by the charged particles.

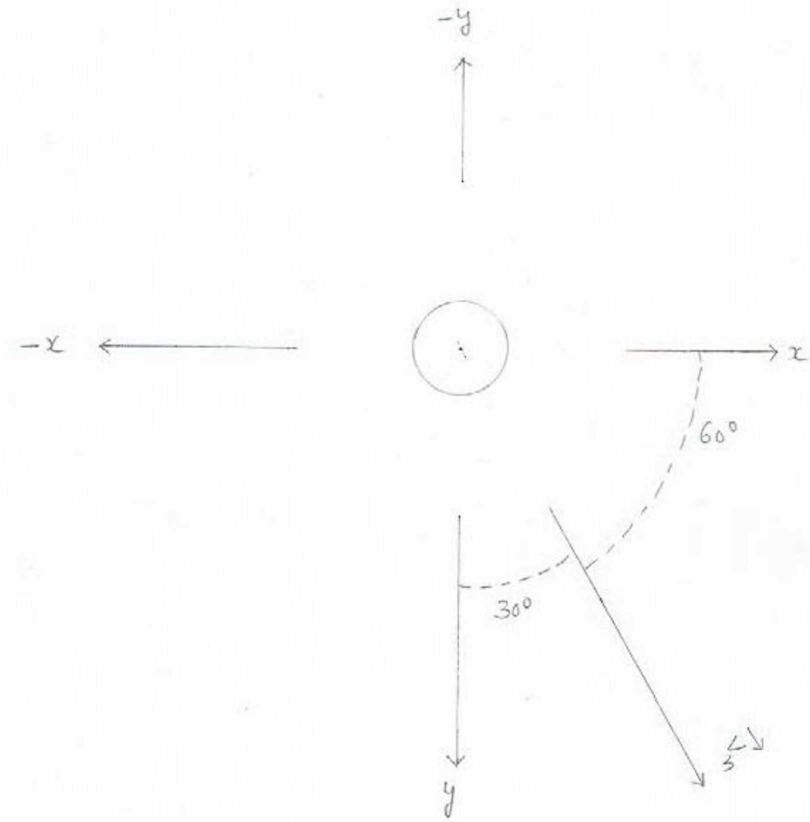
Thus the center of plasma [C_{pm}] differs particle by particlesbut each particle will have a common center of fusion (the point ‘ F ‘).


F
C_d
C_{He-4}
C_{He-3}
C_t
C_p
deuteron
Helion-3
Helion-4
triton
proton

VBM plasma : RF linac injects the bunches of deuterons into the tokamak at point F . such that each deuterons makes angle 30^0 with the x –axis , 60^0 angle with the y-axis and the 90^0 angle with the z-axis . RF linac injects each proton with 153.6kev energy .

Confinement of protons of 1st bunch of deutrerons : -

As the deuterons (s) of first bunch reaches at point F into the tokamak , it experiences a centripetal force due to magnetic fields and hence it follows a confined circular orbit passing through the point of injection (F) by time and again.



V_d = velocity of the deuteron

velocity of the injected deuteron
K.E = ½ $m_d v^2$ = 0.1536Mev

$$= \left(\frac{2 \times 0.1536 \times 1.6 \times 10^{-13}}{3.3434 \times 10^{-27}} \right)^{1/2} m/s$$

$$= \left(\frac{0.49152 \times 10^{14}}{3.3434} \right)^{1/2} m/s$$

$= [\ 0.14701202368 \times 10^{14}\ ]^{½}$ m/s

$= 0.3834 \times 10^{7}$ m/s

Components of the velocity of deuteron at point F : -

As the deuteron is injected at point F making angle $30^{o}$with x – axis , 60^{o} angle with y-axis and 90^{o} angle with z–axis.

so

$, \overrightarrow{V_y} = V \cos 30^{0} = v \times \sqrt{3}/2 = 0.3834 \times 0.866$

$= 0.3320 \times 10^{7}$ m/s

$\overrightarrow{V_x} = V \cos 60^{0} = v \times 0.5 = 0.3834 \times 10^{7} \times 0.5 = 0.1917 \times 10^{7}$ m/s

$\overrightarrow{V_z} = V \cos 90^{0} = v \times 0 = 0$ m/s

Components ofmomentum ofdeuteron at point F : -

$\overrightarrow{p_y} = mv\cos 30^{0} = 3.3434 \times 10^{-27} \times 0.3320 \times 10^{7}$ kg m/s

$= 1.1100 \times 10^{-20}$ kg m/s

$\underset{px}{\rightarrow}$=mvcos 60^0 = 3.3434 x 10^{-27} x 0.1917 x 10^7 kg m/s

= 0.6409 x 10^{-20} kg m/s

$\underset{pz}{\rightarrow}$=mvcos 90^0 = m x 0 =0 kgm/s

The forces acting on the deuteron

1 F_y = q V_x B_z sin θ

$\underset{Vx}{\rightarrow}$ = 0.1917 x 10^7 m/s $\underset{Bz}{\rightarrow}$= -1.001X$10^{-1}$ Tesla

sin θ = sin 90° = 1

Fy = 1.6x 10^{-19} x 0.1917 x 10^7 x 1.001X10^{-1} x 1 N
=0.3070 x 10^{-13}N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ isaccording to - y-axis , so,

$\underset{Fy}{\rightarrow}$ =- 0.3070 x 10^{-13} N

2 F_z =q V_x B_y sin θ

$\underset{By}{\rightarrow}$= 1.0013X$10^{-1}$ Tesla

sin θ= sin 90° = 1

Fz = 1.6 x 10^{-19}x 0.1917 x 10^{7} x 1.0013X10^{-1} x1 N

=0.3071x 10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fz}{\rightarrow}$ is according to -Z- axis ,

so ,

$\underset{Fz}{\rightarrow}$ = -0.3071 x 10^{-13}N

3 F_x = q V_y $B_z$sin θ

$\underset{Vy}{\rightarrow}$ = 0.3320 x 10^{7}

$\underset{Bz}{\rightarrow}$= -1.001X$10^{-1}$ Tesla

sin θ = sin 90° = 1

Fx = 1.6 x 10^{-19} x 0.3320 x 10^{7} x **1.001X10^{-1}**x 1 N

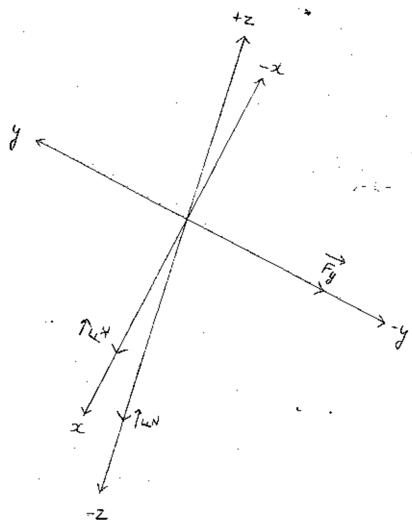
=0.5317x 10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$is according to (+) x axis ,

so ,

$\underset{Fx}{\rightarrow}$ = 0.5317 x 10^{--13}N

Theforces acting on the deuteron



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$$F_x = 0.5317 \times 10^{-13} \quad N$$

$$F_y = 0.3070 \times 10^{-13}$$

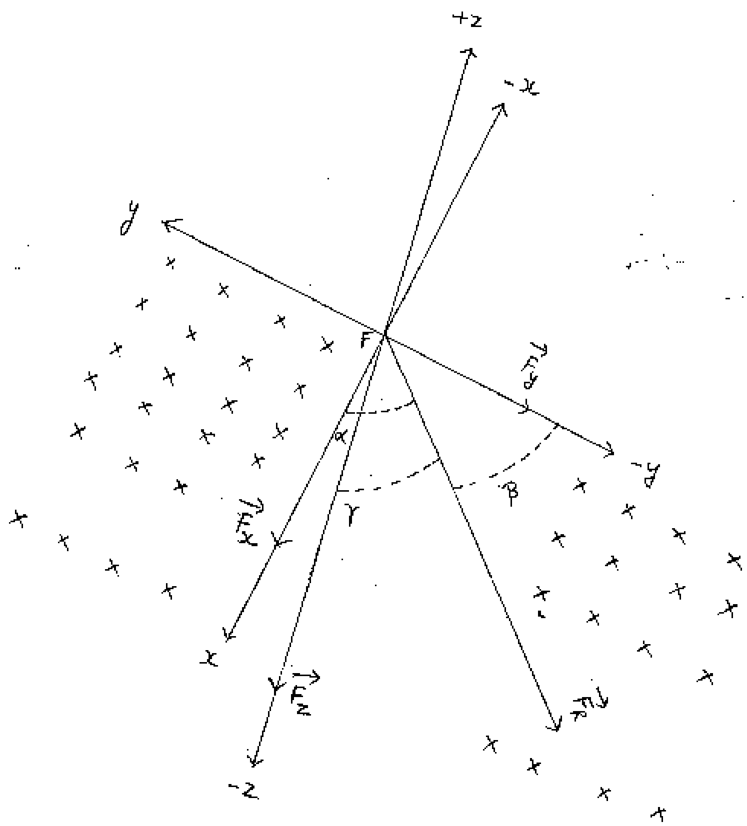
$$= F_z = 0.3071 \times 10^{-13} N$$

$$F_R^2 = (0.5317 \times 10^{-13})^2 + (0.3070 \times 10^{-13})^2 + (0.3071 \times 10^{-13})^2 \quad N^2$$

$$= (0.28270489 \times 10^{-26}) + (0.094249 \times 10^{-26}) + (0.09431041 \times 10^{-26})^2 \quad N^2$$

$$F_R^2 = 0.4712643 \times 10^{-26} \quad N^2$$

$$F_R = 0.6864 \times 10^{-13} \quad N$$


+z
-x
y
F
-y
x
-z
α
β
γ

Radius of the circular path :

Resultant force acts as a centripetal force on the deuteron . so, the deuteron follows a confined circular path.

The radius of the circular orbit obtained by the deuteron is –

$r = mv^2 / F_R$

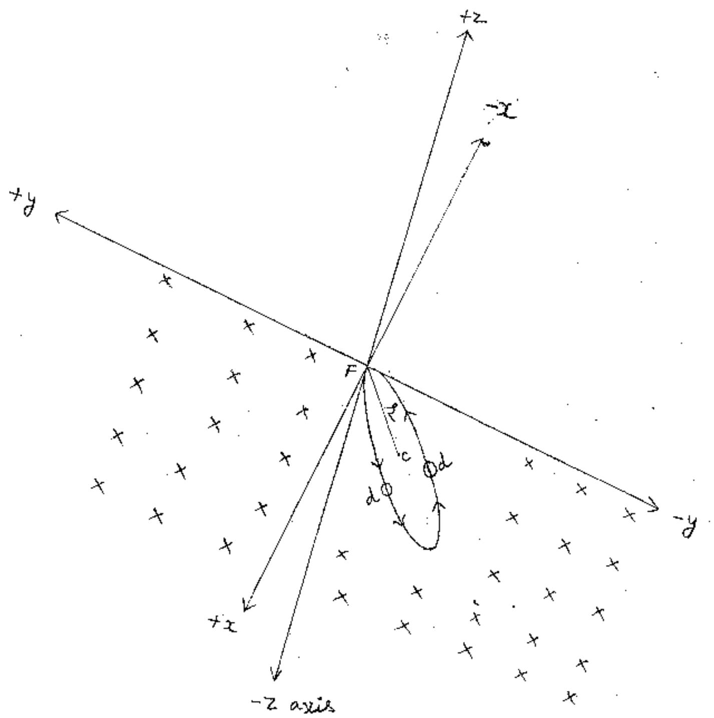
$mv^2 = 2x153.6$ Kev =2x0.1536Mev=2x0.1536x1.6 x J

$mv^2 = 0.4915 \times 10^{-13}$ J

$$r = \frac{0.4915X10^{-13} J}{0.6864 \times 10^{-13} N}$$

= 0.7160 m

The confined deuteron follows the circular orbit as shown below :-



The circular orbit followed by the confined deuteron lies in the IV (down) quadrant or in the plane made up of positice x-axis, negative y-axis and the negative z-axis.

$\overrightarrow{Fr}$ = The resultant force acting on the deuteron when the deuteron is at point ' F ' .

C_d = center of the circular orbit followed by the deuteron.

The plane of the circular orbit followed by the confined deuteron makes angles with positive x , y and z-axesas follows :-

1 with x- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow}$ / F_r

$\underset{Fx}{\rightarrow}$ = 0.5317×10^{-13} N

F_r= 0.6864×10^{-13}N

Putting values

Cosα = 0.7746

α= 39.23degree [∴cos (39.23) = 0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / F_r

$= \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ = -0.3070×10^{-13} N

F_r = 0.6864×10^{-13} N

Putting values

Cos β = -0.4472

β=243.43degree [∴ cos (243.43) = - 0.4472]

3 with y- axis

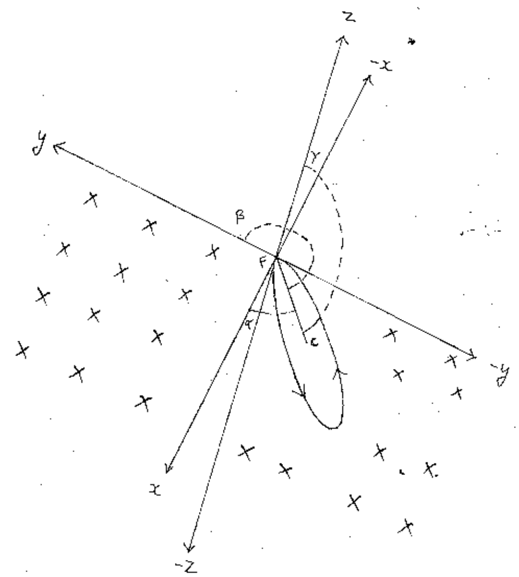
Cos y = $\underline{F_R \cos y}$/ F_r $= \underset{Fz}{\rightarrow}$ / F_r

$\underset{Fz}{\rightarrow}$= -0.3071×10^{-13}N

F_r= 0.6864×10^{-13} N

Cos y = -0.4474

y =243.42 degree



The plane of the circular orbit followed by the confined deuteron makes angles with positive x, y and z axes as follows :-

Where,

α= 39.23 degree

β = 243.43 degree

Y = 243.42 degree

All the angles are in degree.

The direction cosines of the line P_1P_2

The line P_1 P_2 is the diameter of the circle followed (or to be followed) by the particle .
The points P_1 (x_1 y_1 z_1) and P_2 (x_2 y_2 z_2) make the line P_1 P_2 .

The particle starts its circular motion from the point 'F' (- the center of fusion where the particle is either injected or produced).
So, we have denoted the Cartesian coordinates for the

Point 'F' as (0 ,0 , 0) .

Here the point F (0,0,0) and the point P_1 (x_1 y_1z_1) are the same .

So , the direction cosines of the line P_1 P_2 are : -

l = cos α = $x_2 - x_1$ / d
where ,

d = 2 x radius of the circle
cos α = cos component of the angle that make the resultant force ($\underset{Fr}{\rightarrow}$) [acting on the particle when the particle is at point F] with the positive x - axis .

2. m = cos β = $y_2 - y_1$ / d

Where ,

cos β = cos component of the angle that make the resultant force($\underset{Fr}{\rightarrow}$) [acting on the particle when the particle is at point F] with the positive y - axis .

3. n = cos y = $z_2 - z_1$ / d

Where ,

cos y = cos component of the angle that make the resultant force($\underset{Fr}{\rightarrow}$) [acting onthe particle when the particle is at point F] with the positive z - axis .

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle obtained by the deuteron

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

d = 2 x r

= 2x 0.7160 m

= 1.432 m

Cos α = 0.7746

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 1.432 \times 0.7746$ m

$x_2 - x_1 = 1.1092$ m

$x_2 = 1.1092$ m [∴ $x_1 = 0$]

$$\cos \beta = \frac{y_2 - y_1}{d}$$

$\cos \beta = -0.4472$

$y_2 - y_1 = d \times \cos \beta$

$y_2 - y_1 = 1.432 \times (-0.4472)$ m

$y_2 - y_1 = -0.6403$ m

$y_2 = -0.6403$ m [$\therefore$ $y_1 = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = -0.4474$

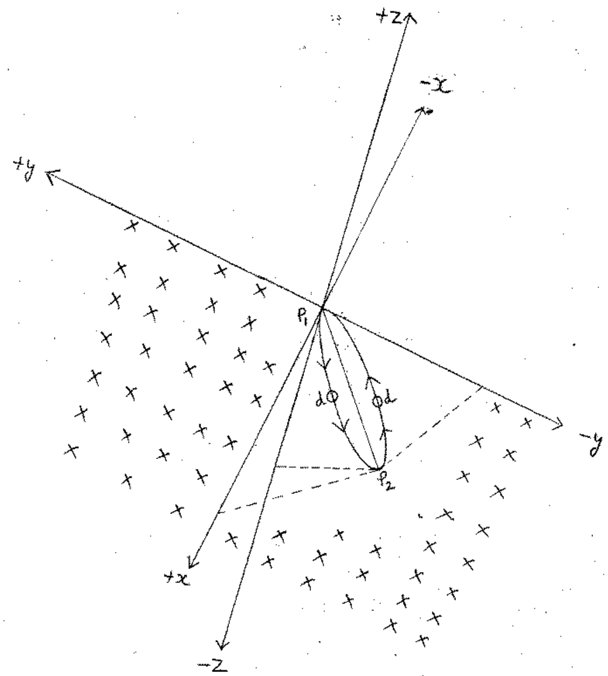
$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 1.432 \times (-0.4474)$ m

$z_2 - z_1 = -0.6406$ m

$z_2 = -0.6406$ m [$\therefore$ $z_1 = 0$]

The cartesian coordinates of the point $p_1(x_1, y_1, z_1)$ and $p_2(x_2, y_2, z_2)$



The cartesian coordinaltes of the points P_1 (0,0,0) and P_2 (3.66 x 10^{-2} , 6.43 x 10^{-2} , -6.43 x 10^{-2}) where the points $P_1(x_1 , y_1 , z_1)$ and $P_2(x_2 , y_2 , z_2)$ are located on the circumfrence of the circleobtained by the deuteron.

The line ___ is the diameter of the circle .

P_1P_2

Conclusion :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that are acting on the deuteron

are along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed bythe deuteron lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields areapplied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the deuteron to undergo to a circular orbit of radius of 0.7160 m. It starts its circular motion from point P_1 (0,0,0) and reachesat point P_2 (1.1092 m , -0.6403 m,-0.6406 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak. And uninterruptedly goes on completing its circle until it fuses with the deuteron of later injected bunch (that reaches at point "F") at point "F"

Time period of the confined particles

resultant force

$F_r^2 = F_x^2 + F_y^2 + F_z^2$

where, $F_x = qV_y B_z$

$F_y = qV_x B_z$

$F_z = qV_x B_y$

For the VBM Fusion reactor

$B_y = B_z = B = 1$ Tesla

so,

$F_x = qV_y B$, $F_y = qV_x B$

and $F_z = qV_x B$

hence $Fy = Fz = F = qV_x B$

putting the values

$F_r^2 = F_x^2 + 2F^2$

$q^2V_y^2B^2 + 2\, q^2V_x^2B^2$

$F_r^2 = q^2B^2 (V_y^2 + 2\, V_x^2)$

$F_r = Bq\, (V_y^2 + 2\, V_x^2)^{1/2}$

2- Radius of the particle

$R = mv^2 / F_R$

$\underline{mv^2\quad}$

Bq $(2V_x^2 + V_y^2)^{1/2}$

3- Time period of the particle

$T = 2\pi r / V$

$= 2\pi / V$ $\underline{mv^2}$

Bq $(2V_x^2 + V_y^2)^{1/2}$

$= 2\pi m / Bq \times \underline{V}$

$(2V_x^2 + V_y^2)^{1/2}$

where , $V = (V_x^2 + V_y^2 + V_z^2)^{1/2}$

but here $V_2 = 0$

so, $V = (V_x^2 + V_y^2)^{1/2}$

$T = 2\pi m / Bq \times \underline{V}$

$(2V_x^2 + V_y^2)^{1/2}$

$T = 2\pi m / Bq \times (V_x^2 + V_y^2 / 2V_x^2 + V_y^2)^{1/2}$

here, $2V_x^2 + V_y^2 > V_x^2 + V_y^2$

so, the time period of the confined particle depends on the x-component of the final velocity of the paritcle while in the cyclotron it does not depend on the velocity of the particle.

Time period of the particle

For deuteron

$T = 2\pi m / Bq \times \underline{V}$

$(2V_x^2 + V_y^2)^{1/2}$

$(2V_x^2 + V_y^2)^{1/2} = 2x(0.271 \times 10^7)^2 + (0.1565 \times 10^7)^2 \quad m^2/s^2$

$= 2 \times 0.073441 \times 10^{14} + 0.02449225 \times 10^{14} \quad m^2/s^2$

$= 0.17137425 \quad m^2/s^2$

$(2V_x^2 + V_y^2)^{1/2} \quad = 04139 \times 10^7 \; m^2/s^2$

put the velue

$V = 0.3130 \times 10^7 \quad B = 1$ Tesla

$q = 1.6 \times 10^{-19}$ c , $m = 3.3434 \times 10^{-27}$ kg

$T = 2 \times 3.14 \times 3.3434 \times 10^{-27} \times 0.3130 \times 10^7$ s

$1 \times 1.6 \times 10^{-19} \times 04139 \times 10^7$

$= \underline{6.571920776 \times 10^{-20}}$ s

0.66224×10^{-12}

$= 9.92 \times 10^{-8}$ second

or

$2\pi\, r / v$

$r = 4.947 \times 10^{-2}$ m

$v = 0.3130 \times 10^7$ m/s

$T = \quad 2 \times 3.14 \times 4.947 \times 10^{-2}$ s

0.3130×10^7

$= \quad \underline{31.06716 \times 10^{-2}}$ s

0.3130×10^7

$= 9.92 \times 10^{-8}$ second

Time of confinement of deuteron (s) :-

The time of confinement of plasma is the time for which the plasma can exist before it radiates away its energy through cyclotron radiations.

Power loss by cylotron radiations :

By the larmor formula , power loss is given as-

$$P = \frac{2^e a^2}{3C^3}$$

exprlession for accleration lising lorentz force :

$$ma = e\underline{v}\, B$$

c

by substition

$$P = \frac{2e^4 v^2 B^2}{3c^5 m^2}$$

$$\frac{dE}{dt} = \frac{-2e^2v^2B^2}{3c^5m^2} = \frac{-4e^4EB^2}{3c^5m^3} \quad [\therefore \; 1/2mv^2 = E]$$

$$\frac{dE}{E} = \frac{-4e^4EB^2}{3c^5m^3}\, dt$$

$$E = E_o\, e^{\frac{-4e^4EB^2}{3c^5m^3} t} = E\, e^{\frac{-t}{t_o}}$$

$$t_o = \frac{3c^5m^3}{-4e^4EB^2} =$$

Time of confinement of deutron

$$t_e = \frac{3c^5m^3}{4e^4B^2}$$

$c = 3 \times 10^{10}$ cm/s

$m = 3.3434^{-24}$ gram

$e = 4.8 \times 10^{-10}$ esu

$B = 1 \times 10^{-1}$ Tesla $= 10^3$ Gauss

$$t_e = \frac{3 \times (3 \times 10^{10})^5 \times (3.3434 \times 10^{-24})^3}{4 \times (4.8 \times 10^{-10})^4 \times (10^3)^2}$$

$$= \frac{3 \times 243 \times 10^{50} \times 37.3736 \times 10^{-72}}{4 \times 530.84 \times 10^{-40} \times 10^6} \text{ seconds}$$

$$= \frac{272445.3544 \times 10^{-22}}{2123.36 \times 10^{-34}}$$

$= 12.83 \times 10^{12}$ seconds

$= 1.283 \times 10^{13}$ seconds

Conclusion : Time of confinement (t_e) of the deuteron is = 1.283×10^{11} seconds. Thus we do not expect to see emission from deutrons (plasma) . As each and every deuteron injected into the tokamak at the center of fusion (point F) is with enough energy required for fusionj, so, in the VBM fusion reactor thre is no need of solenoid (primary transformer) to heat the plasma (seconary transformer) while in the thermonuclear fusion reactors there is a solenoid to heat the plasma.

The fusion reactions :-

In the VBM fusion reactor based on D-D cycle, the following fusion reactions occures .

1.$^2{}_1H + {}^2{}_1 H \rightarrow {}_2{}^3 He + {}^1{}_0n$

[injected] [confined][not confined]

2$^2{}_1H + {}^2{}_1 H \rightarrow {}_1{}^3 H + {}^1{}_1H$

[injected] [confined]

3$^2{}_1H + {}^2{}_1 H \rightarrow {}_2{}^4He$ + y says

[injected] [confined]

4.$^2{}_1H + 4_2He \rightarrow {}_3{}^6 Li$ + y says

[injected][confined][confined]

5.$^2{}_1H + {}^6{}_3Li \rightarrow [{}_4{}^8 Be] \rightarrow {}_3{}^7 Li + {}^1{}_1 H$

[injected] [confined] [not confined] [not confined]

6.$^2{}_1H + {}^6{}_3Li \rightarrow [{}_4{}^8 Be] \rightarrow {}_4{}^7Be + {}^1{}_0 n$

[injected] [confined] [not confined]

7.$^{2}_{1}$H. + $^{6}_{3}$LI →[$_{4}^{8}$ Be] →$_{2}^{4}$ He+ $_{2}^{4}$ He

[injected] [confined][not confined][not confined]

8.$^{2}_{1}$H+ $^{6}_{3}$ Li→[$_{4}^{8}$Be] →$_{2}^{3}$ He+$_{2}^{4}$He+ $^{1}_{0}$ n

[injected] [confined][not confined] [not confined]

9.$^{2}_{1}$H +$^{6}_{3}$ Li+$^{2}_{1}$H→ [$_{5}^{10}$B] →$_{3}^{7}$ Li+ $^{3}_{2}$ He

[injected] [confined] [confined] [not confined] [not confined]

10.$^{2}_{1}$H+ $^{6}_{3}$ Li+$^{2}_{1}$H→[$_{5}^{10}$B] →$_{4}^{7}$ Be+ $^{3}_{1}$ T

[injected] [confined] [confined] [not confined] [not confined]

11.$^{2}_{1}$H+ $^{6}_{3}$ Li+$^{2}_{1}$H→ [$_{5}^{10}$B] →$_{4}^{9}$ Be+ $^{1}_{1}$ P

[injected][confined] [confined] [not confined] [not confined]

How fusion occurs

1 Formation of compound nucleus : -

As the deuteron of Nth bunch reaches at point ‘ F ‘ , it fuses with the deuteron of first bunch(confined deuteron passing through the point ‘ F ‘] to form a compound nucleus .

2 The splitting of compound nucleus : -

The compound nucleus splits into three particles . out of three particles , two are finite nuclei and third one is reduced mass.Due tosplliting of compound nucleus, all the three particles separates from each other with a velocity($\underrightarrow{\mathrm{Vcn}}$) equal to the velocity of the compound nucleus.

Propulsion of the particles : -
Reduced mass converts into energy andact as a propellant for both the produced final nuclei.

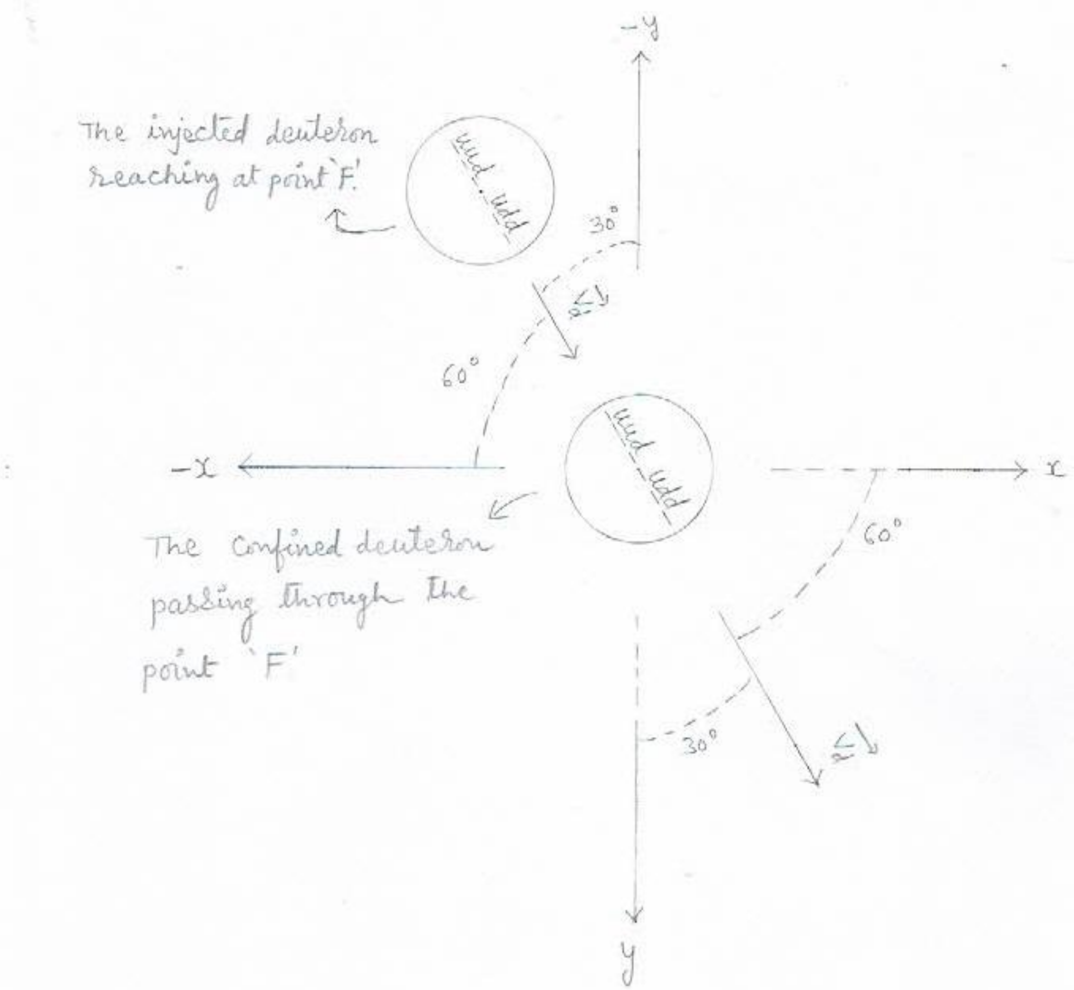
For fusion reaction

$^{2}_{1}H + ^{2}_{1}H \rightarrow _{2}^{3} He + ^{1}_{0}n$

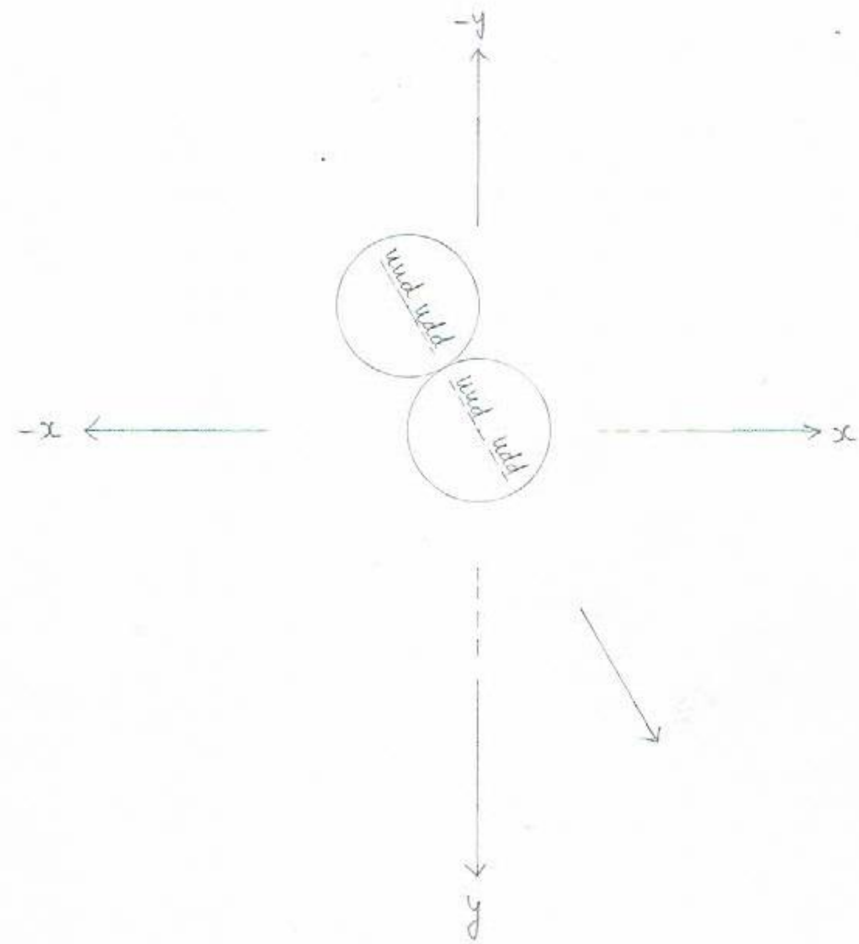
interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined deuteron] with the confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined deuteron.

interaction of nuclei (1)



interaction of nuclei (2)

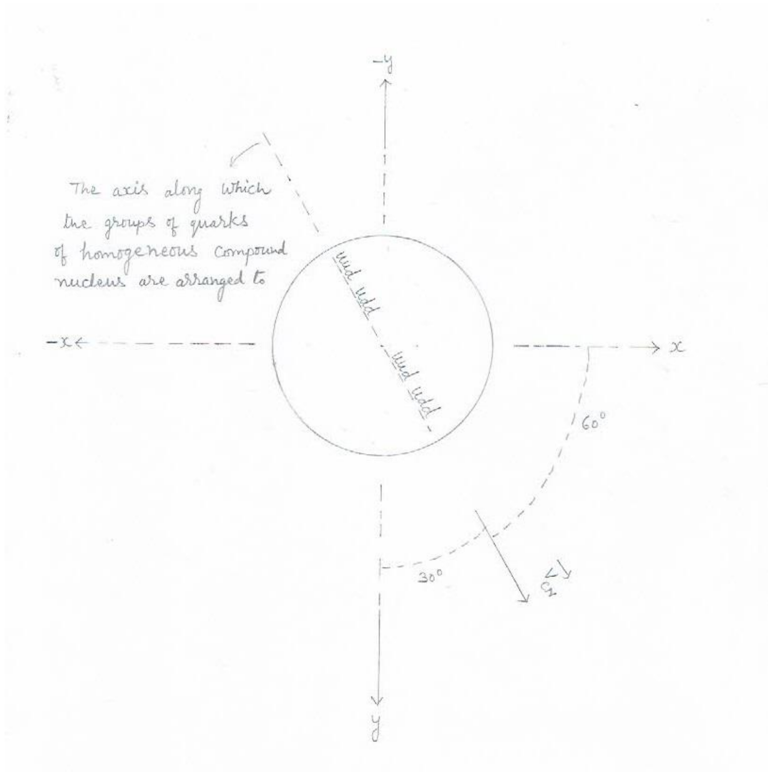


Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 4 groups of quarks surrounded by the gluons.

Formation of homogenous compound nucleus



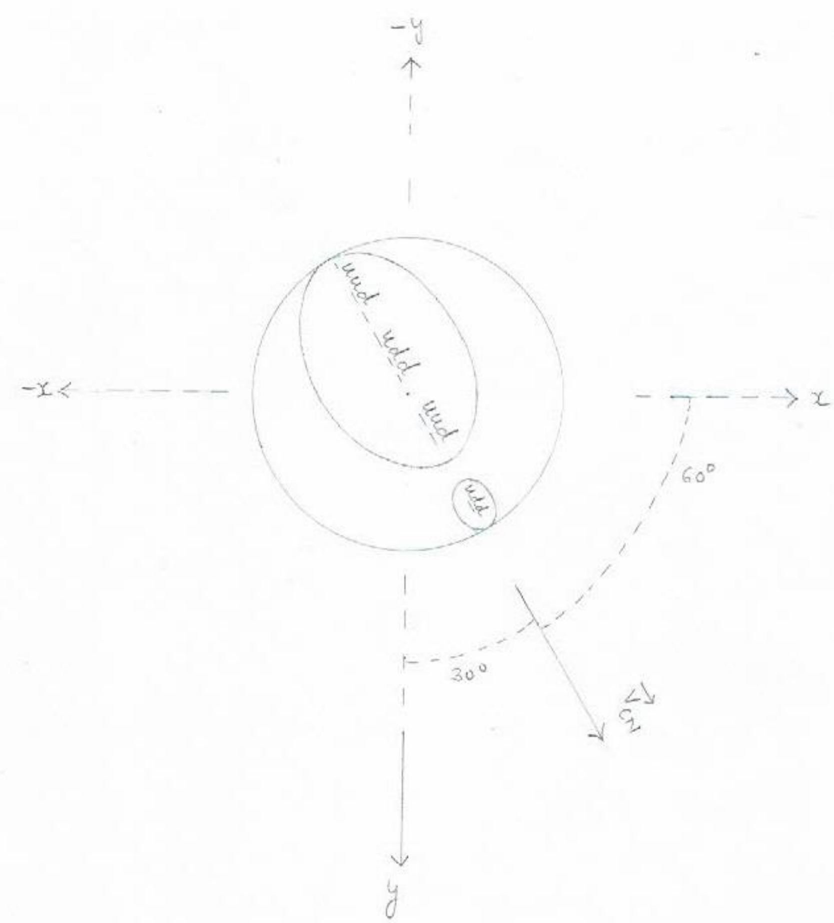
Formation of homogenous compound nucleus

3 Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the helion-3) than the reactant one (the deuteron) includes the other two(nearby located) groups of quarks with their surrounding gluons and rearrange to form the ' A ' lobe of the heterogeneous compound nucleus.

While , the remaining groups of quarks to become a stable nucleus (neutron) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ' A '] and rearrange to form the 'B' lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.



Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the helium-3 nucleus and the smaller one is the neutron while the remaining space represents the remaining gluons .
Within into the homogenous compond nucleus ,the greater nucleus is the lobe 'A ' while the smaller one is the lobe 'B' .

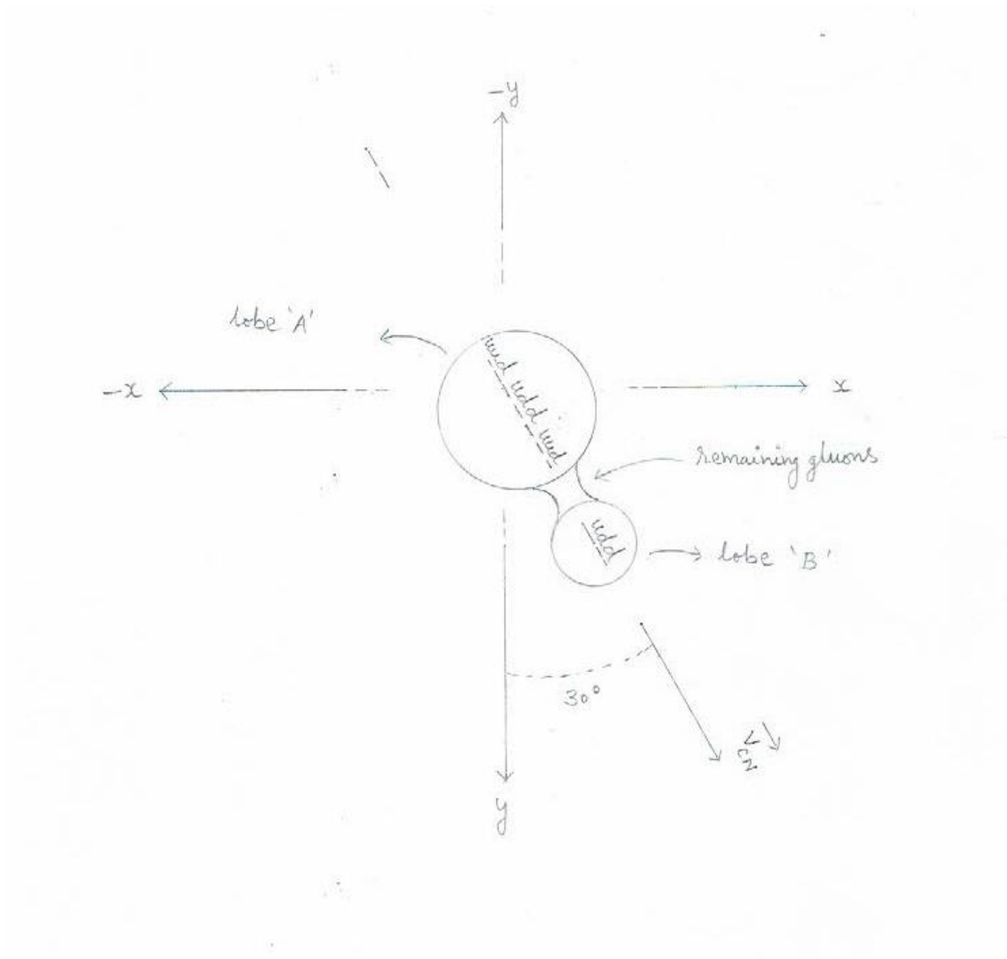
Final stage of the heterogeneous compound nucleus : -

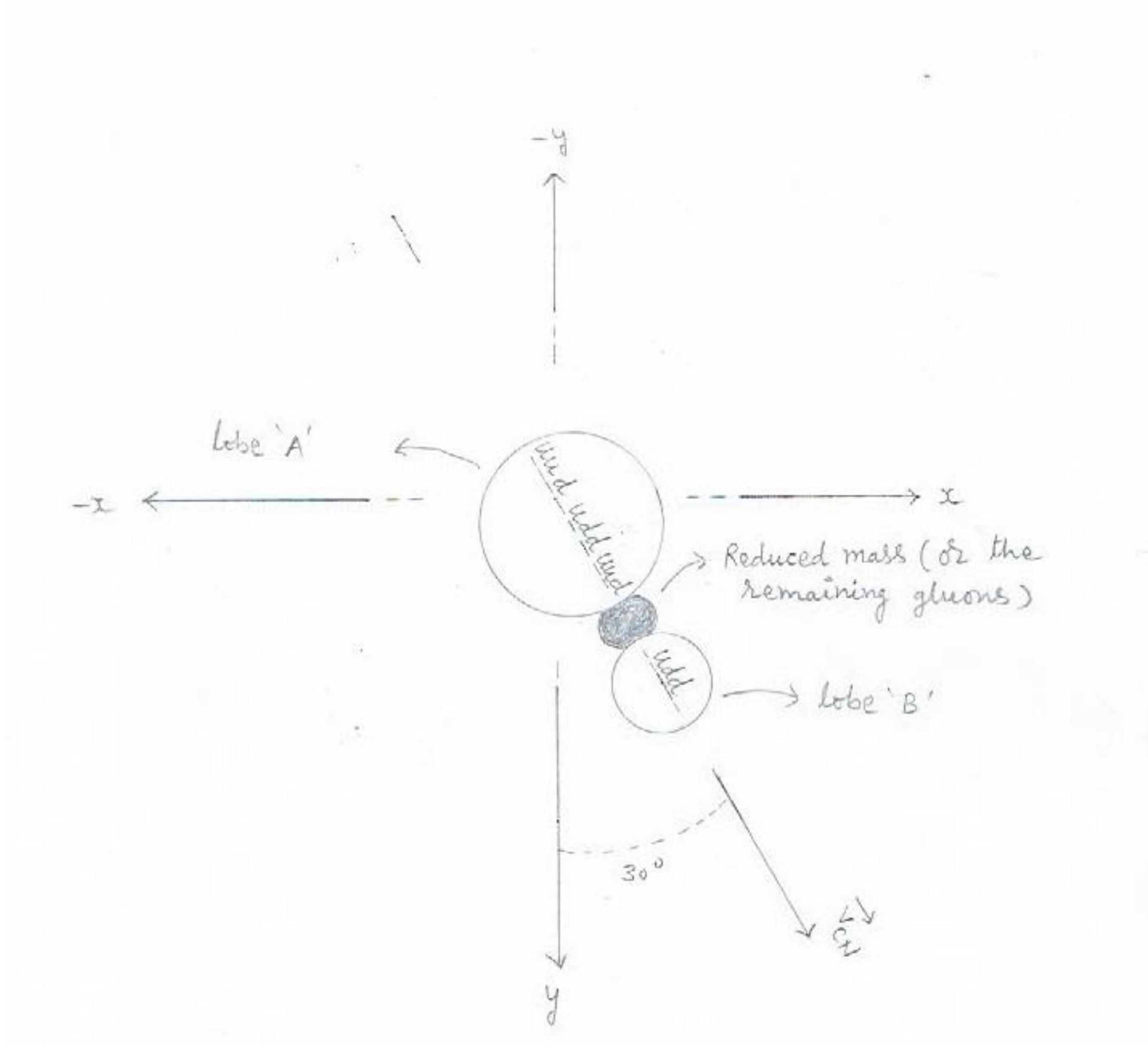
The process of formation of lobes creates void (s) between the lobes . so, the remaining gluons (or the mass) that are not involved in the formation of any lobe) rearrange to fill the void (s) between the lobes . Thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight.

Heterogenous compound nucleus





Final stage of a heteroguons compound nucleus.

Formation of compound nucleus :

As the deuteron of n^{th} bunch reaches at point F , it fuses with the confined deuteron of 1^{st} bunch to form a compund nucleus .

Just before fusion, to overcome the electrostatic repulsive force exerted by the duteron of 1^{st} bunch, the deuteron of n^{th} bunch loses (radiates its energy in the form of eletromagnetic waves) its energy equal to 5.0622 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 5.0622 kev

= 148.5378 kev

= 0.1485378 Mev

velocityof n^{th} deuteron just before fusion

$E_b = ½\ m_d V_b^2$ = 0.1485378 mev

$$v = \left(\frac{2x0.1485378 \times 1.6 \times 10^{-13}}{3.3434x\ 10^{-27}\ \text{kg}} \right)^{½} \text{m/s}$$

$$v = \left(\frac{0.47532096 \times 10^{14}}{3.3434} \right)^{½} \text{m/s}$$

$= [\ 0.14216694382 \times 10^{14}\ ]^{½}$ m/s

$= 0.3770 \times 10^7$ m/s

Just before fusion, to overcome the electrostatic repulsive force exerted by the duteron of 1^{st} bunch, the confined deuteron(of earlierly injected bunch) loses (radiates its energy in the form of eletromagnetic waves)its energy equal to 5.0622 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 5.0622 kev

= 148.5378 kev

E_b = 0.1485378 Mev

Kinetic energy of compound nucleus :- Kinetic energy of compound nucleus is the sum of the kinetic energy of injected deuteron (just before fusion) and kinetic energy of confined deuteron (just before fusion)

$Ecn = ½\ m_d V_b^2 + ½\ m_d V_b^2$

$= m_d V_b^2 = 2x148.5378$ Kev

Mass of compound nucleus (M) :Twice the mass of a deuteron.

Velocity of compound nucleus :

$V_{cn} = (2xE_{cn}/M)^{1/2}$

$=(2xm_d V_b^2\ /2xm_d)^{1/2}$

$=V_b$

Components of velocity ofcompound nucleus at point F.

1 $\overrightarrow{v_x}$ = V_{cn}cos α = $V_b$cos α = V_b cos 60^0

= 0.3770 x 10^7 x 0.5 m/s

=0.1885 x 10^7 m/s

2 $\overrightarrow{v_y}$ = V_{cn} cos β = $V_b$cos β = V_b cos 30^0

= 0.3770 x 10^7 x 0.866 m/s

=0.3264x 10^7 m/s

3 $\overrightarrow{v_z}$ = V_{cn} cos y = $V_b$cos y = $V_b$cos 90^0

= v x 0 = 0 m/s

4.. Mass of the compound nucleus (M) :

M = 2 x mass of deuteron

= 2 x 2.0135 amu

= 4.027 amu

= 6.6868 x 10^{-27}kg

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – helion-3, neutron and reducedmass (Δm) .

Out of them , the two particles (the helion-3 and neutron) are stable while the third one (reduced mass) is unstable .

According to the law of inertia, each particle that isproduceddue to splitting of the compound nucleus ,hasan inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$).

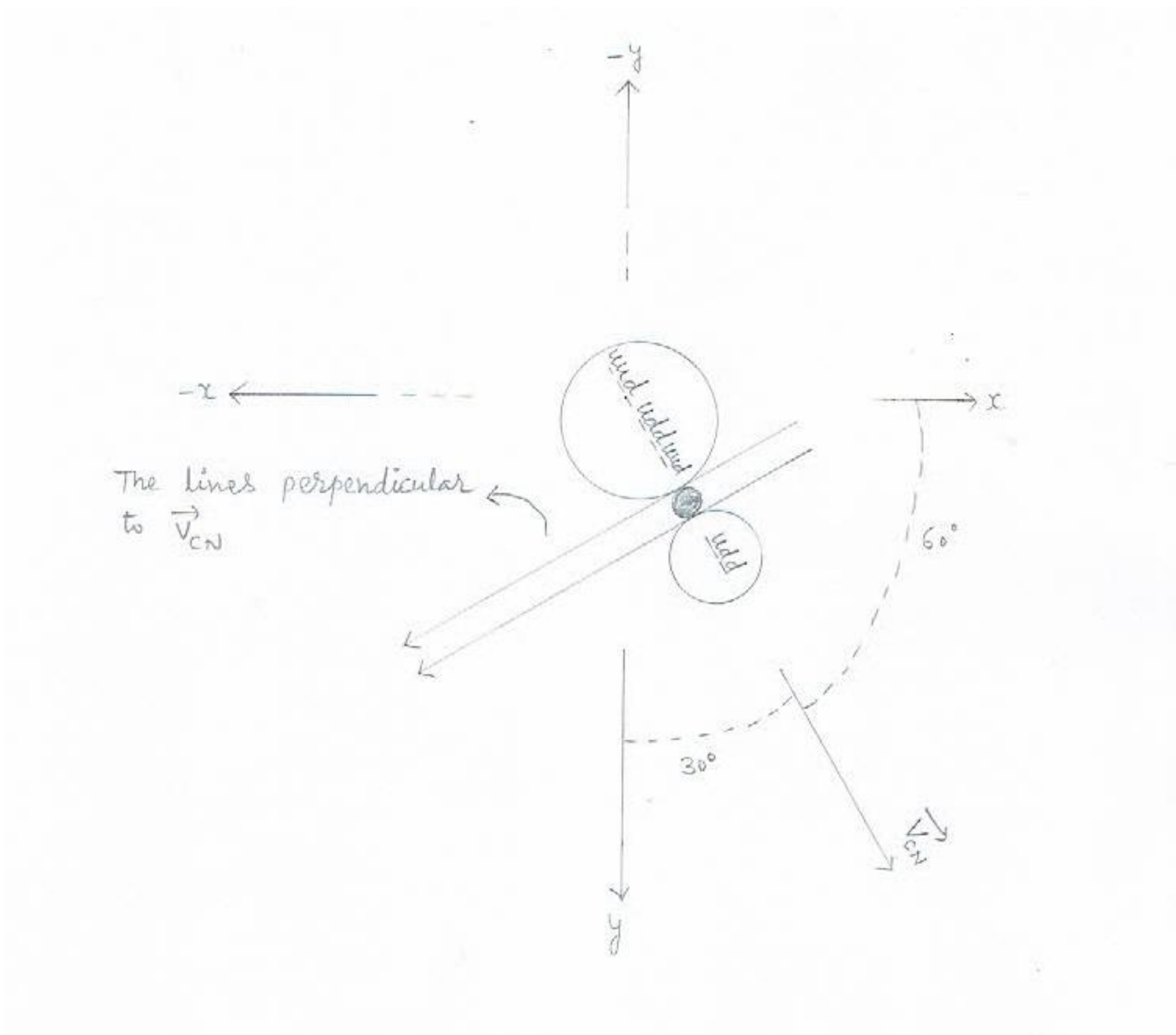
So, for conservation of momentum

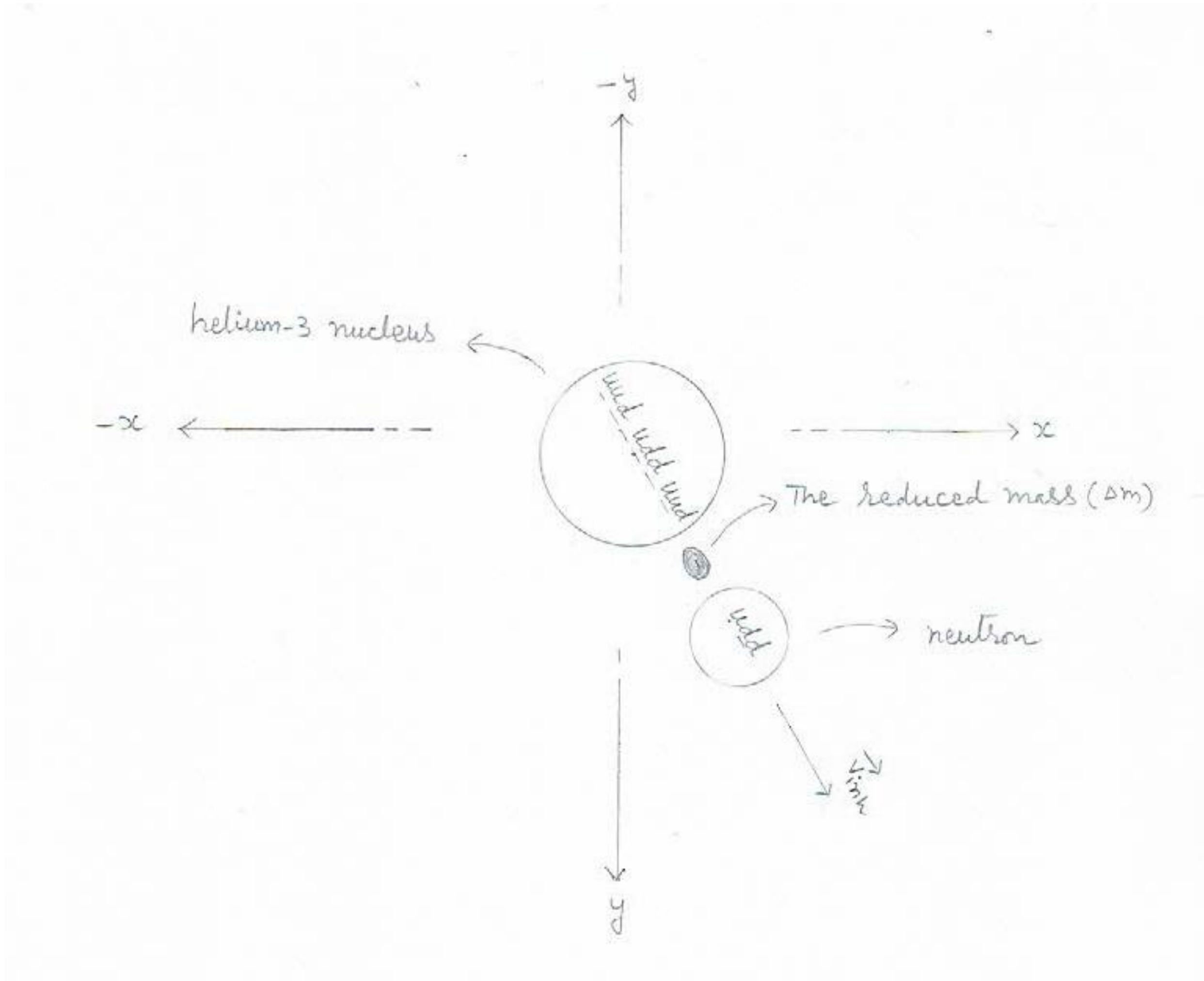
$M\overrightarrow{Vcn}$ =(m_{He-3} + Δm +m_n)$\overrightarrow{Vcn}$

Where ,

M	= mass of the compound nucleus
$\overrightarrow{Vcn}$	= velocity of the compound nucleus
m_{He}	= mass of the helium-3 nucleus
Δm	= reduced mass
m_n	= mass of the neutron

The spllitting of the heterogenous compound nucleus





Inherited velocity ($\overrightarrow{Vinh}$) of the particles : -

Each particlethat isproduced due to splitting ofthe compound nucleus hasan inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\underrightarrow{Vcn}$) .

I . for helion – 3 neucleus

V_{inh} = V_{CN}= 0.3770x 10^7m/s

Components of the inherited velocity ofthe helion – 3

1$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cosα = 0.1885x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inh} cos β =V_{CN}cos β= 0.3264x 10^7m/s

3$\underset{Vz}{\rightarrow}$= V_{inh} cos y = V_{CN}cos y = 0 m/s

II . Inheritedvelocity of the neutron

V_{inh} = V_{CN}= 0.3770 x10^7 m/s

Components of the inherited velocityof the neutron

1$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cosα =0.1885x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inh}cos β = V_{CN}cos β= 0.3264 x 10^7m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

V_{inh} = V_{CN}= 0.3770 x10^7 m/s

Propulsion of the particles

Reduced mass converts into enrgy and thus acts as a propellant for both the particles . (A like , if we put a bowl on the cracker and put the cracker on fire, the bowl and the earth will have equal and opposite momentum.

Similarly, both the particles$^3_2$He and$^1_0$n will have equal and opposite momentum. For this the total energy (E_T) is divided between the particles in inverse proportion to their masses.

Reduced mass

Δm = [m_d +m_d] - [m_{He-3} + m_n]

Δm = [2 x 2.01355]– [3.014932 + 1.00866] amu

$\Delta m = [\, 4.0271 - 4.023592 \,]$ amu
$\Delta m = 0.003508$ amu
$\Delta m = 0.003508 \times 1.6605 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass (Δm) .

$$E_{inh} = \tfrac{1}{2} \Delta m \, V^2_{inh}$$

$$E_{inh} = \tfrac{1}{2} \times 0.003508 \times 1.6605 \times 10^{-27} \times 0.14216694382 \times 10^{14} \text{ J}$$

$$E_{inh} = 0.00041406364 \times 10^{-13} \text{ J}$$

$$E_{inh} = 0.0002587 \text{ Mev}$$

Released energy (E_R)

$$E_R = \Delta mc^2$$

$$E_R = 0.003508 \times 931 \text{ Mev}$$

$$E_R = 3.265948 \text{ Mev}$$

Total energy (E_T)

$$E_T = E_{inh} + E_R$$

$$E_T = 0.0002587 + 3.265948 \text{ Mev}$$

$$E_T = 3.2662067 \text{ Mev}$$

Increased kinetic energy of the particles : -

The total energy (E_T) is divided between the particles ininverseproportion to their masses. so,the increased kinetic energy (E_{inc}) of the particles :-

1.. For $^{3}_{2}He$

$$E_{inc} = \frac{m_n}{m_{he-3} + m_n} \times E_T$$

$$E_{inc} = \frac{1.00866}{1.00866 + 3.014932} \times 3.2662067 \text{ Mev}$$

$$E_{inc} = \frac{1.00866}{4.023592} \times 3.2662067 \text{ Mev}$$

$$E_{inc} = 0.25068645131 \times 3.2662067 \text{ Mev}$$

$$E_{inc} = 0.818793 \text{ Mev}$$

2.. For $^{1}_{0}n$

E_{inc} = [E_T] - [increased energy of the helion -3]

E_{inc} = [3.2662067 - 0.818793] Mev

E_{inc} = 2.4474137 Mev

6..Increased velocity of the particles .

(1) For helium – 3

$E_{inc} = {}^{1}/_{2} m_{He\text{-}3} \; v_{inc}^{2}$

$V_{inc} = 2E_{inc}/m_{He\text{-}3}$

$$= \left(\frac{2x0.818793x1.6x10^{-13}}{5.00629x10^{-27}} \right)^{1/2} \text{ m/s}$$

$$= \left(\frac{2.6201376 \; x10^{-13}}{5.00629x10^{-27}} \right)^{1/2} \text{ m/s}$$

$$= [\; 0.52336912164x \; 10^{14} \;]^{1/2}$$

$$= 0.7234 \text{ x } 10^{7} \text{ m/s}$$

For Neutron

$$V_{inc} = [\; 2E_{inc} \; / \; m_n \;]^{1/2}$$

$$= \left(\frac{2x2.4474137 \text{ x}1.6 \text{ x } 10^{-13} \text{ J}}{1.6749x10^{-27} \text{ kg}} \right)^{1/2}$$

$$= \left(\frac{7.83172384x10^{-13}}{1.6749x10^{-27}} \right)^{1/2} \text{ m/s}$$

$$= [\; 4.67593518419 \text{ x } 10^{14} \;]^{1/2} \text{ m/s}$$

$$= 2.1623 \text{ x } 10^{7} \text{ m/s}$$

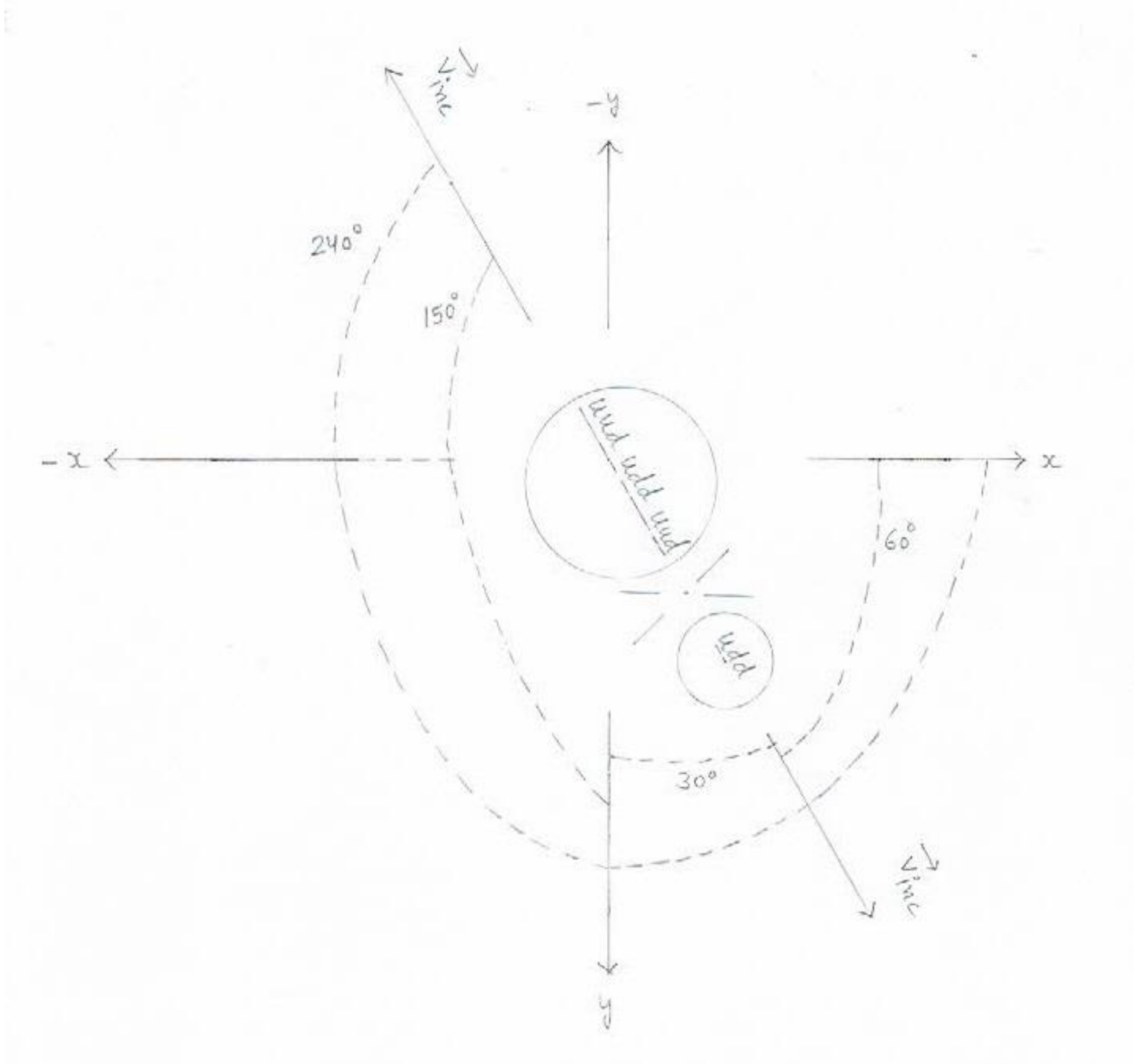
7 Angle of propulsion

1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum .

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

Now,

At point ‘ F ‘ , as V_{CN} makes 60^o angle with x-axis , 30^o angle with y-axis and 90^oangle with z-axis .
so, the neutron is propelled making 60^o angle with x-axis , 30^o angle with y-axis and 90^o angle with z-axis .
While the helium -3 nucleus is propelled making 240^o angle with x-axis, 150^o angle with y-axis and 90^oanglewith z-axis .



The direction along which the neutron is propelled is parallel to the$\overrightarrow{Vcn}$. while both particles(neutron and helium-3)are propelled making 180^0 angle with each other.

Components of the increased velocityof particles.

(i)For neutron

$1_{\overrightarrow{Vx}}$ = $V_{inc}\cos\alpha$

V_{inc} = 2.1623×10^7 m/s

$\cos\alpha$= $\cos 60^o$ = 0.5

$\underset{Vx}{\rightarrow}$ = 2.1623 x 10^7 x 0.5 m/s

= 1.0811x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc}cosβ

cosβ = cos 30º= 0.866

$\underset{Vy}{\rightarrow}$ =2.1623 x 10^7x 0.866 m/s

= 1.8725 x 10^7 m/s

3$\underset{Vz}{\rightarrow}$= V_{inc}cos y

Cos y = cos 90º=

$\underset{Vz}{\rightarrow}$ = V_{inc} x 0= 0 m/s

For Helium -3 nucleus

1$\underset{Vx}{\rightarrow}$= V_{inc} cosα

V_{inc}= 0.7234 x10^7m/s

cosα= cos 240º = -0.5

$\underset{Vx}{\rightarrow}$=0.7234 x 10^7 x (- 0.5) m/s

= -0.3617x10^7m/s

2$\underset{Vy}{\rightarrow}$= V_{inc}cosβ

cos β=cos 150º= - 0.8660

$\underset{Vy}{\rightarrow}$= 0.7234 x 10^7x(-0.866) m/s

=- 0.6264 x 10^7

3 $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

$\underset{Vz}{\rightarrow}$VzVzVzVzVz Vz = V_{inc} cos90^0 = V_{inc}x 0 m/s

= 0 m/s

9.. Components of the final velocityof theparticles

IForneutron

According to -	Inherited Velocity($\underset{Vinh}{\longrightarrow}$)	Increased Velocity($\underset{Vinc}{\longrightarrow}$)	Final velocity ($\overrightarrow{Vf}$) =($\underset{Vinh}{\longrightarrow}$+($\underset{Vinc}{\longrightarrow}$)
X –axis	$\underset{Vx}{\rightarrow}$= 0.1885x$10^7$m/s	$\underset{Vx}{\rightarrow}$=1.0811x$10^7$m/s	$\underset{Vx}{\rightarrow}$ =1.2696x10^7m/s

y –axis	$\overrightarrow{Vy}$= 0.3264x10^7m/s	$\overrightarrow{Vy}$ = 1.8725x10^7m/s	$\overrightarrow{Vy}$ = 2.1989x10^7m/s
z–axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$ =0 m/s

2..For helium-3 nuclens

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\vec{Vf}$) =($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X–axis	$\overrightarrow{Vx}$ = 0.188510^{7}m/s	$\overrightarrow{Vx}$ = - 0.3617x10^7m/s	$\overrightarrow{Vx}$=- 0.1732x10^7m/s
y – axis	$\overrightarrow{Vy}$= 0.3264x10^7m/s	$\overrightarrow{Vy}$ =- 0.6264x10^7m/s	$\overrightarrow{Vy}$ =- 0.3x10^7m/s
z –axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$ =0 m/s

10.. Final Kinetic energy of the particle- neutron

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$= (1.2696\ X10^7)^2 + (2.1989X10^7)^2 + (0)^2 m^2/s^2$

$= (1.61188416X10^{14}) + 4.83516121X10^{14}) + 0\ m^2/s^2$

$V^2 = 6.44704537X\ 10^{14} m^2/s^2$

$V = 2.5391 \times 10^7$ m/s

K.E. = $^1/_2\ mv^2 = ^1/_2 \times 1.6749 \times 10^{-27} \times 6.44704537x10^{14}$J

$= 5.3990781451x10^{-13}$

= 3.3744 Mev

Angles made by the neutron , when it is at point F:-

if α , β , y are anglesmade by the neutron with respect tothe axes x,y,and z respeetively. Then

cos α = Vcos α/ V =$\overrightarrow{Vx}$/V

cos α =<u>1.2696 x 10^7 m/s</u>

2.5391 x 10^7 m/s

cos α = 0.5000

α = 60 degree

2 cos β = Vcos β / V =$\underset{Vy}{\rightarrow}$/V

= $\underline{2.1989 \times 10^7 m/s}$= 0.866

2.5391 x 10^7 m/s

β = 30 degree

3 cos y= V_z / V =$\underset{Vz}{\rightarrow}$/V

= $\underline{0}$

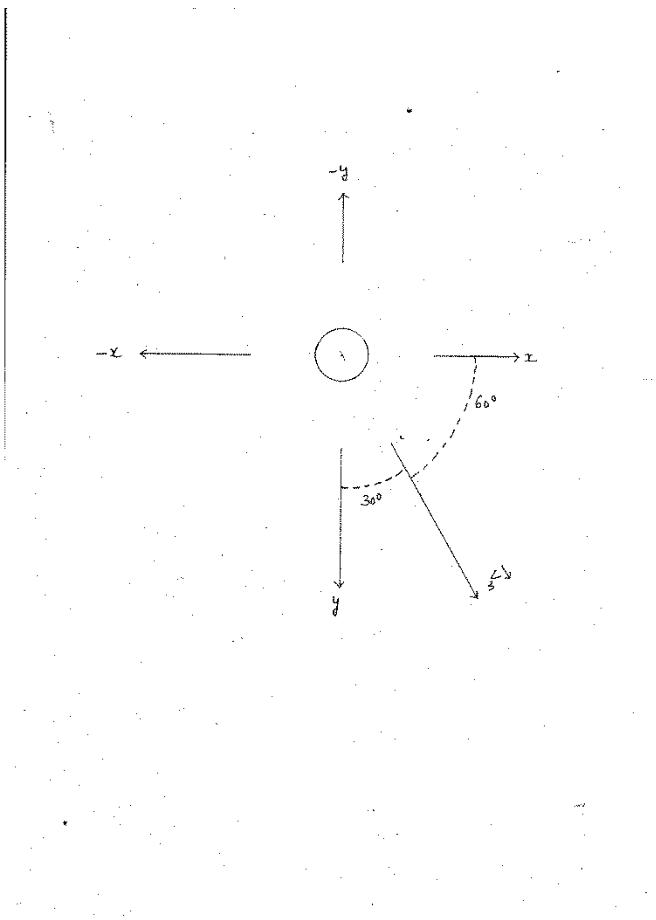
v

= 0

y = 90°

The real path followed by the neutron

The angles thatmake the final velocity of the neutronwith positive x,y and z-axes.



where

a=60 degree

b= 30 degree

y= 90 degree

a,b and y are as usual used.

Components of final momentum ofhelium-3 nucleus

$\underset{Px}{\rightarrow}$= $m_{He-3}\underset{Vx}{\rightarrow}$

= $5.00629 \times 10^{-27} \times (-0.1431 \times 10^{7})$ kg m/s

= -0.7164×10^{-20}kg m/s

2 $\underset{Py}{\rightarrow}$PyPy = $m_{He-3}\underset{Vy}{\rightarrow}$

= $5.00629 \times 10^{-27} \times (-0.2478 \times 10^{7})$ kg m/s

= -1.2405×10^{-20} kg m/s

3 $\underset{Pz}{\rightarrow}$ = $m_{He-3}\underset{Vz}{\rightarrow}$

=$m_{He-3} \times 0$ kg m/s

= 0 kg m/s

10.. Final Kinetic energy of the particle – helium 3 nucleus

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$= (0.1732X10^7)^2 + (0.3X10^7)^2 + (0)^2 \ m^2/s^2$

$= (0.02999824X10^{14}) + (0.09X10^{14}) + 0 \ m^2/s^2$

$V^2 = 0.11999824X10^{14} \ m^2/s^2$

$V = 0.3464x10^7$ m/s

$mv^2 = 5.00629x\ 10^{-27} \times 0.11999824 \times 10^{14}$ J

$= 0.6007x\ 10^{-13}$ J

K.E. = $\frac{1}{2} mv^2 = \frac{1}{2} \times 5.00629x\ 10^{-27} \times 0.11999824x\ 10^{14}$ J

$= 0.30037299446x\ 10^{-13}$ J

= 0.1877 Mev

Angles made by the He-3 nucleusrespect to point F :-

The He-3 nucleus is produced at point F. if α , β, y are the angles made by the He-3 nucleus with respect to the axes x,y,and z respeetively. Then

$\cos\alpha = V\cos\alpha = \underset{Vx}{\rightarrow}/V$

$= \frac{-0.1732x\ 10^7 \ m/s}{0.3464x10^7 \ m/s} = -0.500$

$\alpha = 240^0$

2 $\cos\beta = V\cos\beta = \underset{Vy}{\rightarrow}/V$

$= \frac{-0.3x\ 10^7 m/s}{0.3464x\ 10^7 \ m/s} = -0.866$

$\beta = 150^0$

3 $\cos y = \underset{Vz}{\rightarrow}/V$

$= \frac{0}{0.3464 \ x\ 10^7}$

= 0

$y = 90^o$

Forces acting on the helium-3 nucleus

1 F_y = q V_x B_z sin θ

q= 2 x 1.6 x 10^{-19}c

$\overrightarrow{V_x}$ = - 0.1732x 10^{7} m/s $\overrightarrow{B_z}$ = - 1.001x10^{-1}Tesla

sin θ = sin 90° = 1

Fy = 2 x 1.6 x 10^{-19} x 0.1732 x 10^{7} x 1.001x10^{-1}x 1 N
= 0.5547x10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fy}$ is according to (+) y-axis ,

so ,
$\overrightarrow{Fy}$ = 0.5547 x 10^{-13} N

2F_z= q V_x B_y sin θ

$\overrightarrow{B_y}$ = 1.0013 x10^{-1} Tesla

sin θ = sin 90° = 1

Fz= 2 x 1.6 x 10^{-19}x 0.1732 x 10^{7} x 1.0013 x10^{-1}x 1 N
=0.5549 x 10^{-13} N
Form the right hand palm rule , thedirection of the force $\overrightarrow{Fz}$ is according to(+) Z- axis ,

so ,
$\overrightarrow{Fz}$ =0.5549 x 10^{-13}N

3 F_x = q V_y B_z sin θ

$\overrightarrow{V_y}$ = -0.3 x 10^{7}

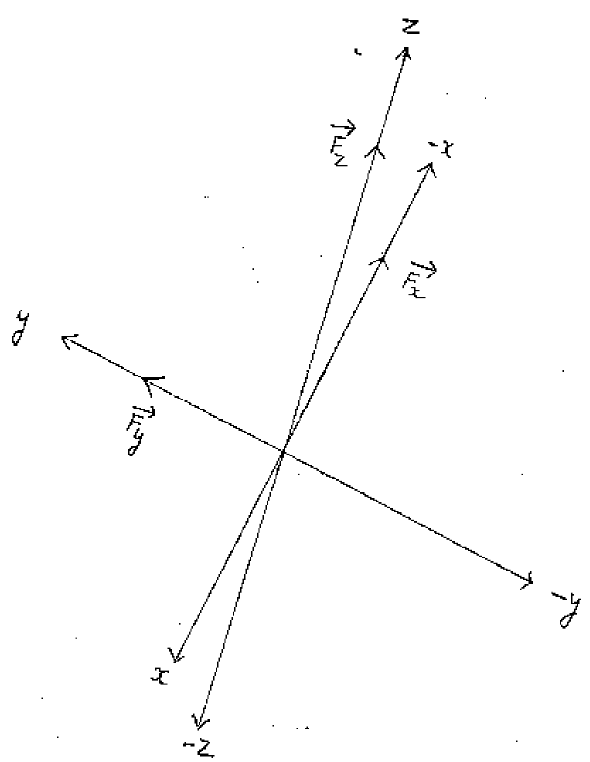
$\overrightarrow{B_z}$ = - 1.001x10^{-1} Tesla

sin θ = sin90° = 1

Fx = 2 x 1.6 x10^{-19} x 0.3x 10^{7} x 1.001x10^{-1} x 1 N
= 0.9609 x 10^{-13} N
Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (-) x axis ,

so ,
$\overrightarrow{Fx}$ = - 0.9609 x 10^{-13} N

forcesacting on the helium-3 nucleus



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 0.9609 \times 10^{-13}$ N

$F_y = 0.5547 \times 10^{-13}$ N

$F_z = 0.5549 \times 10^{-13}$ N

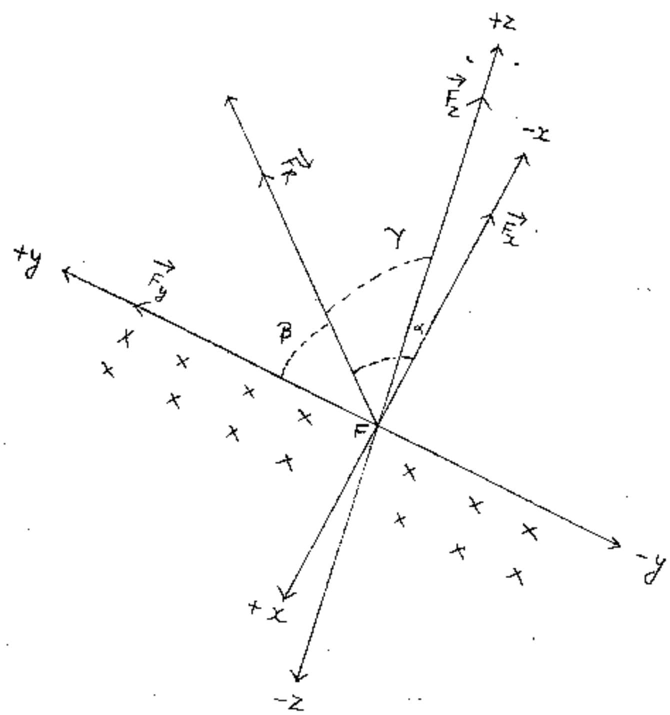
$F_R^2 = (0.9609 \times 10^{-13})^2 + (0.5547 \times 10^{-13})^2 + (0.5549 \times 10^{-13})^2 \quad N^2$

$= (0.92332881 \times 10^{-26}) + (0.30769209 \times 10^{-26}) + (0.30791401 \times 10^{-26}) \quad N^2$

$F_R^2 = 1.53893491 \times 10^{-26} \quad N^2$

$F_R = 1.2405 \times 10^{-13}$ N

Resultant force acting on the helium-3 nucleus


+z
-x
+y
-y
+x
-z
F
β
γ
α

Radius of the circular path :

Resultant force acts as a centripetal force on the helium-3 nucleus . so, the helium-3 nucleus tries to followa confined circular path.

The radius of the circular orbit to be followed by the helium-3 nucleus is –

$R = mv^2 / F_R$

$mv^2 = 0.6007 \times 10^{-13}$ J

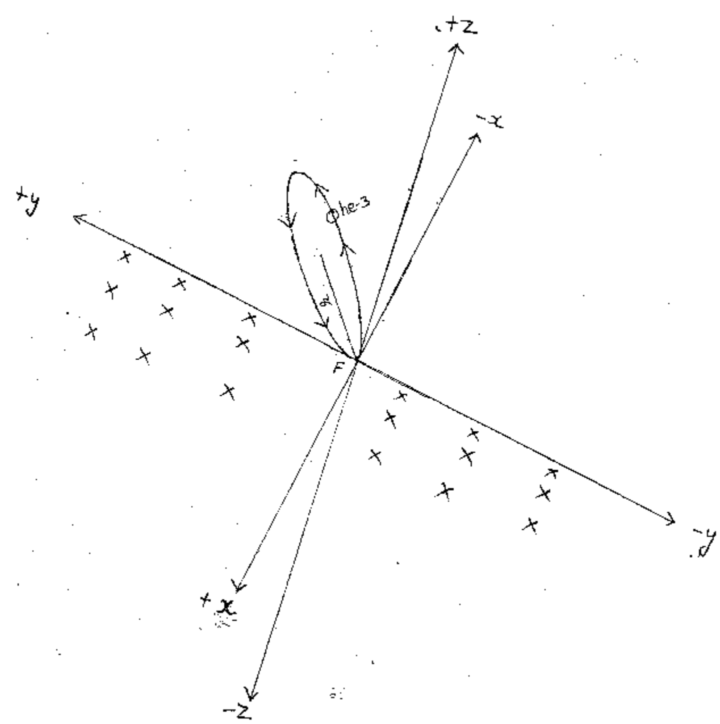
$R = \dfrac{0.6007 \times 10^{-13} \text{ J}}{1.2405 \times 10^{-13} \text{ N}}$

= 0.4842 m

The circular orbit to befollowed by the helion-3 lies in the plane made up of negativex-axis, pisitive y-axis and the positive z-axis.

$\overrightarrow{Fr}$ = The resultant force acting on the particle (at point ‘ F ‘) towards the centre of the circle .

C_{He-3} = center of the circular orbit tobefollowed by the helion-3.



Theplaneof the circular orbit to be followed by the helion -3makes angles with respect to positive x , y and z-axes as follows :-

1 with x- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow}$ / F_r

$\underset{Fx}{\rightarrow}$ -0.9609×10^{-13} N

___= ________________________

F_r 1.2405×10^{-13} N

Cos α = - 0.7746

α = 219.23degree [∴ cos(219.23) = -0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ $= 0.5547 \times 10^{-13}$N

$F_r = 1.2405 \times 10^{-13}$ N

Putting values

Cos β= 0.4471

β= 63.44 degree [∴ cos (63.44) =0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow}$ / F_r

$\underset{Fz}{\rightarrow} =$ $\underline{0.5549 \times 10^{-13}\text{N}}$

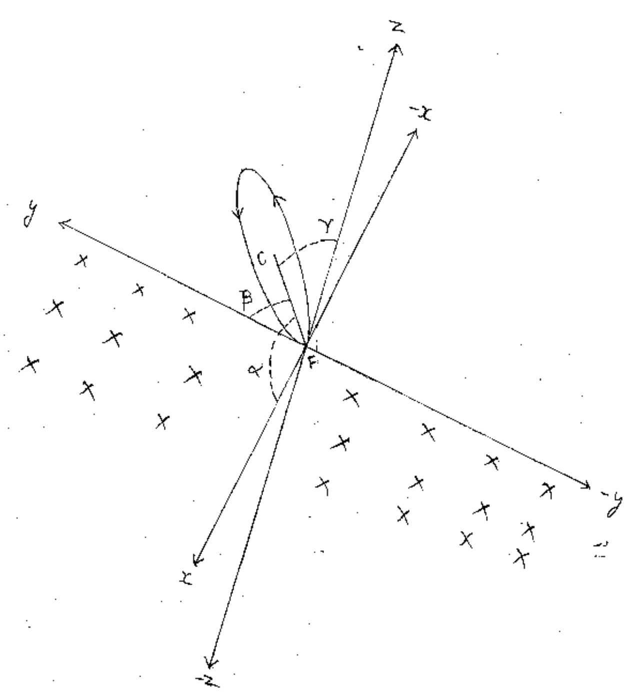
$F_r = 1.2405 \times 10^{-13}$ N

Putting values

Cos y = 0.4473

y =63.425 degree

The planeof the circular orbit to be followed by the helion -3 makes angles with respect to positive x , y , and z axes as follows :-



Where,

α = 219.23 degree

β= 63.44 degree

Y = 63.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the helion-3

$\cos \alpha = \frac{x_2 - x_1}{d}$

d = 2 x r

= 2x 0.4842 m

= 0.9684 m

Cos α = -0.7746

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 0.9684 \times (-0.7746)$ m

$x_2 - x_1 = - 0.7501$ m

$x_2 = - 0.7501$ m [$\therefore x_1 = 0$]

$\cos \beta = \frac{y_2 - y_1}{d}$

cos β = 0.4471

$y_2 - y_1 = d \times \cos \beta$

$y_2 - y_1 = 0.9684 \times 0.4471$ m

$y_2 - y_1 = 0.4329$ m

$y_2 = 0.4329$ m [$\therefore y_1 , = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

cos y = 0.4473

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 0.9684 \times 0.4473$ m

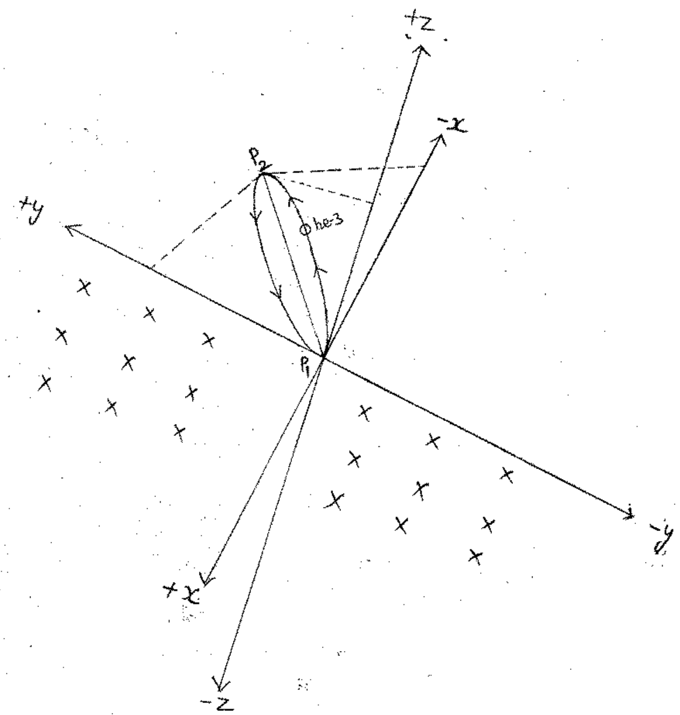
$z_2 - z_1 = 0.4331$ m

$z_2 = 0.4331$m [$\therefore z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumfrence of the circle to be obtained by the helium-3 nucleus are as shown below.

The line ___ is the diameter of the circle .

P_1P_2


+z
-x
P_2
he-3
+y
P_1
-y
+x
-z

Conclusion :-

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the helium-3 nucleus are along **-x , +y and +z** axes respectively .

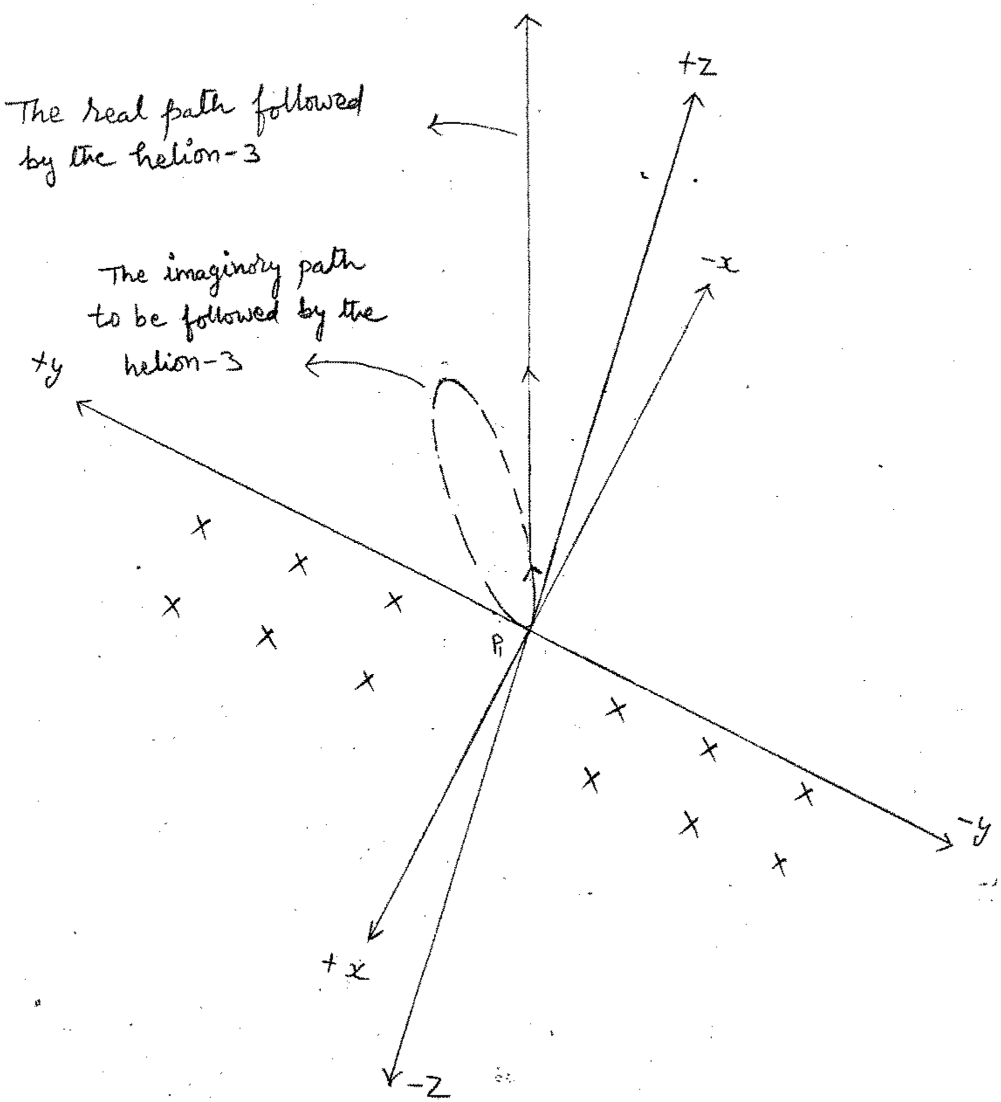
So by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the helium-3 nucleus to undergo to a circular orbit of radius 0.4842 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-0.7501 m, 0.4329 m,0.4331m)where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circularpath (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is not confined.


The real path followed
by the helion-3
The imaginary path
to be followed by the
helion-3
+z
-x
+y
P1
-y
+x
-Z

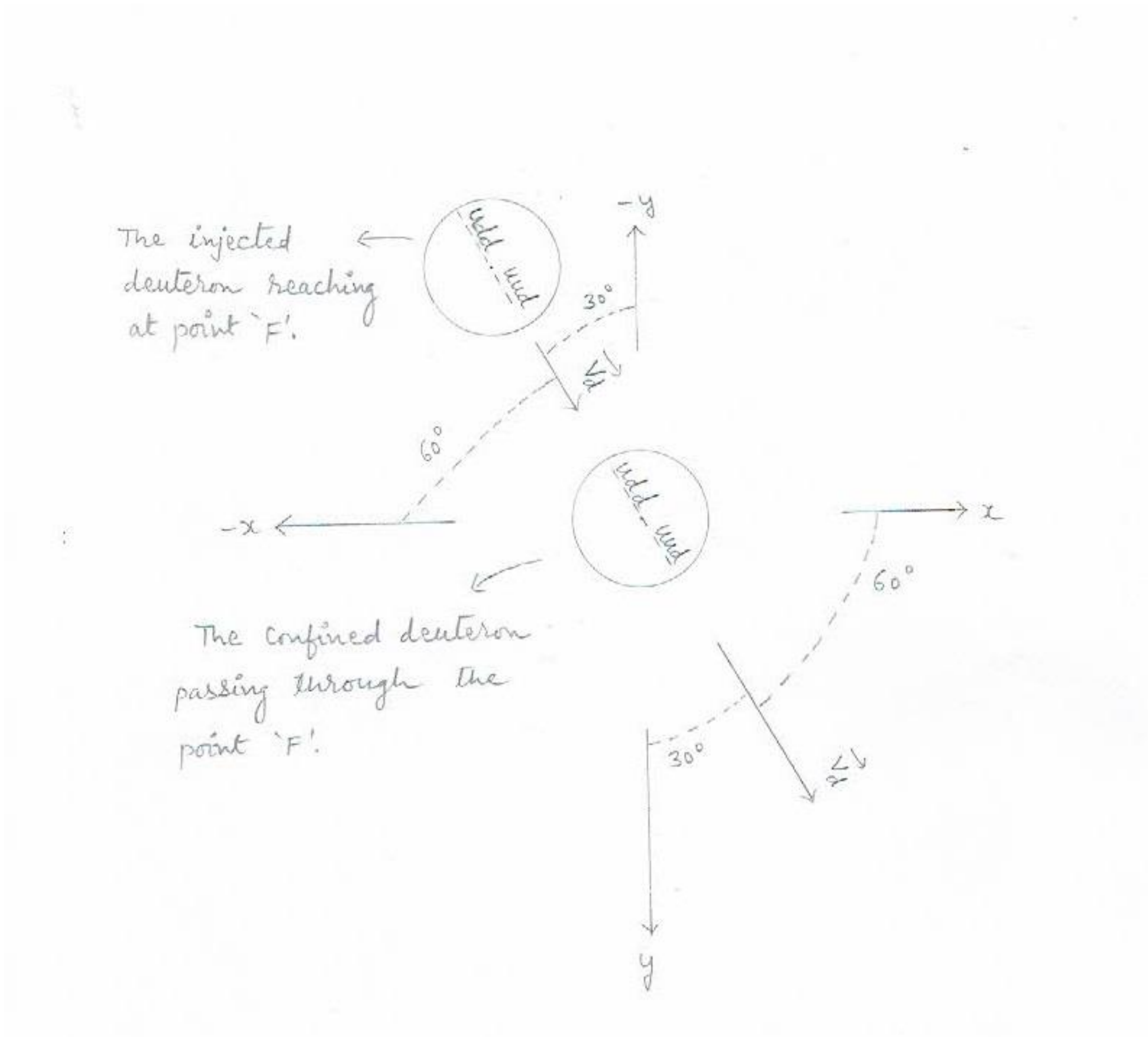
For fusion reaction

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H$$

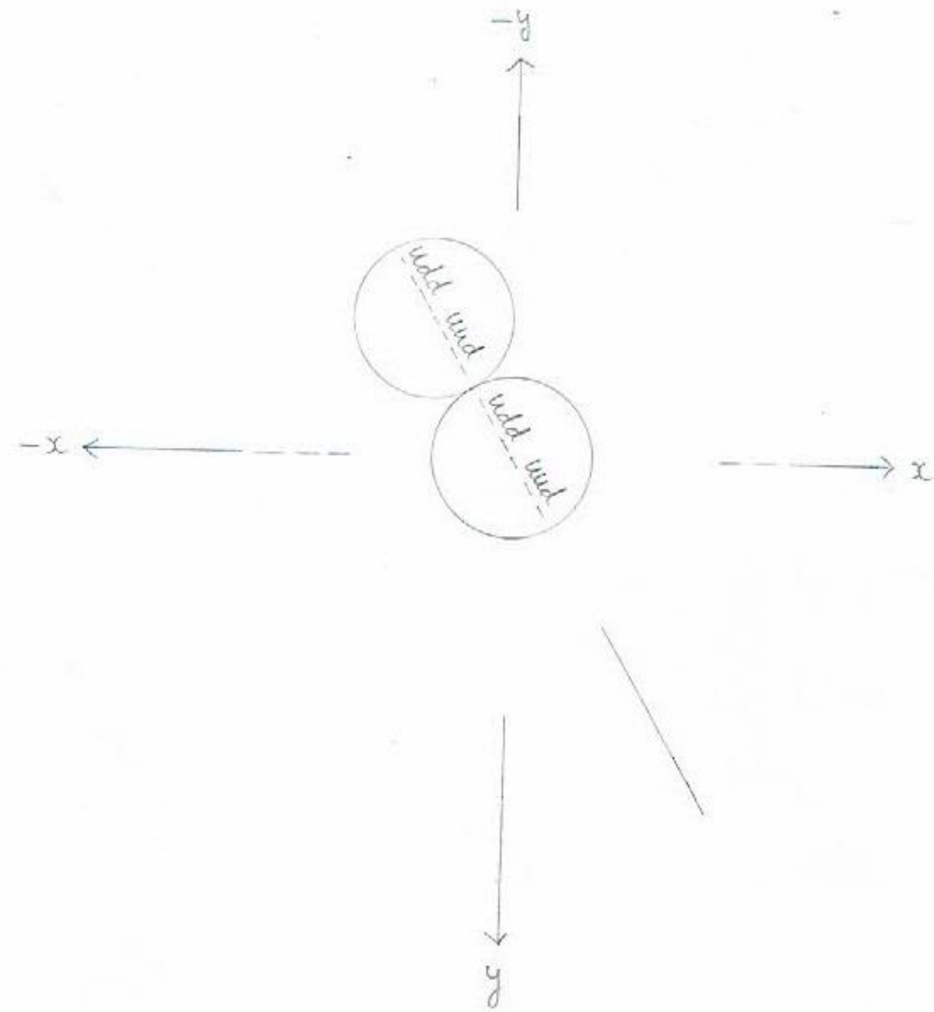
interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined deuteron] with the confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined deuteron.

interaction of nuclei (1)



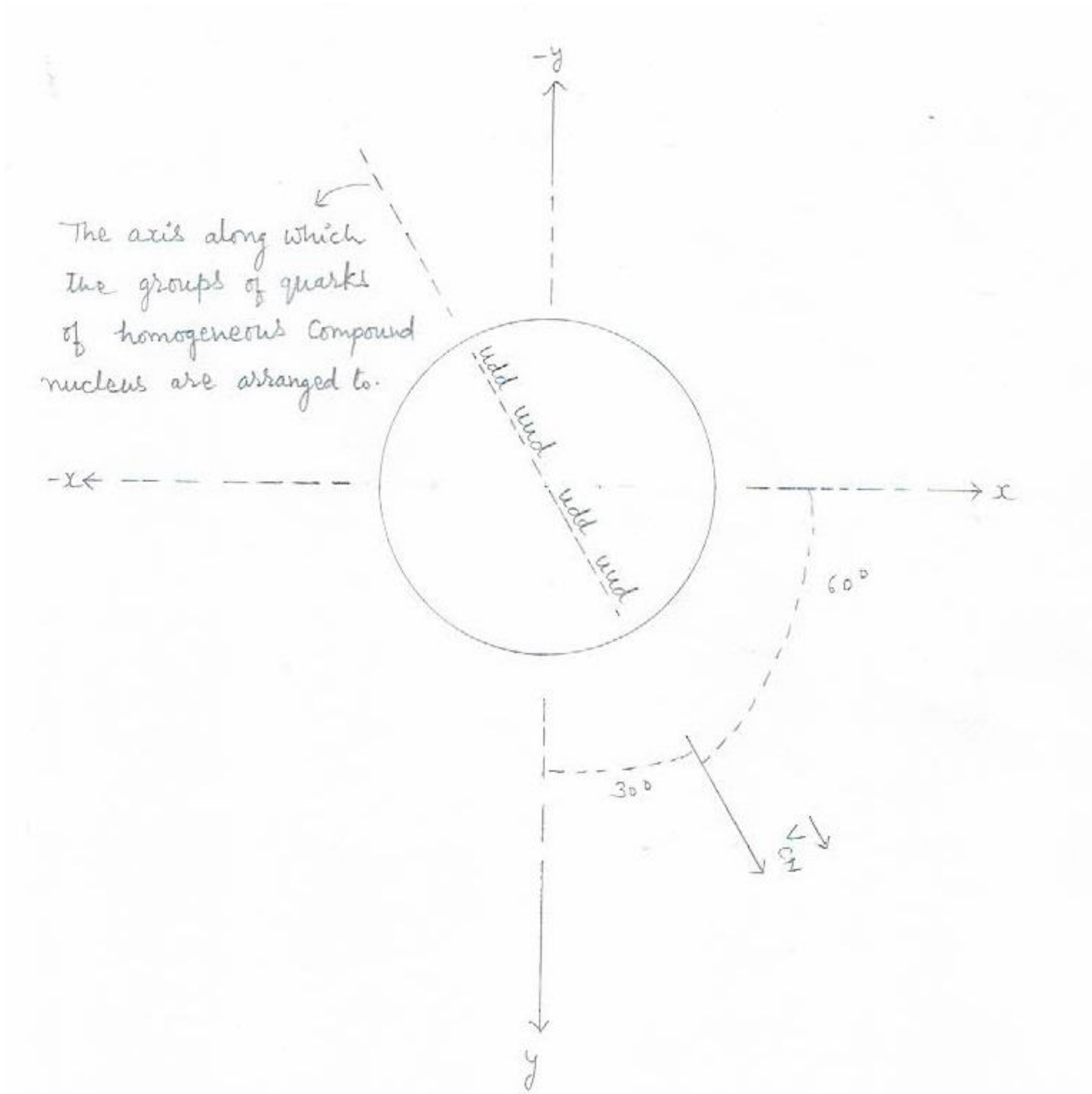
interaction of nuclei(2)



1..Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus in a homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 4 groups of quarks with surrounded gluons.



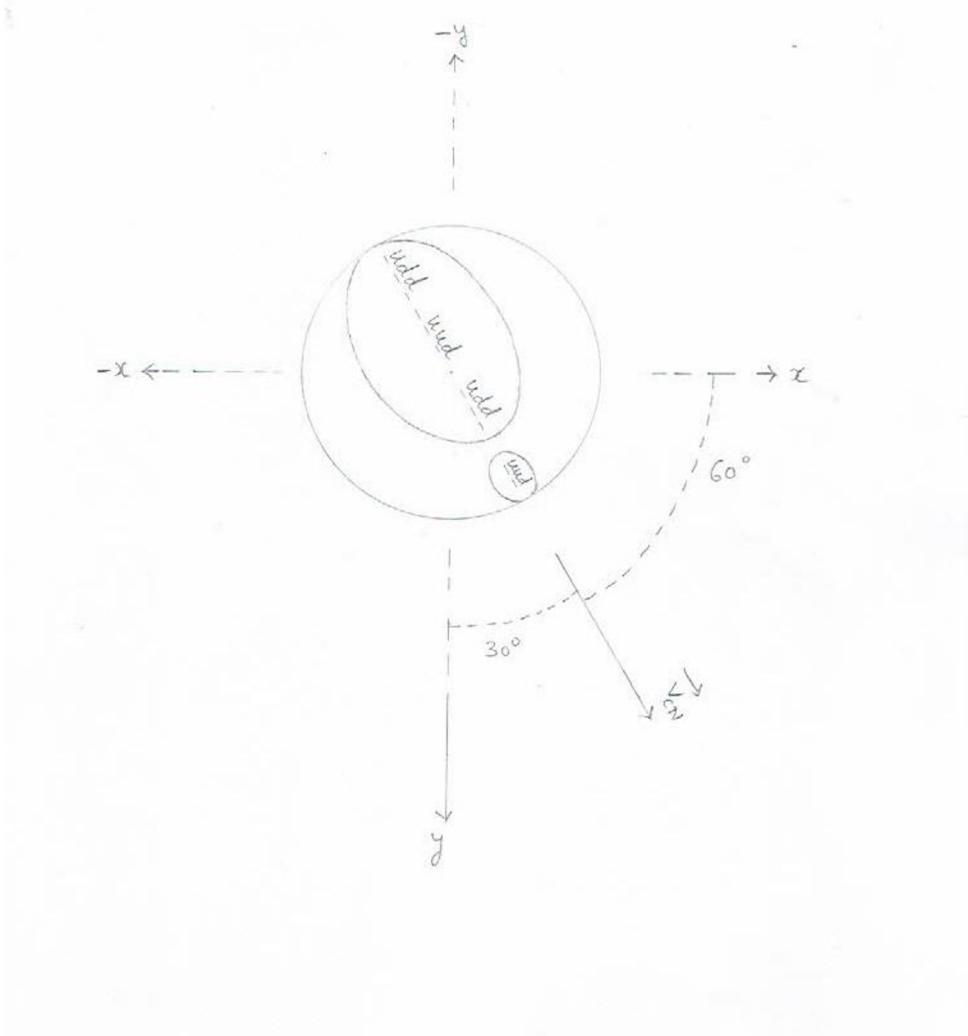
Formation of homogenous compound nucleus

3 Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the triton) than the reactant one (the deuteron) includes the other two (nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

While , the remaing groups of quarks to become a stable nucleus (the proton) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.



Formation of lobes

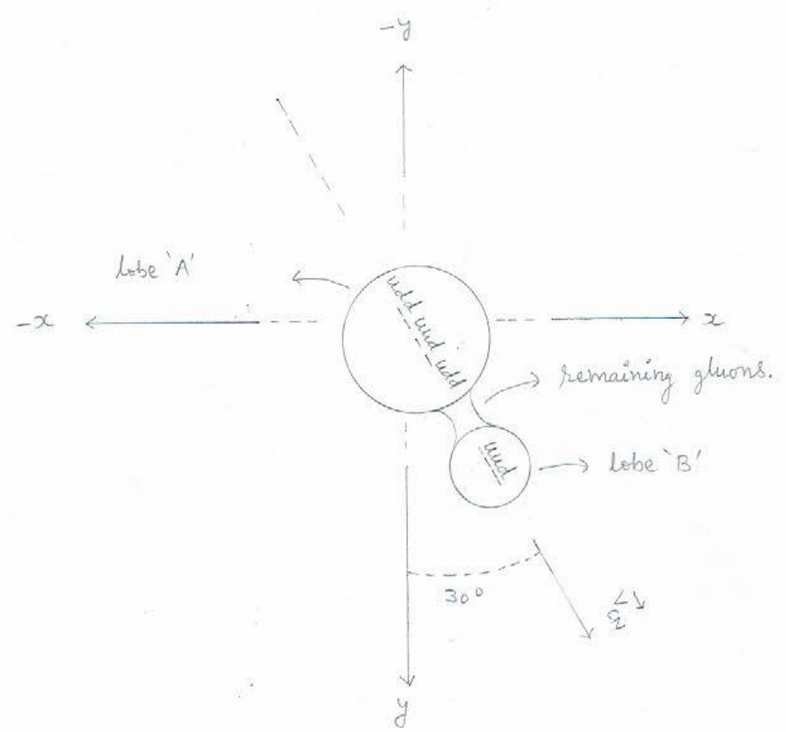
Within into the homogeneous compound nucleus the greater nucleus is the triton and the smaller one is the proton while the remaining space repesents the remaining gluons ..
within into the homogenous compound nucleus , the greater nucleus is the lobe 'A ' while the smaller nucleus is the lobe 'B' .

4..Final stage of the heterogeneous compound nucleus : -

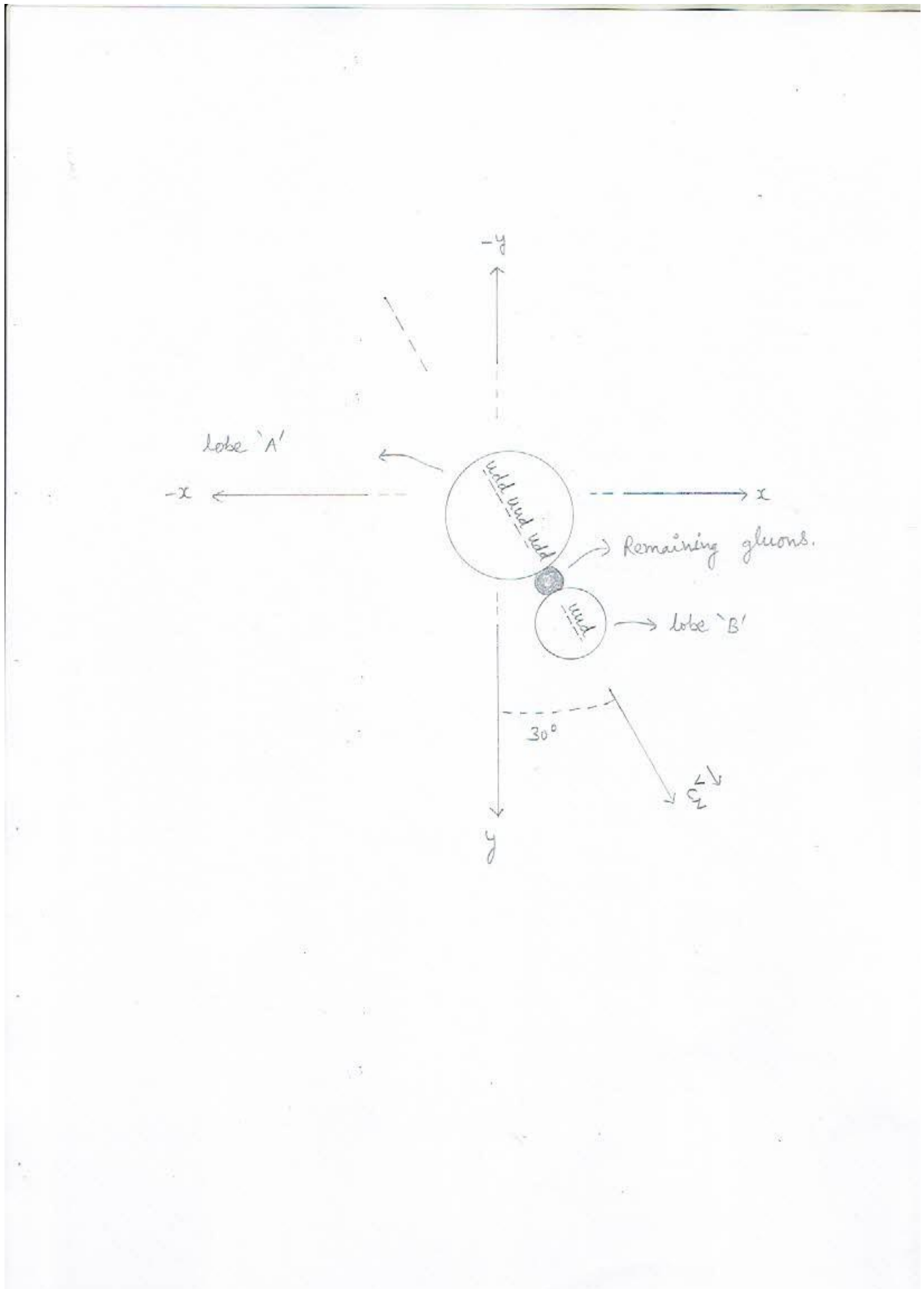
The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids (s) between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus



Final stage of a heterogeuous compound nucleus.

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the directionof the velocity of thecompound nucleus($\overrightarrow{Vcn}$) into the three particles – triton , the proton and the reduced mass (Δm) .

Out of them , the two particles (the triton and protron) are stable while the third one (reduced mass) is unstable .

According to the law of inertia , each particlethatis produced due to splitting of the compound nucleus, has an inherited velocity($\underrightarrow{Vinh}$) equal to the velocityof the compound nucleus($\overrightarrow{Vcn}$) .

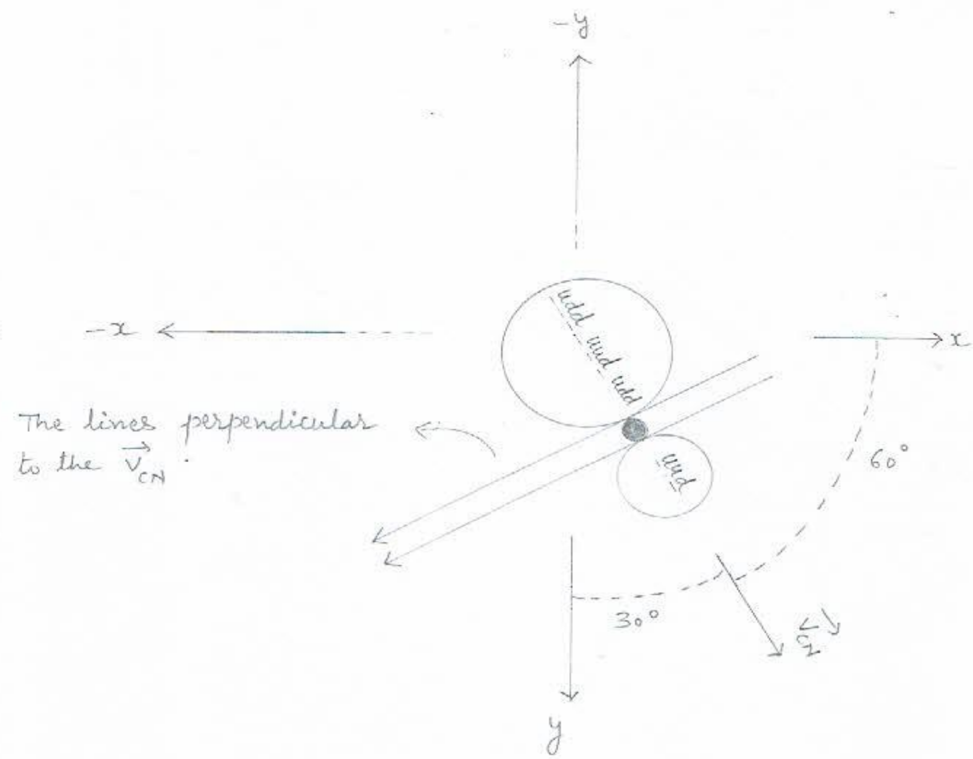
So, for conservation of momentum

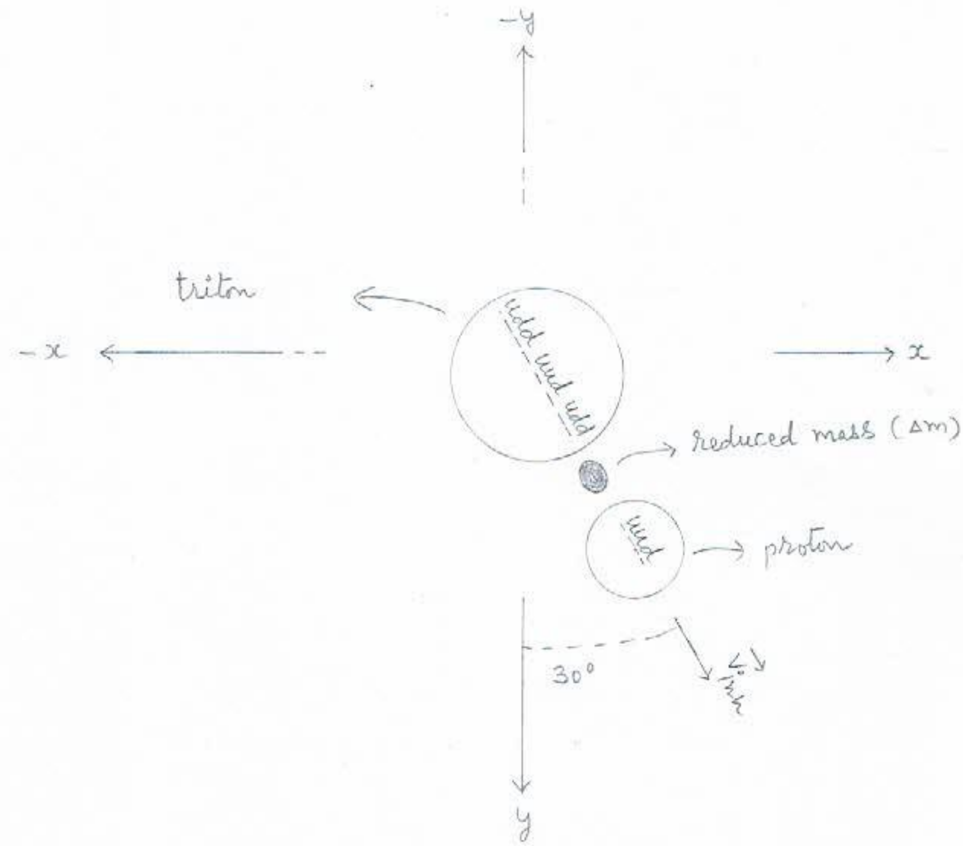
$M\overrightarrow{Vcn} = (m_t + \Delta m + m_p)\overrightarrow{Vcn}$

Where ,

M	= mass of the compound nucleus
$\overrightarrow{Vcn}$	= velocity of the compound nucleus
m_t	= mass of the triton
Δm	= reduced mass
m_p	= mass of the proton

The splitting of the herogenous compound nucleus


-y
-x
x
y
udd uud udd
uud
The lines perpendicular to the $\vec{V}_{CN}$.
60°
30°
$\vec{V}_{CN}$


-y
triton
-x
x
udd uud udd
reduced mass (Δm)
uud
proton
30°
y

Components of Inherited velocity of the particles : -

Each particles has inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\underrightarrow{Vcn}$) .

I. For triton ($^3{}_1H$)

V_{inh} = V_{CN} = 0.3770x10^7 m/s

Components oftheinherited velocity of the triton

1 $\underrightarrow{Vx}$ = V_{inh} cos α =V_{CN} cosα = 0.1885x 10^7 m/s

2 $\underrightarrow{Vy}$ = V_{inh} cos β = V_{CN}cos β= 0.3264 x 10^{7}m/s

3 $\underrightarrow{Vz}$ = V_{inh}cos y = V_{CN} cos y = 0 m/s

II . Inhereted velocity of the proton

V_{inh} = V_{CN}= 0.3770x10^7 m/s

Components oftheinherited velocity of the proton

1 $\underrightarrow{Vx}$ = V_{inh} cos α =V_{CN} cosα= 0.1885x 10^7 m/s

2 $\underrightarrow{Vy}$ = V_{inh} cos β=V_{CN}cos β= 0.3264x 10^{7}m/s

3 $\underrightarrow{Vz}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

iii Inhereted velocity of the reduced mass

V_{inh} = V_{CN} = 0.3770 x 10^7 m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propels both the particles with equal and opposite momentum.

Reduced mass

Δm = [m_d +m_d]- [m_t + m_p]

Δm = [2 x 2.01355]– [3.0155 + 1.00727] amu

Δm = [4.0271] – [4.02277] amu

$\Delta m = 0.00433$ amu

$\Delta m = 0.00433 \times 1.6605 \times 10^{-27}$ kg

$\Delta m = 0.007189 \times 10^{-27}$ kg

Inherited kinetic energy of reduced mass (Δm) .

$E_{inh} = ½\Delta m V^2_{cn}$

$E_{inh} = ½ \times 0.007189 \times 10^{-27} \times 0.14216694382 \times 10^{14}$ J

$E_{inh} = 0.00051101907 \times 10^{-13}$ J

$E_{inh} = 0.000319$ Mev

Released energy (E_R)

$E_R = \Delta mc^2$

$E_R = 0.00433 \times 931$ Mev

$E_R = 4.03123$ Mev

Total energy (E_T)

$E_T = E_{inh} + E_R$

$E_T = [0.000319] + [4.03123]$ Mev

$E_T = 4.031549$ Mev

Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles ininverse proportion toinverse masses. so,the increased energy (E_{inc}) of the particles :-

1.. Increased energy of the triton

$$E_{inc} = \frac{m_p}{mt + m_p} \times E_T$$

$$E_{inc} = \frac{1.00727 \text{ amu}}{[\,1.00727 + 3.0155\,] \text{ amu}} \times 4.031549 \text{ Mev}$$

$$E_{inc} = \frac{1.00727}{4.02277} \times 4.031549 \text{ Mev}$$

$$E_{inc} = [\,0.25039214272] \times 4.031549 \text{ Mev}$$

$$E_{inc} = 1.009468 \text{Mev}$$

2..increased energy of the proton

E_{inc} = [E_T] - [increased energy of the triton]

E_{inc} = [4.031549] - [1.009468] Mev

E_{inc} = 3.022081 Mev

6..Increased velocity of the particles .

(1) For triton

$E_{inc} = {}^{1}/_{2} m_t \; v_{inc}^2$

$V_{inc} = [\, 2 \times E_{inc}/m_t \,]^{½}$

$$= \left(\frac{2x1.009468\ x1.6x10^{-13}\ J}{5.0072x10^{-27}\ \ kg} \right)^{½}$$

$$= \left(\frac{3.2302976\ x10^{-13}}{5.0072x10^{-27}} \right)^{½} \text{ m/s}$$

$$= [\ 0.64513053203 \times 10^{14}\ ]^{½} \text{ m/s}$$

$$= 0.8032 \times 10^{7} \text{ m/s}$$

(2) For proton

$V_{inc} = [\, 2\ E_{inc}\ /\ m_p \,]^{½}$

$$= \left(\frac{2x3.022081x1.6x10^{-13}\ \ J}{1.6726x10^{-27}\ \ kg} \right)^{½}$$

$$= \left(\frac{9.6706592x10^{-13}}{1.6726x10^{-27}} \right)^{½} \text{ m/s}$$

$= [\ 5.78181226832 \times 10^{14}\ ]^{½}$ m/s

$= 2.4045 \times 10^{7}$ m/s

7 Angle of propulsion

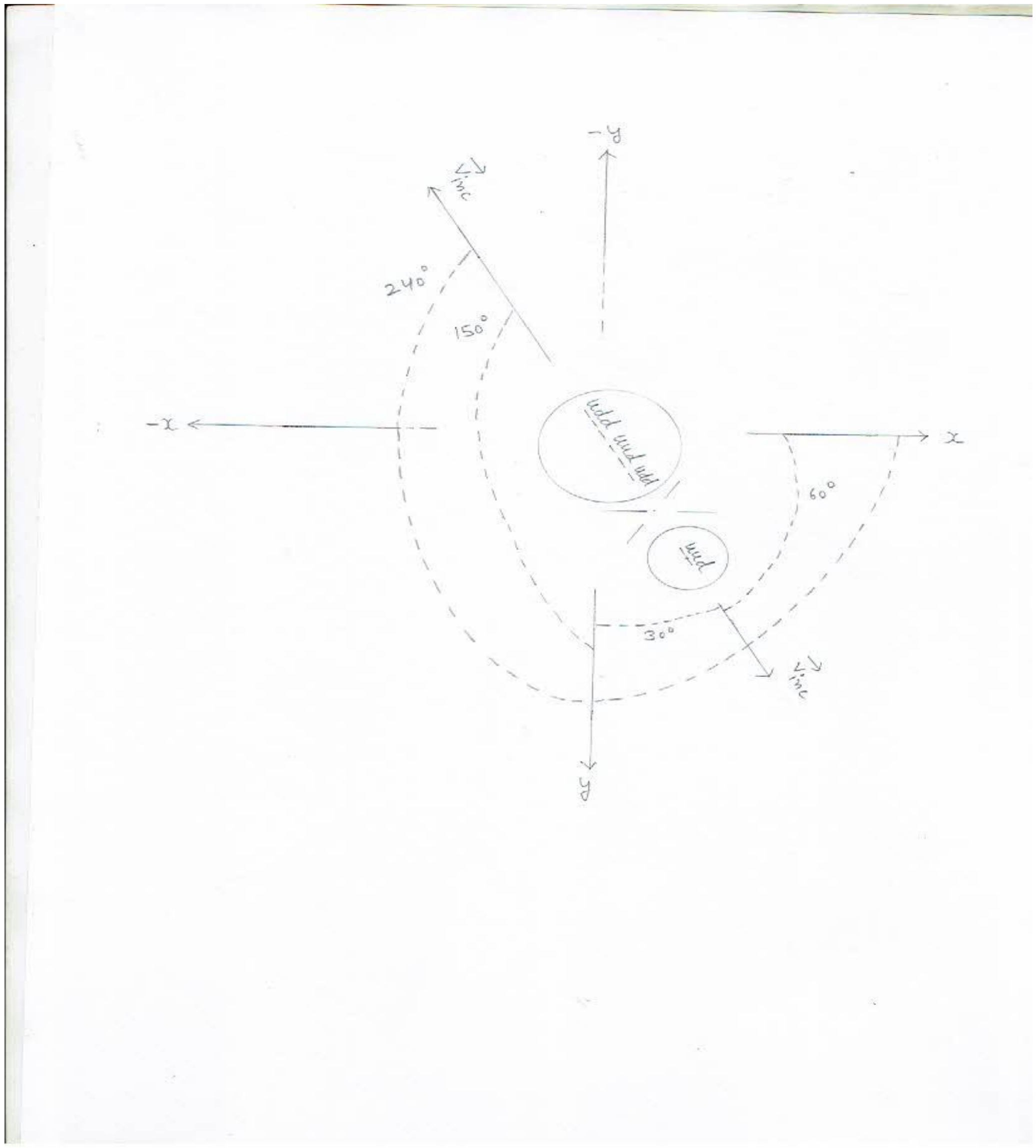
1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of thecompound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ‘ F ‘ , as V_{CN} makes 60° angle with x-axis , 30° angle with y-axis and 90°angle with z-axis .

so, the proton is propelled making 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

While the triton is propelled making 240° angle with x-axis , 150° angle with y-axis and 90° angle with z-axis .



The direcction along which the proton is propelled make angle 180^0 with the direction along which the triton is propelled.

Components of the increased velocity (V_{inc}) of the particles.

(i) For proton

$1_{\overrightarrow{Vx}} = V_{inc} \cos \alpha$

$V_{inc} = 2.4045 \times 10^7$ m/s

$\cos \alpha = \cos 60^0 = 0.5$

$\underset{Vx}{\rightarrow}$ = 2.4045 x 10^7 x 0.5 m/s

= 1.2022 x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β= cos 30^0 =0.8666666

$\underset{Vy}{\rightarrow}$= 2.4045 x 10^7x 0.866 m/s

= 2.0822 x 10^7 m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc} cos y = V_{inc} cos90^0 = V_{inc}x 0= 0m/s

For triton

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.8032 x 10^7m/s

cosα = cos240^0 =-0.5

$\underset{Vx}{\rightarrow}$=0.8032 x 10^7x (-0.5)m/s

= -0.4016 x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$= V_{inc} cos β

cosβ= cos 150^0=−0.866.866.866866

= 0.8032 x 10^7 x(−0.866)m/s

= - 0.6955 x10^7 m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc} cos y = V_{inc} cos90^0 =V_{inc}x 0 =0 m/s

9.. Components of the final velocity(Vf)of the particles

I Fortriton

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$)=($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X – axis	$\underset{Vx}{\rightarrow}$=0.1885 x$10^7$m/s	$\underset{Vx}{\rightarrow}$=- 0.4016x$10^7$m/s	$\underset{Vx}{\rightarrow}$= - 0.2131x$10^7$m/s

y–axis	$\vec{V_y}$= 0.3264x10^7m/s	$\vec{V_y}$= - 0.6955x10^7m/s	$\vec{V_y}$ = - 0.3691x10^7m/s
z –axis	$\vec{V_z}$ =0m/s	$\vec{V_z}$ = 0m/s	$\vec{V_z}$=0 m/s

2..For proton

According to -	Inherited Velocity($\overrightarrow{\text{Vinh}}$)	Increased Velocity($\overrightarrow{\text{Vinc}}$)	Finalvelocity ($\overrightarrow{Vf}$) =($\overrightarrow{\text{Vinh}}$) +($\overrightarrow{\text{Vinc}}$)
X – axis	$\vec{V_x}$ = 0.1885x10^7m/s	$\vec{V_x}$= 1.2022x10^7m/s	$\vec{V_x}$= 1.3907x10^7m/s
y– axis	$\vec{V_y}$ =0.3264x10^7m/s	$\vec{V_y}$=2.0822x10^7m/s	$\vec{V_y}$= 2.4086x10^7m/s
z –axis	$\vec{V_z}$= 0 m/s	$\vec{V_z}$ = 0 m/s	$\vec{V_z}$ =0 m/s

10.. Final Kinetic energy of theparticle -triton

$V^2= V_x^2 + V_Y^2 + V_Z^2$

$= (0.2131X10^7)^2 + (0.3691X10^7)^2 + (0)^2 \ m^2/s^2$

$= (0.04541161X10^{14}) + (0.13623481X10^{14}) + 0 \ m^2/s^2$

$V^2 = 0.18164642X10^{14} \ m^2/s^2$

$V = 0.4261x10^7 \ m/s$

$mv^2 = 5.0072x\ 10^{-27}\ x0.18164642x\ 10^{14}\ J$

$= 0.9095\ x10^{-13}\ J$

$K.E. = {}^1/_2\ mv^2 = {}^1/_2\ X\ 5.0072x\ 10^{-27}\ x\ 0.13391461\ x\ 10^{14}\ J$

$= 0.45476997711X10^{-13}\ J$

=0.2842Mev

Forces acting on the triton

1 F_y = q V_x B_z sin θ

$\underset{Vx}{\rightarrow}$ = - 0.2131 x 10^7 m/s $\underset{Bz}{\rightarrow}$= - 1.001 X$10^{-1}$ Tesla

sin θ = sin 90°= 1

Fy = 1.6 x 10^{-19}x 0.2131x 10^7 x 1.001 X10^{-1} x 1 N
= 0.3413 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (+) y-axis ,

so ,
$\underset{Fy}{\rightarrow}$= 0.3413 x 10^{-13} N

2 F_x =q V_Y B_z sin θ

$\underset{Vy}{\rightarrow}$= - 0.3691 x 10^7 m/s

sin θ = sin 90° = 1

Fx = 1.6 x 10^{-19} x 0.3691 x 10^7 x 1.001 X10^{-1} x 1 N
= 0.5911x 10^{-13}N
Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is according to (-) x- axis ,
so ,
$\underset{Fx}{\rightarrow}$ = - 0.5911x 10^{-13} N

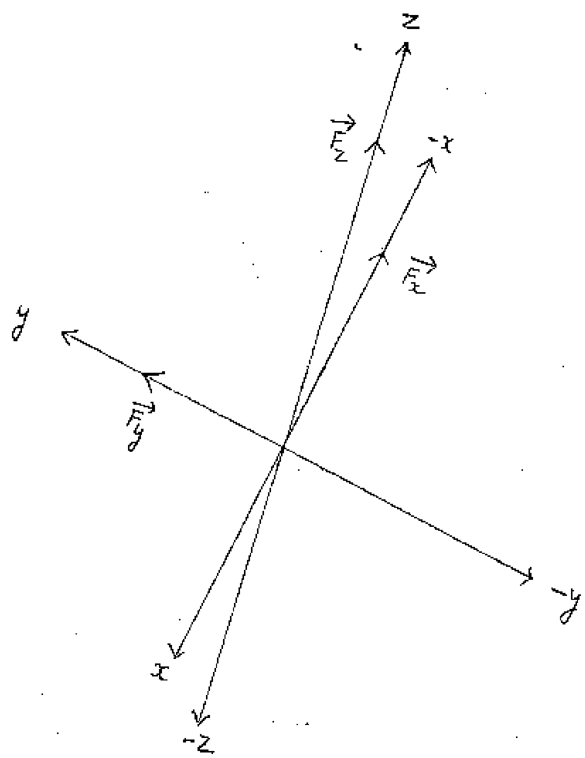
3 F_z = q V_x B_y sinθ

$\underset{By}{\rightarrow}$= 1.0013 X$10^{-1}$Tesla

sin θ = sin 90° = 1

Fz = 1.6 x 10^{-19}x 0.2131 x 10^7 x 1.0013 X10^{-1} x 1 N
=0.3414 x 10^{-13} N
Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is according to (+) z axis ,
so ,
$\underset{Fz}{\rightarrow}$ = 0.3414 x 10^{-13} N

Forces acting on the triton



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 0.5911 \times 10^{-13}$ N

$F_y = 0.3413 \times 10^{-13}$ N

$F_z = 0.3414 \times 10^{-13}$

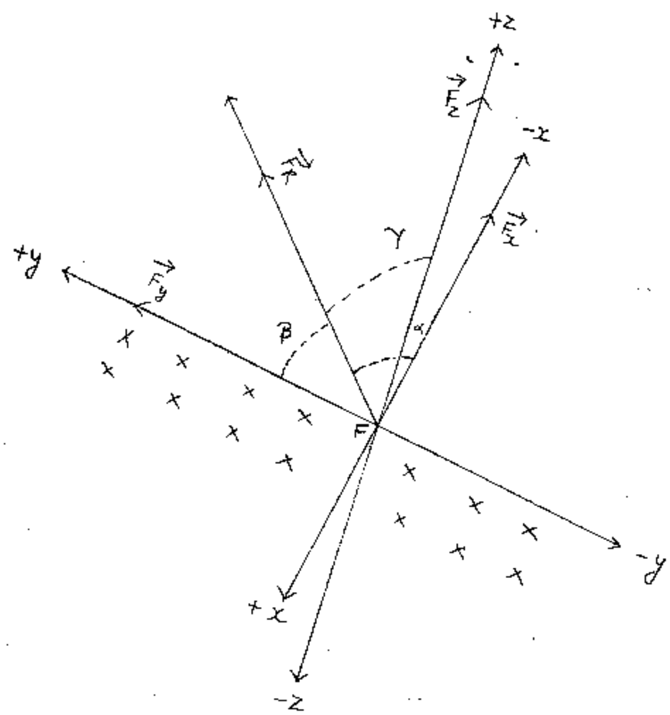
$F_R^2 = (0.5911 \times 10^{-13})^2 + (0.3413 \times 10^{-13})^2 + (0.3414 \times 10^{-13})^2 \, N^2$

$= (0.34939921 \times 10^{-26}) + (0.11648569 \times 10^{-26}) + (0.11655396 \times 10^{-26}) \, N^2$

$F_R^2 = 0.58243886 \times 10^{-26} \, N^2$

$F_R = 0.7631 \times 10^{-13}$ N

Resultant force acting on the triton



Radius of the circular path :

Resultant force acts as a centripetal force on the triton . so, thetriton tries to follow a confined circular path.

The radius of the circular orbit to be obtained by the triton is –

$r = mv^2 / F_R$

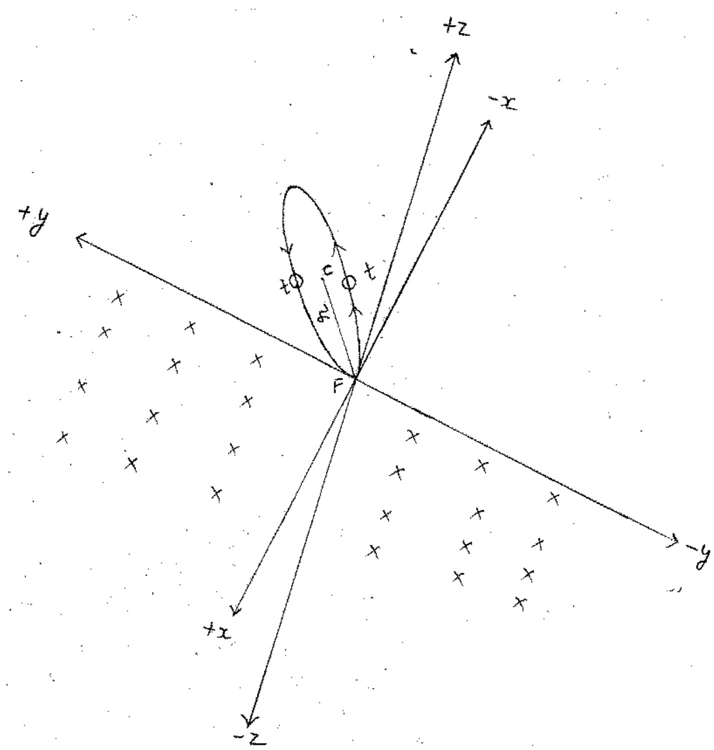
$$r = \frac{0.9095 \times 10^{-13}\ J}{0.7631 \times 10^{-13}\ N}$$

$r = 1.1918$ m

The circular orbitto be followed by the triton lies in the plane made up ofnegative x-axis, positive y-axisand the positive z-axis.

$\overrightarrow{Fr}$ = The resultant force acting on the particle (at point ' F ') towards the centre of the circle .

C_t = center of the circular orbit to be followed by the triton.



The plane of the circular orbit to be followed by the triton makes angles with respect to positive x , y and z-axesas follows :-

1 withx- axis

Cosα = $\underline{F_R \cos \alpha}$ /Fr $= \vec{F_x} / F_r$

$\vec{F_x}$ = -0.5911 x 10^{-13} N

$F_r = 0.7631 \times 10^{-13}$ N

Puttingvalues

Cos α = - 0.7746

α=219.23 degree [∴ cos (219.23) = -0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow} = 0.3413 \times 10^{-13}$ N

$F_r = 0.7631 \times 10^{-13}$ N

Putting values

Cos β = 0.4472

β = 63.43 degree [∴ cos (63.43) = 0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow}$ / F_r

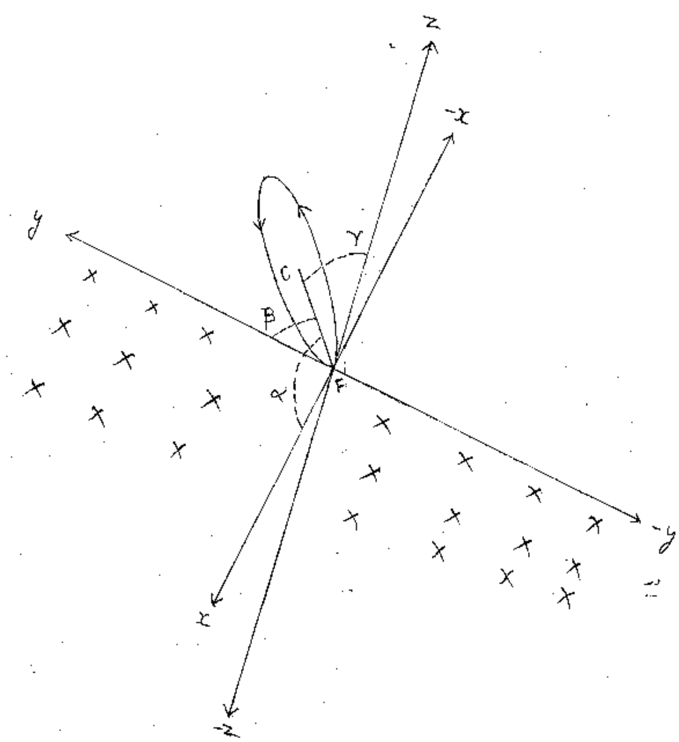
$\underset{Fz}{\rightarrow} = \underline{0.3414 \times 10^{-13} N}$

$F_r = 0.7631 X 10^{-13}$ N

Putting values

Cos y = 0.4473
y = 63.425 degree

The plane of the circular orbit to be followed by the triton makes angles with positive x , y , and z axesas follows:-



Where,

α = 219.23 degree

β= 63.43 degree

Y = 63.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circleto be obtained by the triton

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

= 2x 1.1918 m

= 2.3836 m

Cos α = -0.7746

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 2.3836 \times (-0.7746)$ m

$x_2 - x_1 = -1.8463$m

$x_2 = -1.8463$ m [∴ $x_1 = 0$]

$\cos\beta = \frac{y_2 - y_1}{d}$

cosβ = 0.4472

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 2.3836 \times 0.4472$m

$y_2 - y_1 = 1.0659$ m

$y_2 = 1.0659$ m [∴ y_1 , = 0]

$\cos y = \frac{z_2 - z_1}{d}$

cosy = 0.4473

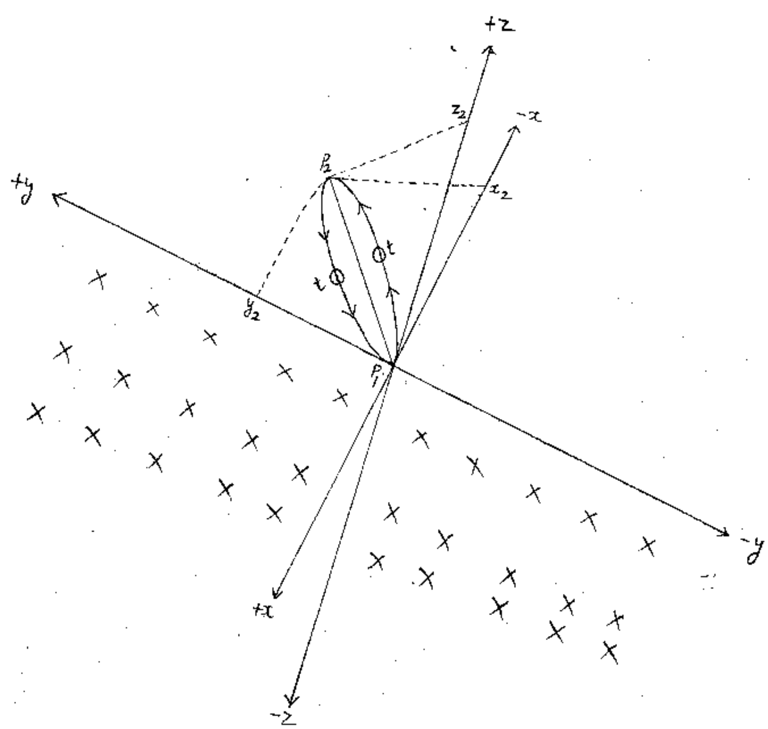
$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 2.3836 \times 0.4473$ m

$z_2 - z_1 = 1.0661$ m

$z_2 = 1.0661$ m [∴ $z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1 , y_1, z_1) and p_2(x_2 , y_2 , z_2) located on the circumference of the circular orbit to be followed bythe triton.



A

Conclusion :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that are acting on the triton

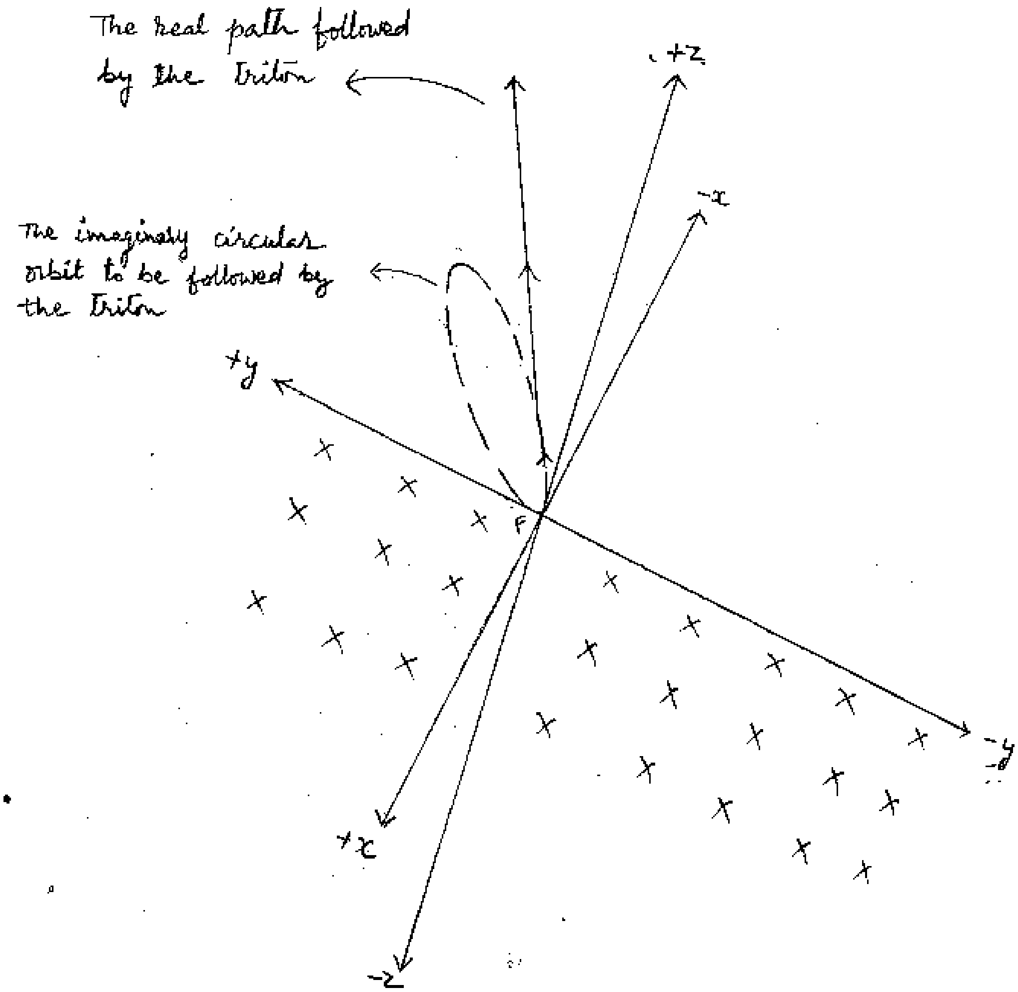
are along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the tirton lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the tirton to undergo to a circular orbit of radius 1.1918m . It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-1.8463 m, 1.0659 m,1.0661 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the tirton gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the triton is not confined.


The real path followed
by the Triton
The imaginary circular
orbit to be followed by
the Triton
+z
-x
+y
F
-y
+x
-z

10.. Final Kinetic energy of the particle - proton

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$= (1.3907 X10^7)^2 + (2.4086X10^7)^2 + (0)^2 \ m^2/s^2$

$= (1.93404649 X10^{14}) + (5.80135396X10^{14}) + 0 \ m^2/s^2$

$V^2 = 7.73540045X10^{14} \ m^2/s^2$

$V = 2.7812x10^7 \ m/s$

$mv^2 = 1.6726 \times 10^{-27} x7.73540045 \times 10^{14} \ J$

$= 12.9382 \times 10^{-13} \ J$

K.E. $= {}^1/_2 \ mv^2 = {}^1/_2 \times 1.6726 \times 7.73540045 \times 10^{14}$ J

= 6.4691

= 4.0431 Mev

Forces actingon the proton

1 $F_y = q V_x B_z \sin\theta$

$\overrightarrow{Vx} = 1.3907x \ 10^7$ m/s

$\overrightarrow{Bz} = - 1.001x \ 10^{-1}$ Tesla

$\sin\theta = \sin 90^o = 1$

$Fy = 1.6 \times 10^{-19} x 1.3907 \times 10^{7} x\ 1.001 x\ 10^{-1} \times 1$ N

$= 2.2273 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (-) y-axis ,

so ,

$\underset{Fy}{\rightarrow} = - 2.2273 x\ 10^{-13}$ N

2 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow} = 2.4086 x\ 10^{7}$

$\underset{Bz}{\rightarrow} = - 1.001 x\ 10^{-1}$ tesla

$\sin\theta = \sin 90^o = 1$

$Fx = 1.6 \times 10^{-19} x\ 2.4086 \times 10^{7} \times 1.001 x\ 10^{-1} x\ 1$ N

$= 3.8576 x\ 10^{-13}$ N

Form the right hand palm rule , thedirection of the force $\underset{Fx}{\rightarrow}$ is according to (+) x- axis ,

so ,

$\underset{Fx}{\rightarrow} = 3.8576 \times 10^{-13}$ N

3 $F_z = q V_x B_y \sin \theta$

$\underset{By}{\rightarrow} = 1.0013 \times 10^{-1}$ m/s

$\sin \theta = \sin 90^o = 1$

$Fz = 1.6 \times 10^{-19} \times 1.3907 x\ 10^{7} x\ 1.0013 \times 10^{-1} \times 1$ N

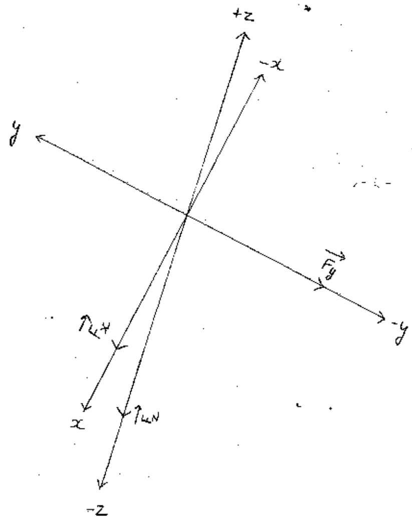
$= 2.2280 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fz}{\rightarrow}$ is according to (-) z axis ,

so ,

$\underset{Fz}{\rightarrow} = - 2.2280 \times 10^{-13}$ N

The forces acting on the proton



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 3.8576 \times 10^{-13}$ N

$F_y = = 2.2273 \times 10^{-13}$ N

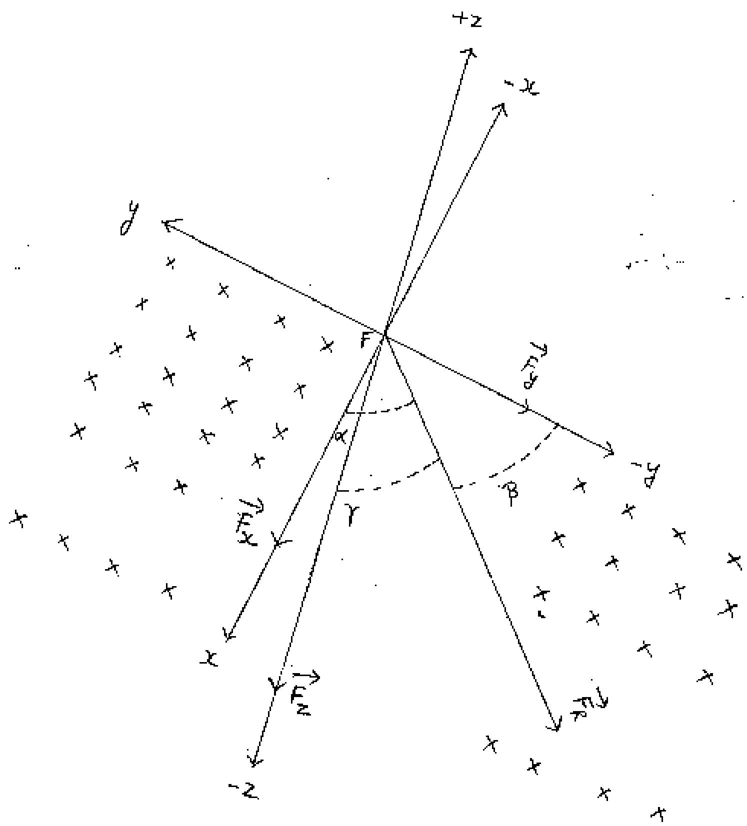
$F_z = 2.2280 \times 10^{-13}$

$F_R^2 = (3.8576 \times 10^{-13})^2 + (2.2273 \times 10^{-13})^2 + (2.2280 \times 10^{-13})^2 \; N^2$

$= (14.88107776 \times 10^{-26}) + (4.96086529 \times 10^{-26}) + (4.963984 \times 10^{-26}) \; N^2$

$F_R^2 = 24.80592705 \times 10^{-26} \; N^2$

$F_R = 4.9805 \times 10^{-13} \; N$


+z
-x
y
F
-y
x
-z
α
β
γ

Radius of the circular path :

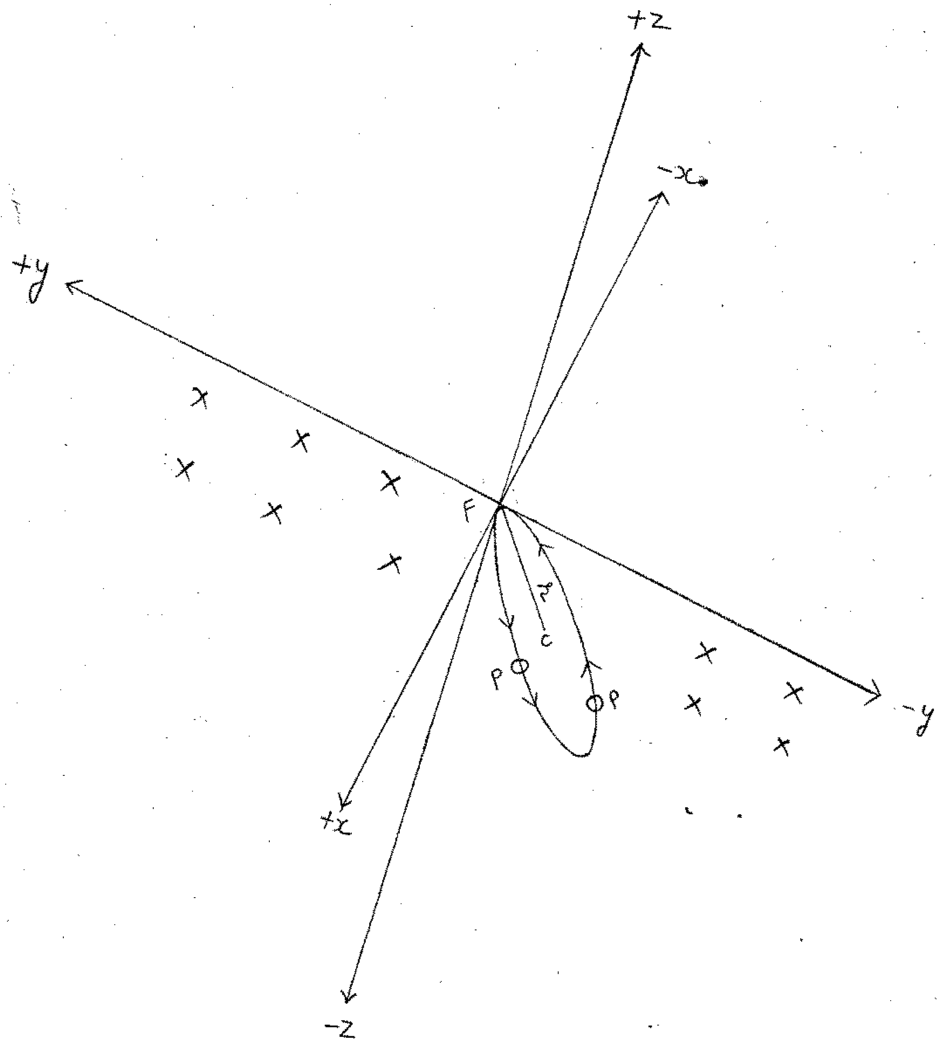
Resultant force acts as a centripetal force on the proton . so, the proton tries to followa confined circular path.

The radius of the circular orbit to be obtained by the porton is –

$r = mv^2 / F_R$

$r = \frac{12.9382 \times 10^{-13}\ J}{4.9805 \times 10^{-13}\ N}$

r = 2.5977 m


+z
-x
+y
F
r
c
P
P
-y
+x
-z

The plane of the circular orbit to be followed by the protonmakes angles with respect to positive x , y and z-axesas follows :-

1 withx- axis

Cos α= $\underline{F_R \cos\alpha}$/Fr $= \underset{Fx}{\rightarrow} / F_r$

$\underset{Fx}{\rightarrow} = 3.8576 \times 10^{-13}$ N

$F_r = 4.9805 \times 10^{-13}$ N

Puttingvalues

Cos α = 0.7745

α =39.24 degree [∴ cos (39.24) = 0.7745]

2 with y- axis

Cosβ= $\underline{F_R \cos\beta}$ $/F_r = \underset{Fy}{\rightarrow} / F_r$

$\underset{Fy}{\rightarrow} = -2.2273 \times 10^{-13}$ N

$F_r = 4.9805 \times 10^{-13}$ N

Putting values

Cos β = - 0.4472

β = 243.43 degree [∴ cos (243.43) =-0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow} / F_r$

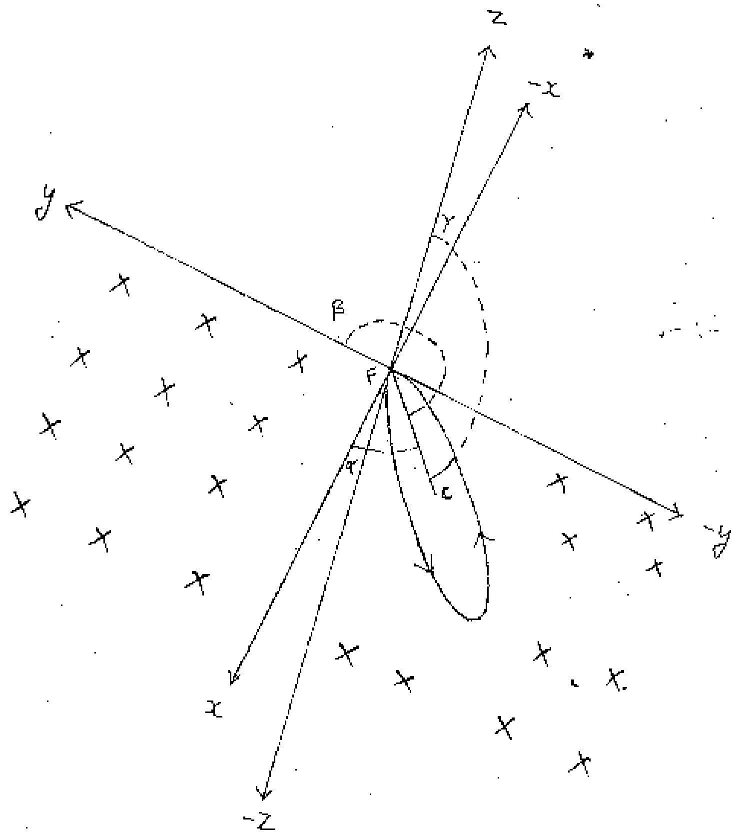
$\underset{Fz}{\rightarrow} = \underline{-2.2280 \times 10^{-13} N}$

$F_r = 4.9805 X 10^{-13}$ N

Putting values

Cos y = - 0.4473

y = 243.425 degree


Z
-x
y
β
γ
F
α
c
-y
x
-Z

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2(x_2, y_2 , z_2) located on the circumference of the circle to beobtained by the proton

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$d = 2 \times r$

$= 2x\ 2.5977$ m

$= 5.1954$m

$\cos \alpha = 0.7745$

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 5.1954 \times 0.7745$ m

$x_2 - x_1 = 4.0238$ m

$x_2 = 4.0238$ m [$\therefore x_1 = 0$]

$$\cos \beta = \frac{y_2 - y_1}{d}$$

$\cos \beta = -0.4472$

$y_2 - y_1 = d \times \cos \beta$

$y_2 - y_1 = 5.1954 \times (-0.4472)$ m

$y_2 - y_1 = -2.3233$ m

$y_2 = -2.3233$ m [$\therefore y_1 = 0$]

$$\cos y = \frac{z_2 - z_1}{d}$$

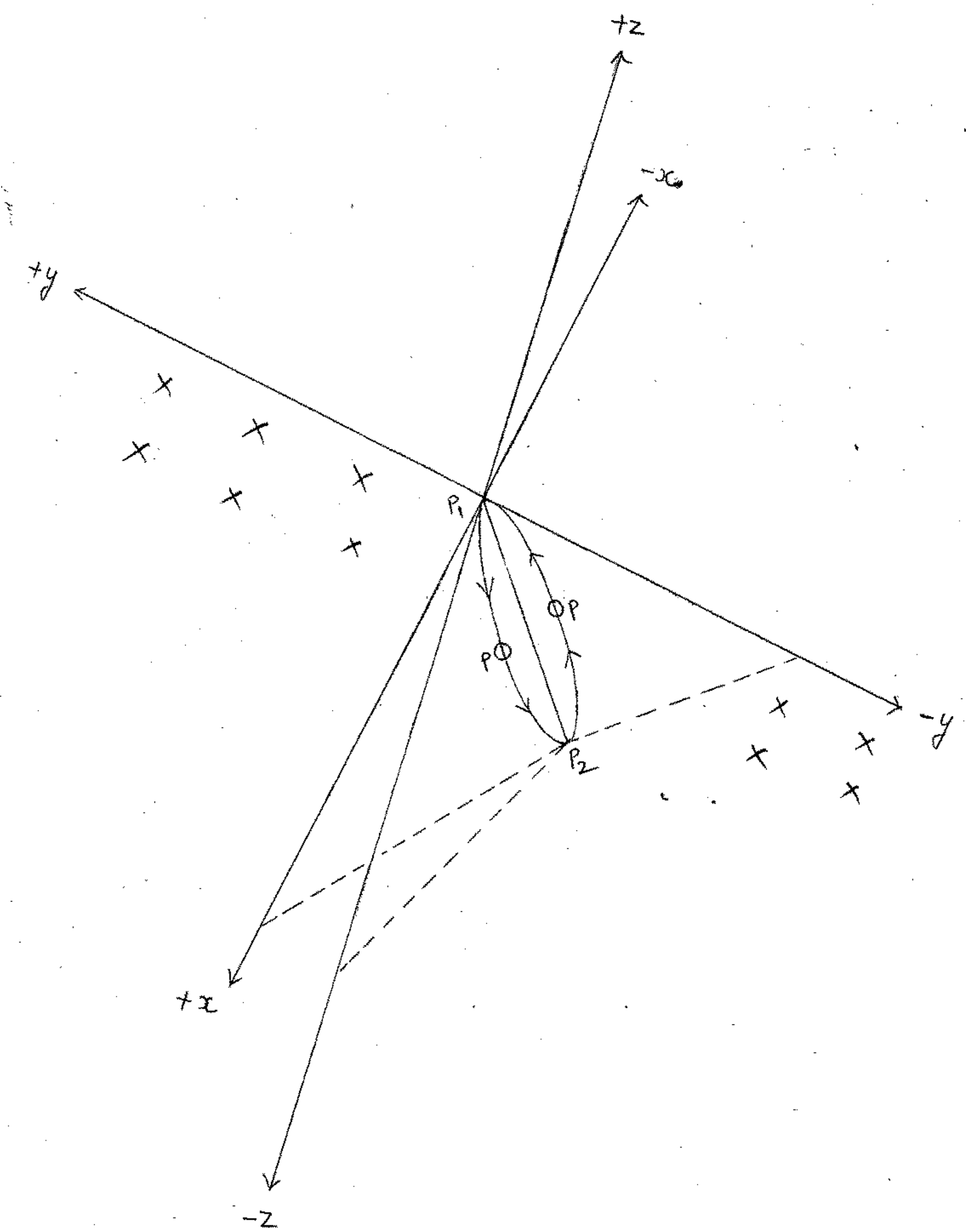
$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 5.1954 \times (-0.4473)$ m

$z_2 - z_1 = -2.3239$m

$z_2 = -2.3239$ m [$\therefore z_1 = 0$]


+z
-x
+y
P1
P
P
P2
-y
+x
-z

Conclusion :-

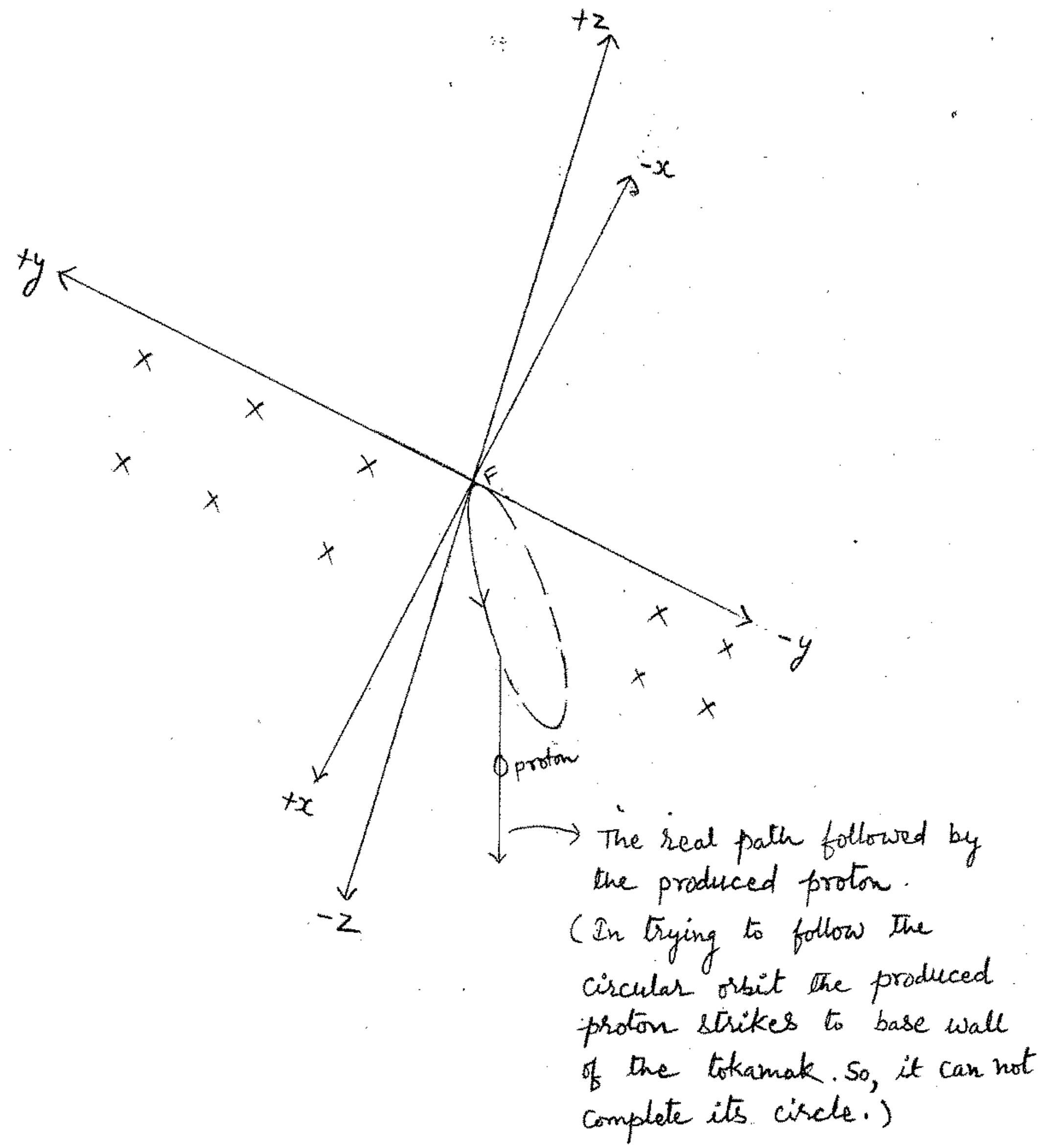
The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the proton are along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis where the magnetic fields are applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the proton to undergo to a circular orbit of radius2.5977 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.0238 m,- 2.3233 m ,-2.3239 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.


+z
-x
+y
F
-y
proton
+x
-z
The real path followed by the produced proton.
(In trying to follow the circular orbit the produced proton strikes to base wall of the tokamak. So, it can not complete its circle.)

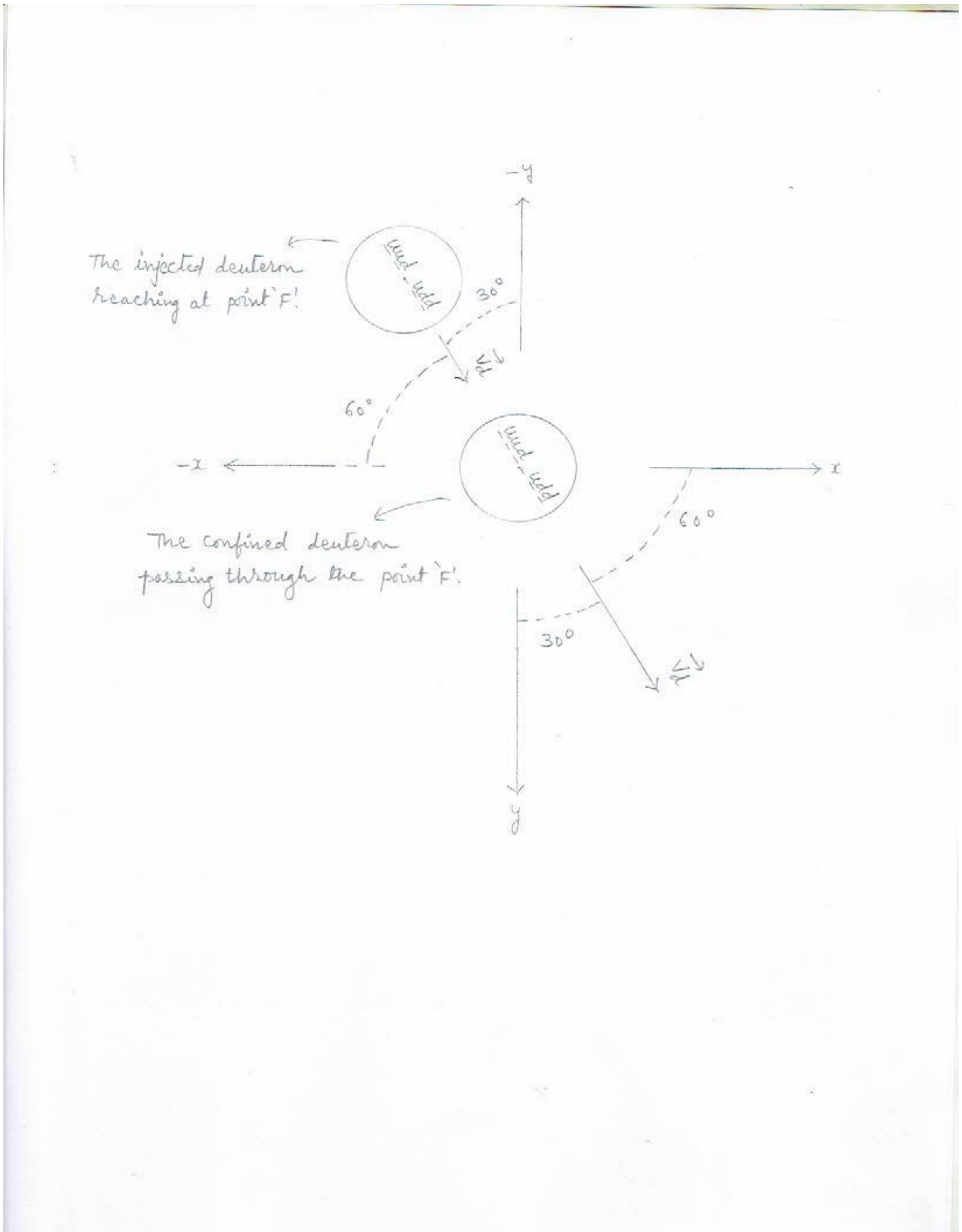
For fusion reaction

$^{2}_{1}H + ^{2}_{1} H \rightarrow ^{4}_{2} He$ + y rays

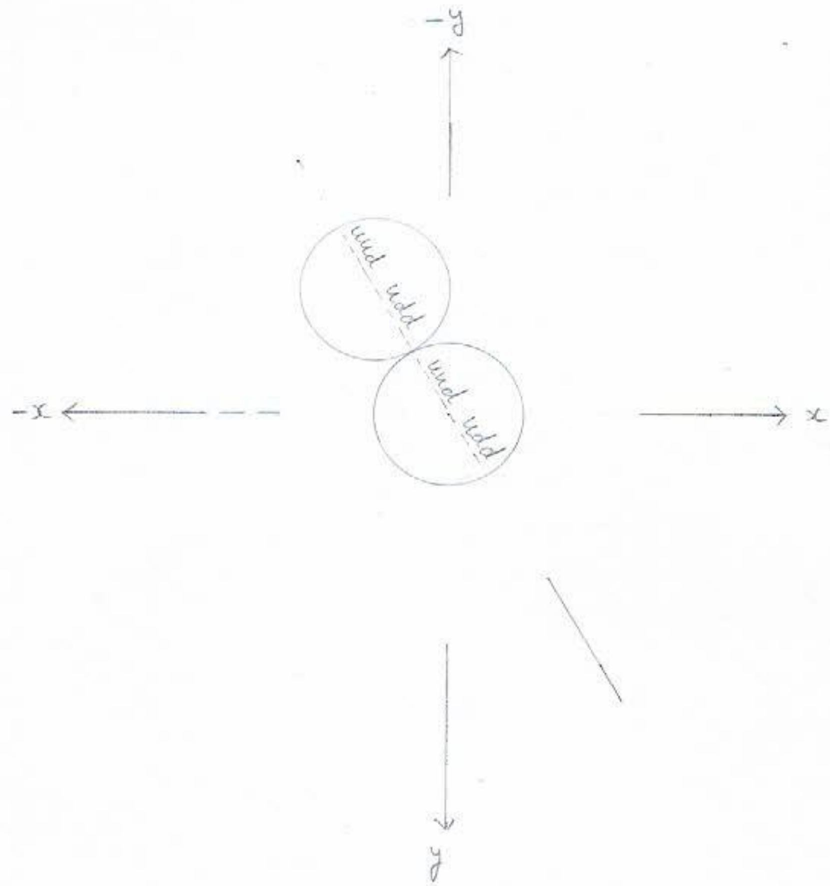
interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined deuteron] with the confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined deuteron.

interaction of nuclei(1)



interaction of nuclei (2)

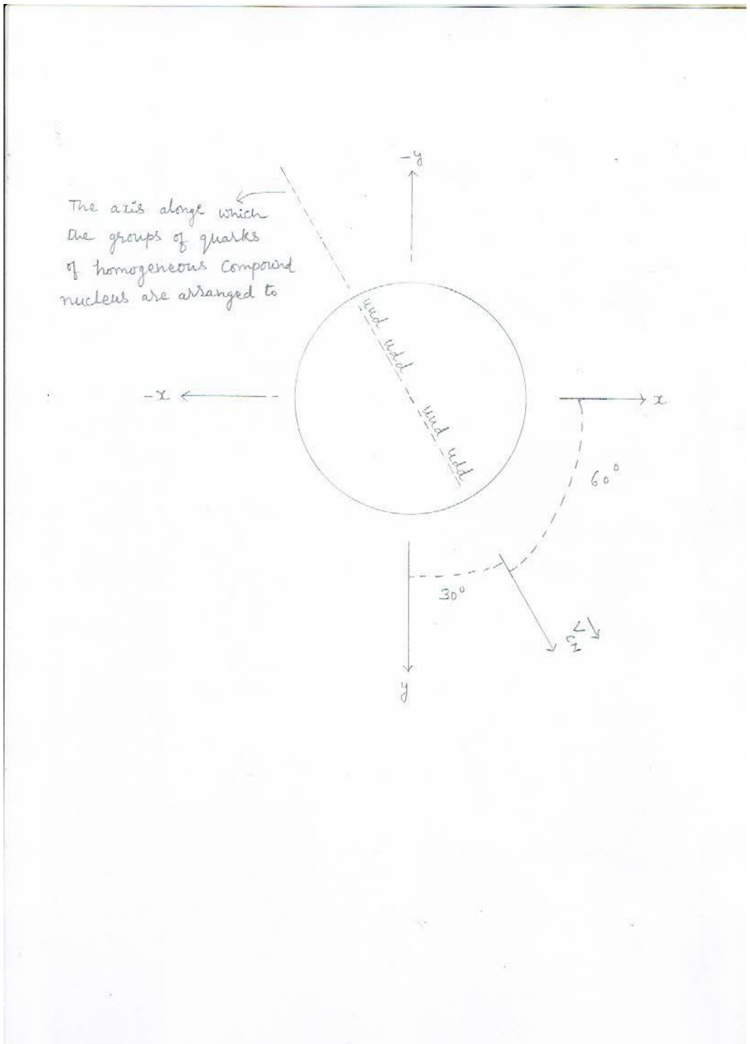

-y
-x
x
y
uud udd
uud udd

1.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus in a homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 4 groups of quarks with surrounded gluons.

The homogenous compound nucleus



The axis along which the group of quarks of the homogenous compound nucleus are arranged is parallel to direction of velocity of compound nucleus.

V_{CN} = velocity of the compound nucleus

3 Formation of lobes within into the homogeneous compound nucleus [$^{4}{}_{2}m$]or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

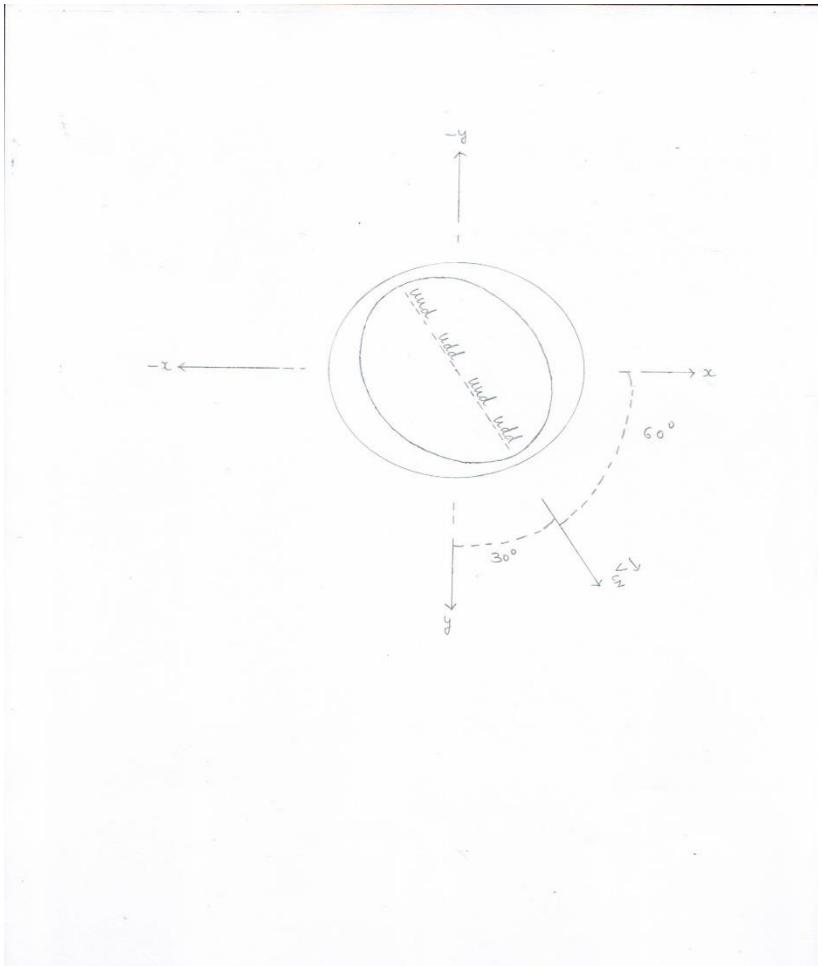
The homogenous compound nucleus [$^4{}_2 m$] is unstable . so, for stability ,the central group of quarks with its surrounding gluons to become a stable and the just lower nucleus (the helion-4) than the homognous one [$^4{}_2 m$] includes the other 3 groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

While , the remaining gluons [the gluons (or mass) that is not included in the formation of the lobe ‘ A ‘] rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

The homogenous compound nucleus [$^4{}_2 m$] has more mass than the helium-4 nucleus.

Formation of lobes Within into the homogeneous compound nucleus :-



where,

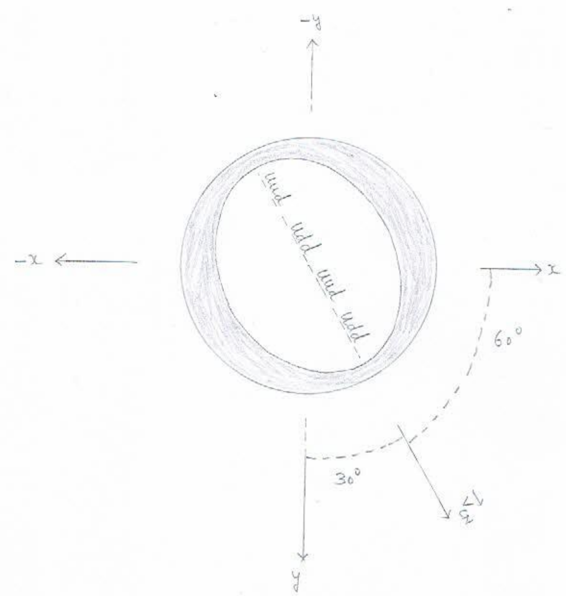
1 inner side - lobe ‘A ‘ formed [that is helium-4 nucleus is formed]

outter side – The remaining gluons [or the reduced mass] .

4..Final stage of the heterogeneous compound nucleus : -

The remaining gluons (that compose the ‘ B’ lobe of the heterogenous compound nucleus]remainloosely bonded to the helium-4 nucleus [that compose the ‘A’ lobe of the heterogenous compound nucleus] thus the heterogenous compound nucleus , finally, becomes like a coconut into which the outer shield is made up of the remaining gluons while the inner part is made up of the helium-4 nucleus.

Final stage of the heterogenous compound nucleus :-



The splitting of the heterogenous compound nucleus

The remaining gluons are loosely bonded to the helium-4 nucleus.

At the poles of the helium-4 nucleus, the remaining gluons are lesser in amount than at the equator . So, during the rearrangement of the remaining gluons [or during the formation of the 'B' lobe of the heterogenous compound nucleus] , the remaining gluons to be homogenously distributed all around , rush from the eqator to the poles.

In this way, the loosely bonded remaining gluons separates from the helium-4 nucleus and also divides itself into two parts giving us three particles –the first one is the one-half of the reduced mass, second one is the helium-4nucleus and the third one is theanother half of the reduced mass.

Thus the heterogenous compound nucleus splits according to the lines perpendicular to the velocity of the compound nucleus into three paticles the first one is the one-half of the reduced mass (Δm/2) , the second one is the helium -4 nucleus and the third one is the another one-half of the reduced mass (Δm/2).

By the law of inertia, each particle that has separated from the compound nucleus has an inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of thecompound nucleus($\overrightarrow{Vcn}$) .

So, for conservation of momentum

$M\overrightarrow{Vcn}$ = (Δm/2 + m_{He-4} + Δm/2)$\overrightarrow{Vcn}$

Where ,

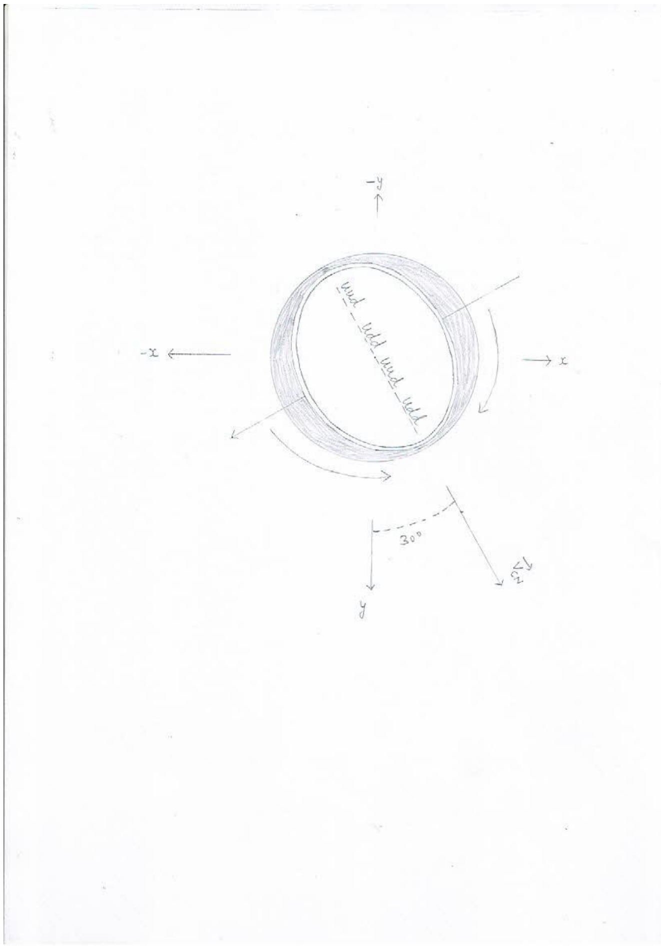
M = mass of the compound nucleus

$\overrightarrow{Vcn}$ = velocity of the compound nucleus

m_{He-4} = mass of the helium-4 nucleus

Δm/2 = one –half of the reduced mass

The splitting of the heterogenous compound nucleus :-

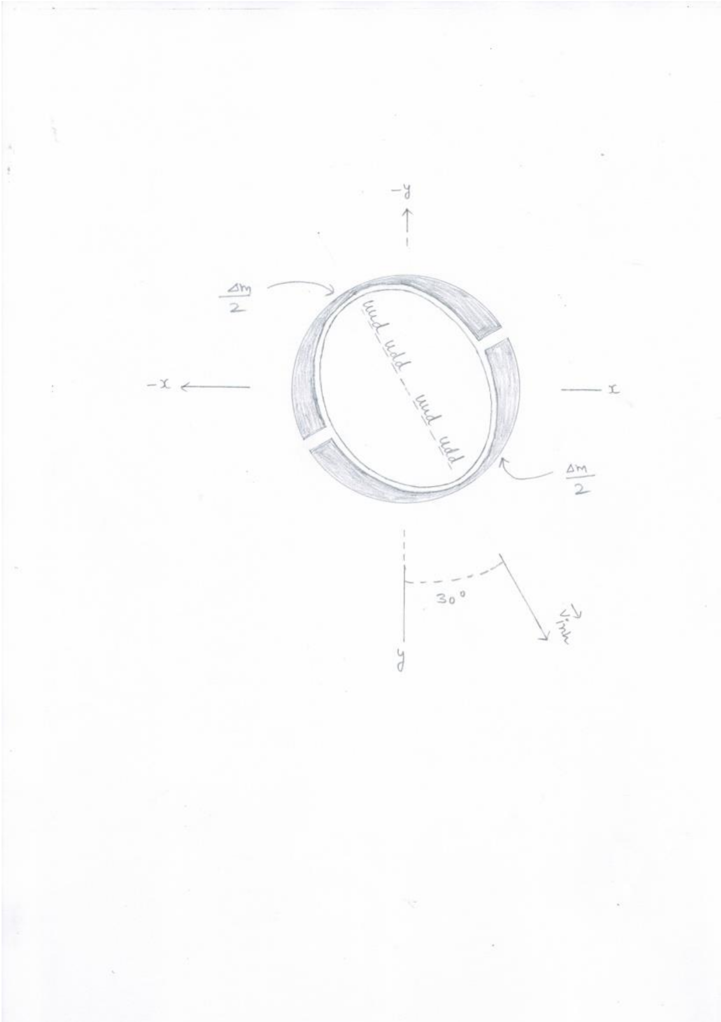


The remaining gluouns are loosely bonded to the helium-4 nucleus.
At the poles of the helium-4 nucleus , the remaining gluons are lesser in amount than at theequator.so, during the rearrangement of the remaining gluons [or during the formationof the 'B' lobe of the heterogenous compound nucleus] the remainging gluons, for balance , rush from the equator to poles.

In this way, the loosely bonded remaining gluonsseparates from the helium-4 nucleusgiving us three particles helium-4 nucleus, Δm/2 and Δm/2

Thus ,the heterogenous compound nucleus splits according to the lines perpendicular to the velocity of the compound nucleus into three paticles-one half of reduced mass (Δm/2) , helium -4 nucleus and another half of the reduced mass (Δm/2).

The splitting of the heterogenous compound nucleus :-



The heterogenous compound nucleus splits into three particles – The one-half of the reduced mass, the helium-4 nucleus (inside) and another half of the reduced mass.

Inherited velocity ($\overrightarrow{Vinh}$) of the particles : -

Each particles that is produced due to splitting ofthe compound nucleus has an inherited velocity ($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

I . Inherited velocity of the helium-4 nucleus

$V_{inh} = V_{CN} = 0.3770 \times 10^7$ m/s

Components of the inherited velocity of the helion – 4 nucleus

1 $\underset{Vx}{\rightarrow}$ = V_{inh} cos α= V_{CN}cos α= 0.1885×10^7m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inh} cos β = V_{CN}cos β= 0.3264×10^7m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

ii Inherited velocity of the each one-half of the reduced mass

$V_{inh} = V_{CN} = 0.3770 \times 10^7$ m/s

Propulsion of the particles

1.. Reduced mass

$\Delta m = [m_d + m_d] - [m_{He-4}]$
$\Delta m = [2 \times 2.01355] – [4.0015]$ amu
$\Delta m = [4.0271] – [4.0015]$ amu
$\Delta m = 0.0256$ amu
$\Delta m = 0.0256 \times 1.6605 \times 10^{-27}$ kg
$\Delta m = 0.0425088 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass .

$E_{inh} = ½\Delta m V^2 = ½\Delta m V^2_{CN}$

$V^2_{CN} = 0.14216694382 \times 10^{14}$ m^2/s^2

$E_{inh} = ½ \times 0.0425088 \times 10^{-27} \times 0.14216694382 \times 10^{14}$ J

E_{inh} = 0.00302167309 x 10^{-13} J

E_{inh} = 0.001888Mev

$E_{Released}$ = $\Delta m\ C^2$

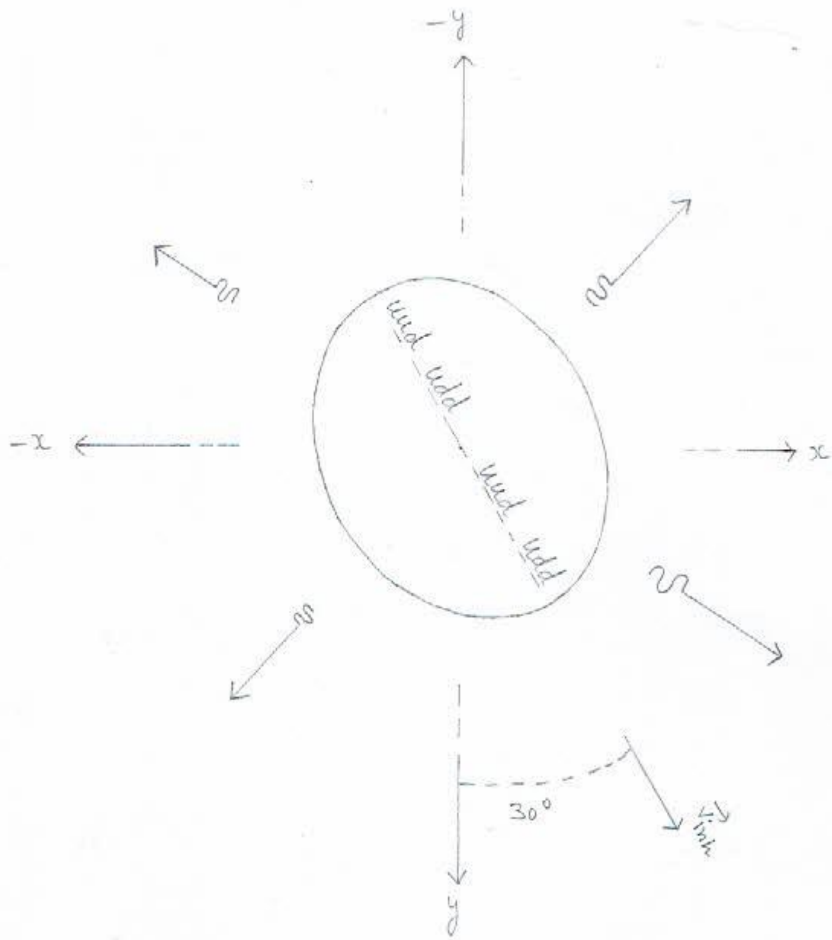
= 0.0256 x 931 Mev

=23.8336 Mev

E_{Total} = $E_{Inherited}$ + $E_{Released}$

= [0.001888] + [23.8336] Mev

=23.835488Mev



-y
-x
x
y
uud udd uud udd
30°

.. Components of the final velocity(Vf)of helium-4 nucleus

IForhelium-4

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$)=($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X –axis	$\overrightarrow{Vx}$ =0.1885x10^7m/s	$\overrightarrow{Vx}$ = 0 m/s	$\overrightarrow{Vx}$ = 0.1885x10^7m/s
y – axis	$\overrightarrow{Vy}$= 0.3264x10^7m/s	$\overrightarrow{Vy}$= 0 m/s	$\overrightarrow{Vy}$ = 0.3264x10^7m/s
z – axis	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$= 0 m/s

Final velocity (vf)of the helion-4 nucleus :-

$V_f^2 = V_x^2 + V_Y^2 + V_Z^2$

$= 0.3770$

Final kinetic energy of the helion-4 nucleus

$E = ½\, m_{He\text{-}4} V_f^2$

$V_f^2 = 0.14216694382 \times 10^{14} m^2/s^2$

$E = ½ \times 6.64449 \times 10^{-27} \times 0.14216694382 \times 10^{14} J$

$= 0.47231341827 \times 10^{-13}$ J

= 0.2951958 Mev

$m_{He\text{-}4} V_f^2 = 6.64449 \times 10^{-27} \times 0.14216694382 \times 10^{14} J$

$= 0.9446 \times 10^{-13} J$

Forces acting on the helium-4 nucleus

1 $F_y = q\, V_x\, B_z \sin\theta$

$\overrightarrow{Vx} = 0.1885 \times 10^7$ m/s $\qquad \overrightarrow{Bz} = -1.001 \times 10^{-1}$ Tesla

$q=2 \times 1.6 \times 10^{-19}$ c

$\sin\theta = \sin 90^o = 1$

$F_y = 2 \times 1.6 \times 10^{-19} \times 0.1885 \times 10^7 \times 1.001 \times 10^{-1} \times 1$ N

$= 0.6038 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to(-) y-axis,

so ,

$\underset{Fy}{\rightarrow} = -0.6038 \times 10^{-13}$N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow} = 1.0013 \times 10^{-1}$ Tesla

$\sin\theta = \sin 90^o = 1$

$F_z = 2 \times 1.6 \times 10^{-19} \times 0.1885 \times 10^7 \times 1.0013 \times 10^{-1} \times 1$ N

$= 0.6039 \times 10^{-13}$ N

Form the right hand palm rule , thedirection of the force $\underset{Fz}{\rightarrow}$ is according to(-) Z- axis ,

so ,

$\underset{Fz}{\rightarrow} = -0.6039 \times 10^{-13}$N

3 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow} = 0.3264 \times 10^7$ m/s

$\underset{Bz}{\rightarrow} = -1.001 \times 10^{-1}$Tesla

$\sin\theta = \sin 90^o = 1$

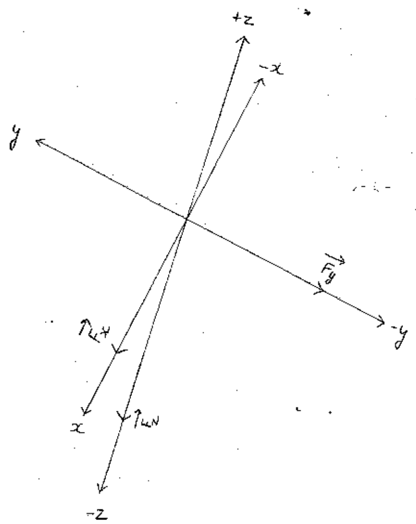
$F_x = 2 \times 1.6 \times 10^{-19} \times 0.3264 \times 10^7 \times 1.001 \times 10^{-1} \times 1$ N

$= 1.0455 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is according to(+) x axis , so ,

$\underset{Fx}{\rightarrow} = 1.0455 \times 10^{-13}$N

The forces acting on the helium-4 nucleus



Resultant force acting on the heluim-4 nucleus (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 1.0455 \times 10^{-13}$ N

$F_y = 0.6038 \times 10^{-13}$ N

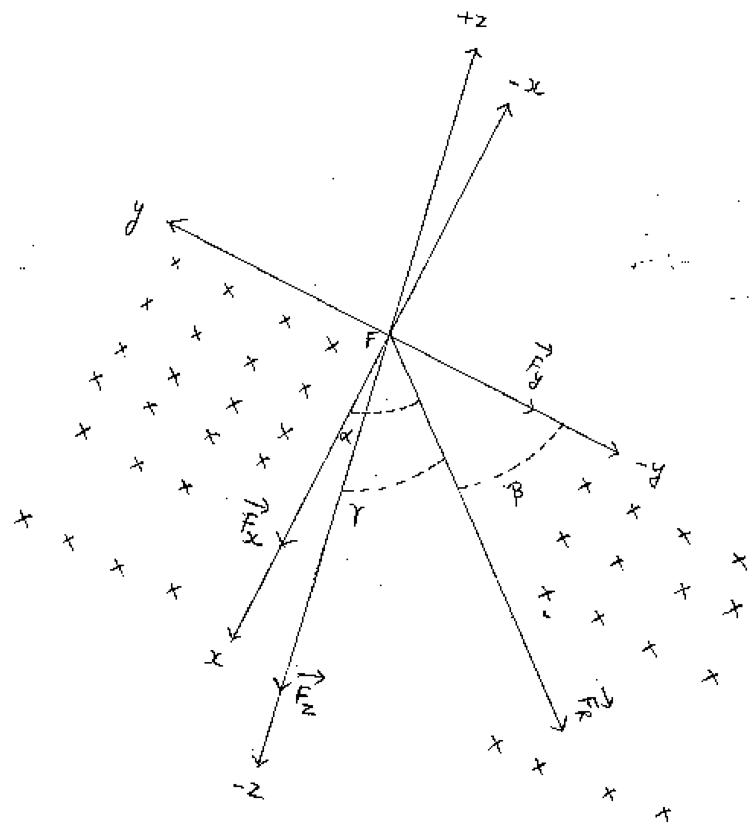
$F_z = 0.6039 \times 10^{-13}$ N

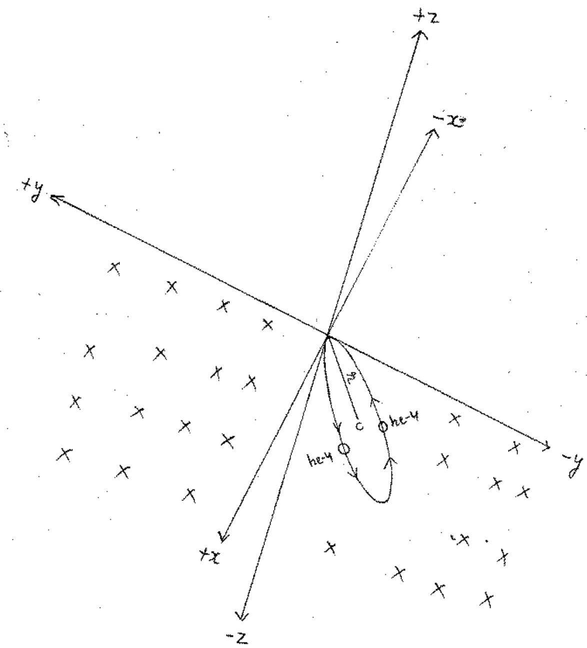
$F_R^2 = (1.0455 \times 10^{-13})^2 + (0.6038 \times 10^{-13})^2 + (0.6039 \times 10^{-13})^2$ N^2

$$F_R^2 = (1.09307025 \times 10^{-26}) + (0.36457444 \times 10^{-26}) + (0.36469521 \times 10^{-26}) \quad N^2$$

$$F_R^2 = 1.8223399 \times 10^{-26} \quad N^2$$

$$F_R = 1.3499 \times 10^{-13} N$$


+z
-x
y
F
-y
x
-z
α
β
γ



The circular orbit followed by the helion-4 lies in the plane made up of positive x-axis, negative y-axis and the negative z-axis.

$\overrightarrow{Fr}$ = The resultant force .

C= center of the circular orbit followed by the helium-4 nucleus.

The plane of the circular orbit followed by the helium -4 makes angleswith positive x , y and z-axesas follows :-

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow}$ / F_r

$\underset{Fx}{\rightarrow}$ = 1.0455×10^{-13} N

F_r= 1.3499×10^{-13}N

Puttingvalues

Cos α = 0.7745

α =39.24 degree [∴ cos (39.24) = 77.45]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ =- 0.6038×10^{-13} N

F_r = 1.3499×10^{-13} N

Putting values

Cos β= - 0.4472

β=243.43 degree [∴ cos (243.43) = - 0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow}$ / F_r

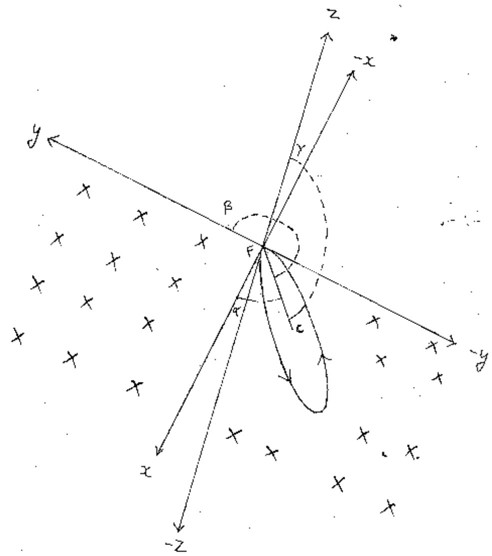
$\underset{Fz}{\rightarrow}$ = $\underline{-0.6039 \times 10^{-13} N}$

F_r = 1.3499×10^{-13} N

Putting values

Cos y = - 0.4473

y = 243.425 degree



The plane of the circular orbit followed by the helium -4 makes angles with respect to positive x, y and z-axes as follows :-
Where,
α = 39.24 degree
β = 243.43 degree
Y = 243.425degree

Radius of the circular orbit followed by the helion -4 nucleus :

$r = mv^2 / F_R$

$mv^2 = 0.9446x\ 10^{-13} J$

$F_r = 1.3499x\ 10^{-13}\ N$

$r = \frac{0.9446x\ 10^{-13}\ J}{1.3499\ x\ 10^{-13}\ N}$

$r = 0.6997\ m$

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2, z_2) located on the circumference of the circle obtained by the helion-4 nucleus.

$\cos \alpha = \frac{x_2 - x_1}{d}$

$d = 2\ x\ r$

$= 2x\ 0.6997\ m$

$= 1.3994\ m$

$\text{Cos}\ \alpha = 0.7745$

$x_2 - x_1 = d\ x\ \cos \alpha$

$x_2 - x_1 = 1.3994\ x\ 0.7745\ m$

$x_2 - x_1 = 1.0838\ m$

$x_2 = 1.0838\ m [\therefore\ x_1 = 0\ ]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = -0.4472$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 1.3994 \times (-0.4472)$ m

$y_2 - y_1 = -0.6258$m

$y_2 = -0.6258$ m $[\therefore\ y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

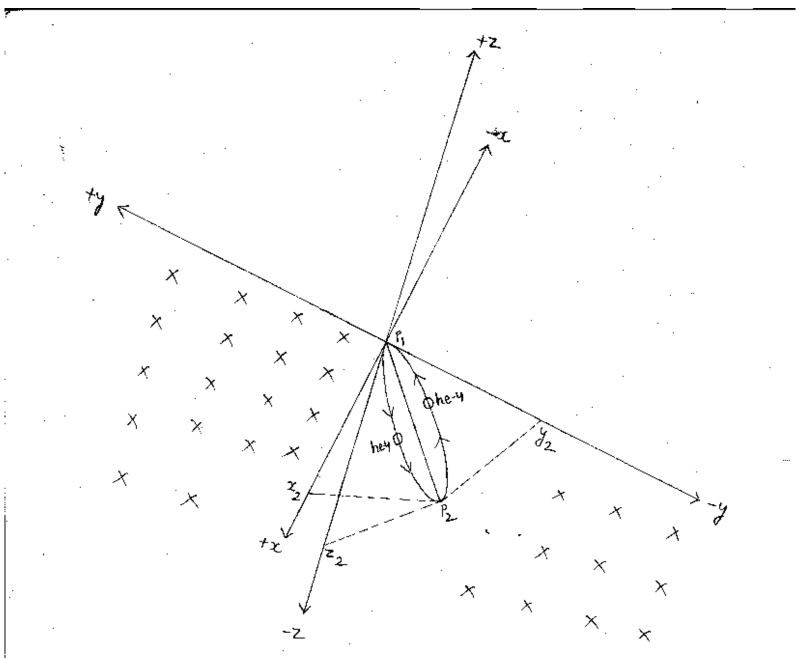
$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 1.3994 \times (-0.4473)$ m

$z_2 - z_1 = -0.6259$m

$z_2 = -0.6259$ m $[\therefore\ z_1 = 0]$



Conclusion :-

The directions components[$\vec{F_x}$,$\vec{F_y}$,and$\vec{F_z}$] of the resultant force($\vec{F_r}$)that areacting on the helium-4 nucleusare along **+x , -y and -z** axes respectively . So by seeing the direction of the resultant force($\vec{F_r}$) we come to know that the circular orbit to be followed bythe helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields areapplied.

The resultant force($\vec{F_r}$) tends the helium-4 nucleus to undergo to a circular orbit of radius of 0.6997 m. It starts its circular motion from point P_1(0,0,0) and reaches at point P_2(1.0838 m, -0.6258 m,-0.6259 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circle until it fuses with the confined deuteron or deuteronof later injected bunch (that reaches at point "F") at point "F"

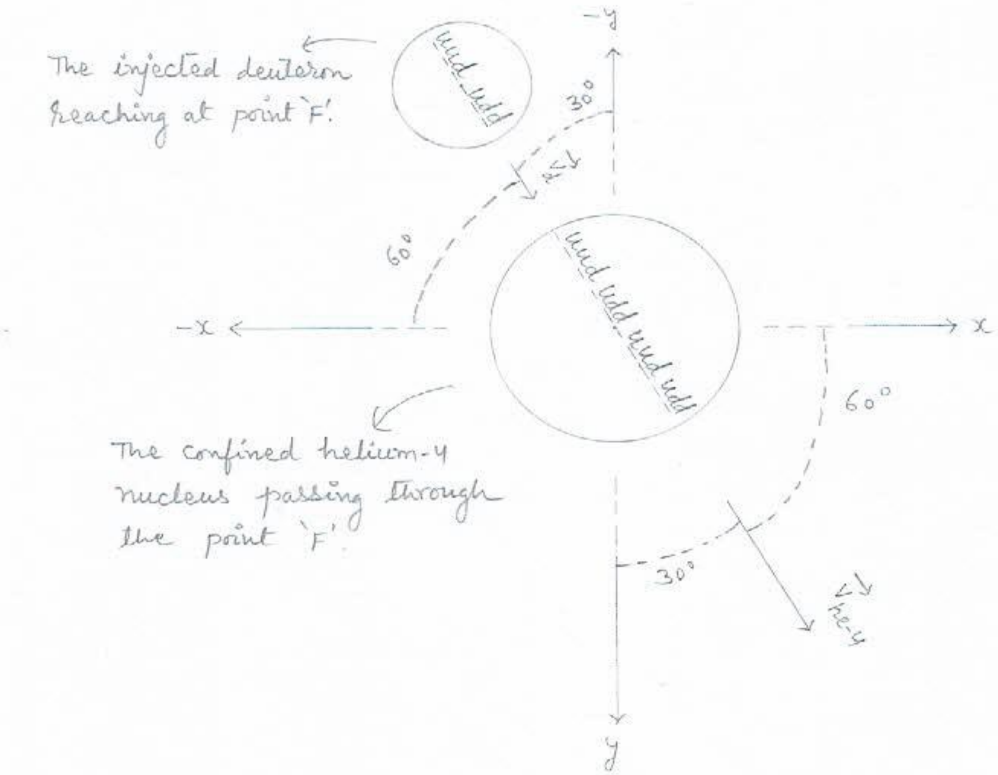
For fusion reaction

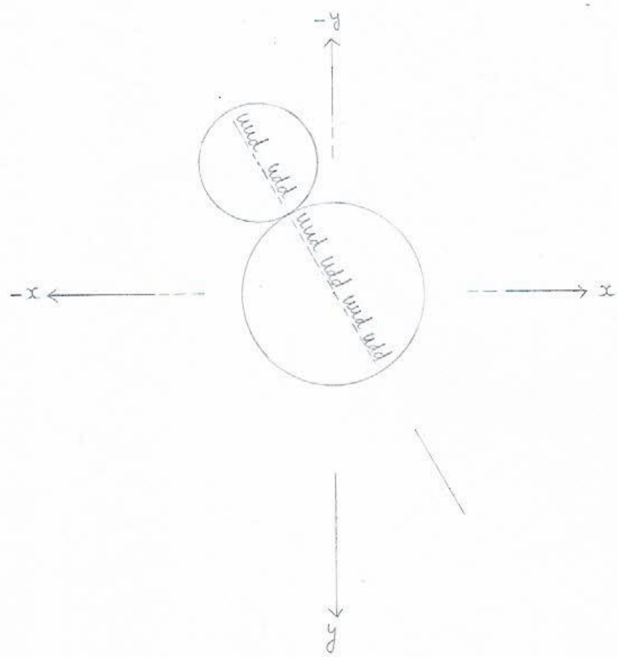
$^{2}_{1}H + {}^{4}_{2}He \rightarrow {}^{6}_{3}Li$ + y rays

interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined helion-4] with the confined helion-4 passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined helion-4.

interaction of nuclei(1)


The injected deuteron reaching at point 'F'.
uud udd
30°
60°
−y
−x
x
y
uud udd uud udd
60°
30°
The confined helium-4 nucleus passing through the point 'F'.

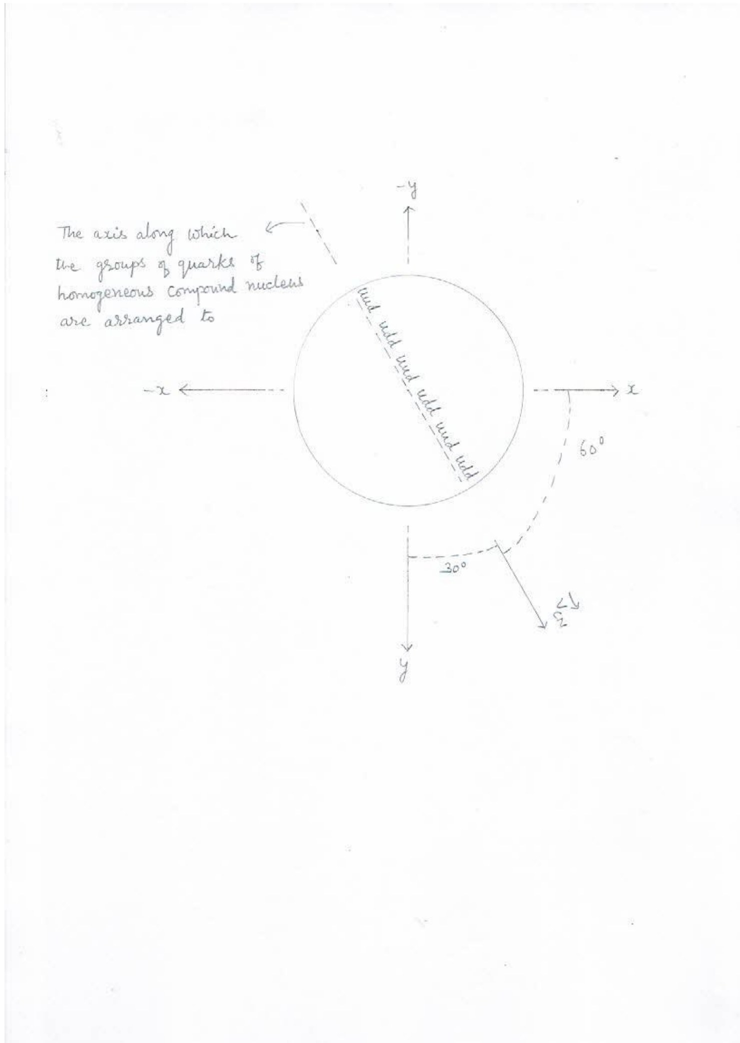


1..Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron and helion-4) behave like a liquid and form a homogeneous compound nucleus . having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus in a homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 6 groups of quarks with surrounded gluons.

The homogenous compound nucleus



The axis along which the group of quarks of the homogenous compound nucleus are arranged to is parallel to the direction of the velocity of compound nucleus.

V_{CN}= velocity of the compound nucleus

3 . Formation of lobes within into the homogeneous compound nucleus [${}^{4}{}_{2}$m]or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

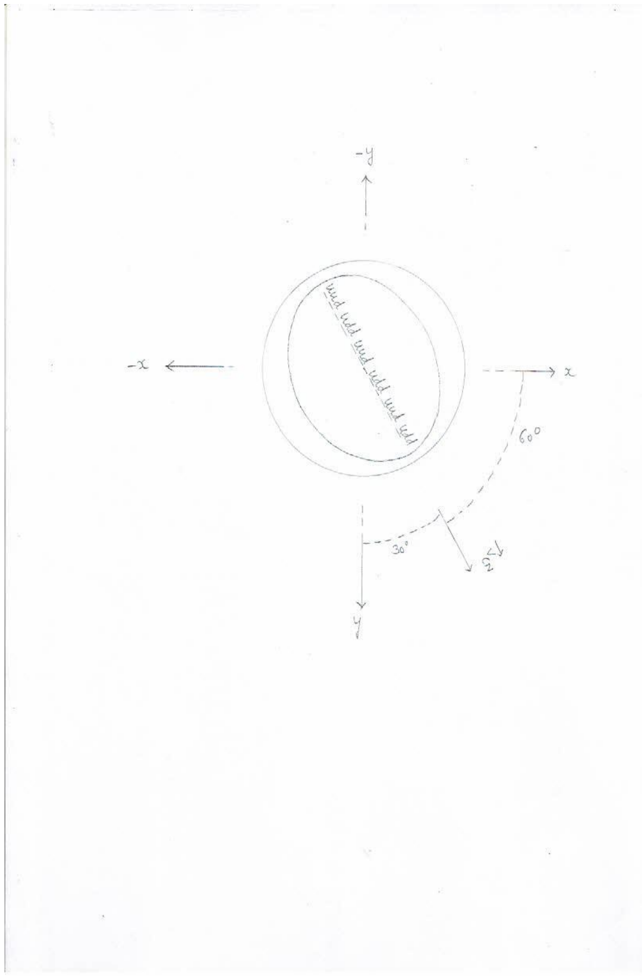
The homogenous compound nucleus [$^{6}_{3}Li$] is unstable . so, for stability ,the central group of quarks with its surrounding gluons to become a stable and the just lower nucleus (the lithion-6) than the homognous one [$^{6}_{3}Li$] includes the other 6 groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

While , the remaing gluons [the gluons (or mass) that is not included in the formation of the lobe ‘ A ‘] rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

The homogenous compound nucleus [$^{6}_{3}Li$] has more mass than the lithion-6 nucleus.

Formation of lobes Within into the homogeneous compound nucleus :-



where,

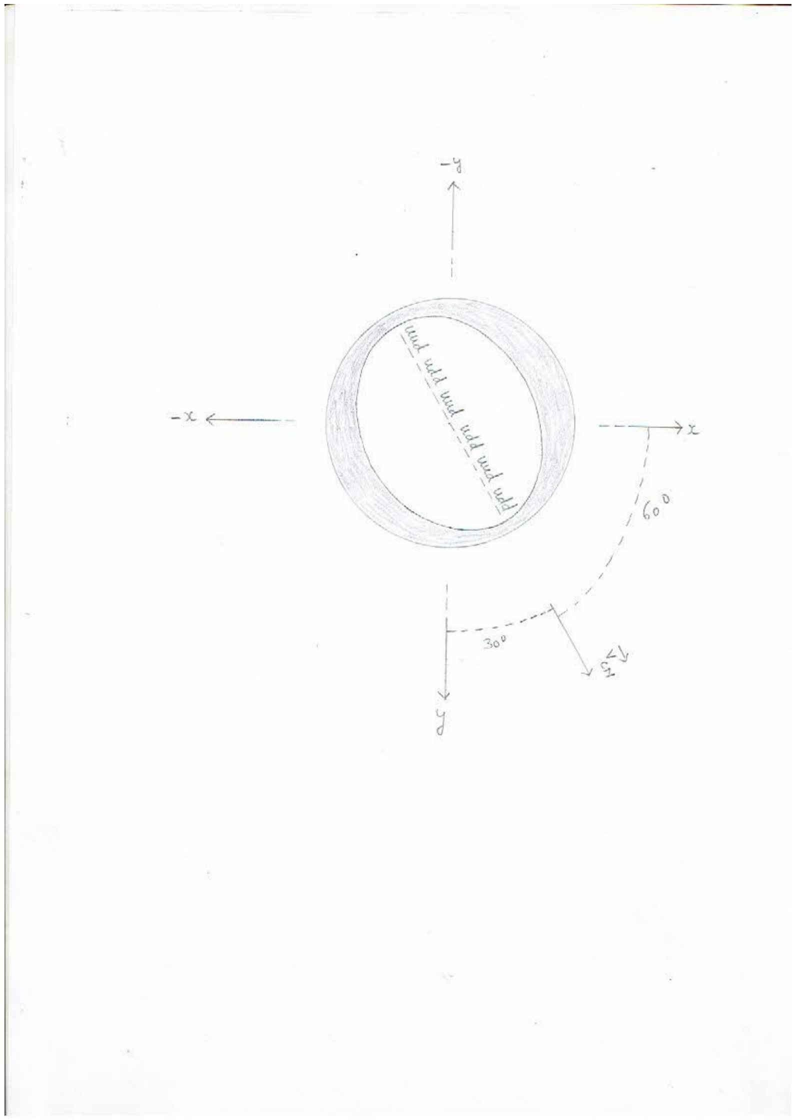
1 inner side - lobe ‘A ‘ formed [that is helium-4 nucleus is formed]

outter side – The remaining gluons [or the reduced mass] .

4..Final stage of the heterogeneous compound nucleus : -

The remaining gluons (that compose the ‘ B’ lobe of the heterogenous compound nucleus]remaining loosely bonded to the lithium-6 nucleus [that compose the ‘A’ lobe of the heterogenous compound nucleus] thus the heterogenous compound nucleus , finally, becomes like a coconut into which the outer shield is made up of the remaining gluons while the inner part is made up of the lithium-6 nucleus.

Final stage of the heterogenous compound nucleus :-



Formation of compound nucleus :

As the deuteron of n^{th} bunch reaches at point F , it fuses with the confined hellion-4 to form a compund nucleus .

(1)Just before fusion, to overcome the electrostatic repulsive force exerted by the hellion-4 , the deuteron of nth bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 20.2488 kev.

so, just before fusion,

the kinetic energy of nth deuteon is –

E_b = 153.6 kev – 20.2488 kev

= 133.3512 kev

= 0.1333512 Mev

(2).Just before fusion, to overcome the electrostatic repulsive force exerted by the deuteron , the confined helion -4 loses (radiates its energy in the form of eletromagnetic waves)its energy equal to 40.2420 kev.

so, just before fusion,

the kinetic energy of helion-4 is –

E_b = 295.1958 kev – 40.242 kev

= 254.9538 kev

= 0.2549538 Mev

Kinetic energy of the compound nucleus

K.E. =[E_b of $^{2}_{1}D$] + [E_b of $^{4}_{2}He$]

= [133.3512 Kev] +[254.9538 Kev]

= 388.305 Kev.

$= 0.388305$ Mev

$M = m_d + m_{he-4}$

$= [3.3434 \times 10^{-27}$ Kg$] + [6.64449 \times 10^{-27}$ Kg$]$

$= 9.98789 \times 10^{-27}$ Kg

Velocity of compound nucleus

K.E. $= \frac{1}{2} MV^2_{CN} = 0.388305$ Mev

$V_{CN} = \left(\frac{2 \times 0.388305 \times 1.6 \times 10^{-13}}{9.98789 \times 10^{-27}\ \text{kg}}\right)^{1/2}$ m/s

$V_{CN} = \left(\frac{1.242576 \times 10^{-13}}{9.98789 \times 10^{-27}}\right)^{1/2}$ m/s

$V_{CN} = [0.1244082584 \times 10^{14}]^{1/2}$ m/s

$V_{CN} = 0.3527 \times 10^{7}$ m/s

Components of velocity of compound nucleus

$\overrightarrow{Vx} = V_{CN} \cos \alpha$

$= 0.3527 X 10^7 X 0.5$ m/s

$= 0.1763 X 10^7$ m/s

$\overrightarrow{Vy} = V_{CN} \cos \beta$

$= 0.3527 X 10^7 X 0.866$ m/s

$= 0.3054$ m/s

$\overrightarrow{Vz} = V_{CN} \cos y$

$= 0.3527 X 10^7 X 0$ m/s

$= 0$ m/s

The splitting of the heterogenous compound nucleus

The remaining gluons are loosely bonded to the lithium-6 nucleus.

At the poles of the lithium-6 nucleus, the remaining gluons are lesser in amount than at the equator . So, during the rearrangement of the remaining gluons [or during the formation of the 'B' lobe of the heterogenous compound nucleus] , the remaining gluons to be homogenously distributed all around , rush from the eqator to the poles.

In this way, the loosely bonded remaining gluons separates from thelithium -6 nucleus and also divides itself into two parts giving us three particles –the first one is the one-half of the reduced mass, second one is the lithium-6 nucleus and the third oneis the one-half of the reduced mass.

Thus the heterogenous compound nucleus splits according to the lines perpendicular to the velocity of the compound nucleus into three paticles - the first one is the one-half of the reduced mass (Δm/2) , the second one is the lithium-6 nucleus and the third one is the another one-half of the reduced mass (Δm/2).

By the law of inertia, each particle thatisproduced due to splitting ofthe compound nucleus, has an inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of thecompound nucleus($\overrightarrow{Vcn}$) .

So, for conservation of momentum

$$M\overrightarrow{Vcn} = (\Delta m/2 + m_{Li\text{-}6} + \Delta m/2)\overrightarrow{Vcn}$$

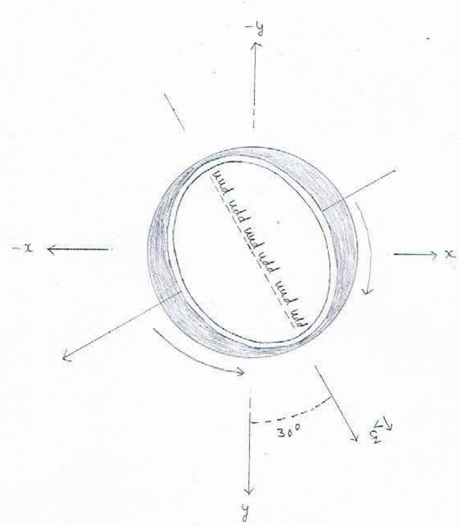
Where ,

M	= mass of the compound nucleus
$\overrightarrow{Vcn}$	= velocity of the compound nucleus

$m_{Li\text{-}6}$ = mass of thelithium-6 nucleus

$\Delta m/2$ = one –half of the reduced mass

The splitting of the heterogenous compound nucleus :-



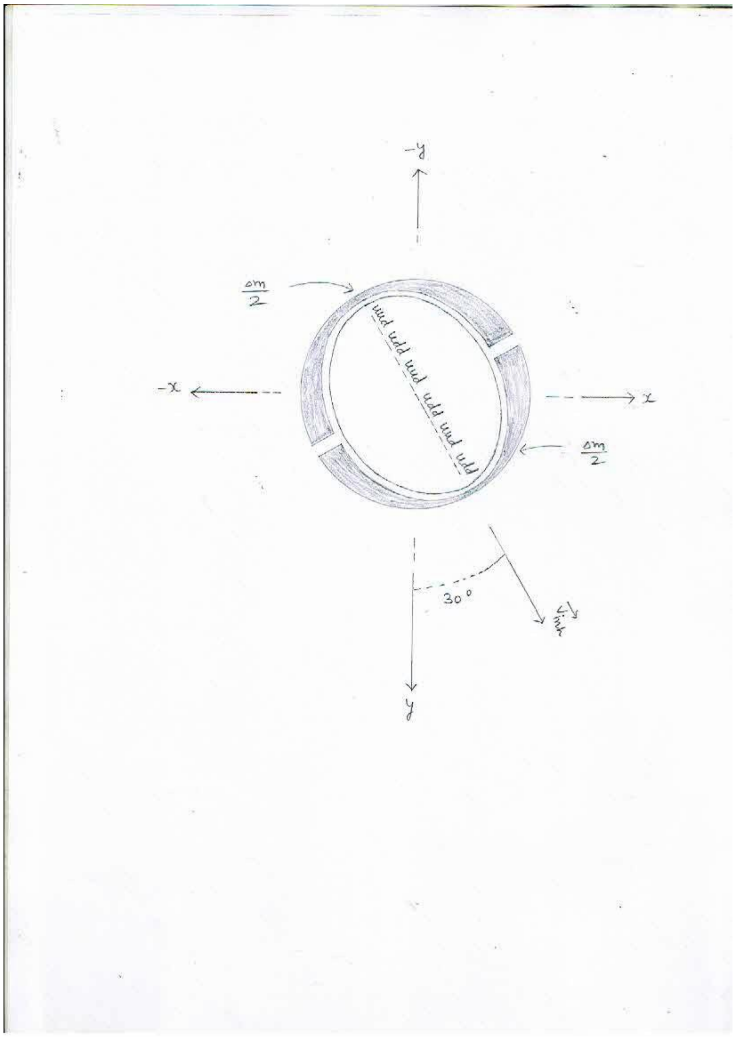
The remaining gluouns are loosely bonded to the lithium -6 nucleus.

At the poles of the lithium-6 nucleus , the remaining gluons are lesser in amount than at the equator .so, during the rearrangement of the remaining gluons [or during the formationof the 'B' lobe of the heterogenous compound nucleus] the remainging gluons, to be homogeneously distributed all around (or for balance) , rush from the equator to poles.

In this way, the loosely bonded remaining gluons separates from the lithium -6 nucleus giving us three particles- lithium -6 nucleus, $\Delta m/2$and $\Delta m/2$

Thus ,the heterogenous compound nucleus splits according to the lines perpendicular to the velocity of the compound nucleus into three paticles- one half of reduced mass ($\Delta m/2$) , lithium -6 nucleus and another half of the reduced mass ($\Delta m/2$).

The splitting of the heterogenous compound nucleus :-



The heterogenous compound nucleus splits into three particles – The one-half of the reduced mass, thelithium -6 nucleus (inside) and another half of the reduced mass.

Inherited velocity ($\overrightarrow{Vinh}$) of theparticles : -

Each particles thatisproduced due to splitting of the compound nucleus has an inherited velocity ($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

I . Inhereted velocity of thelithium-6 nucleus

$V_{inh} = V_{CN} = 0.3527 \times 10^7$ m/s

Components of the inherited velocity of the lithium-6 nucleus

1 $\overrightarrow{Vx}$ = $V_{inh} \cos \alpha$ $= V_{CN} \cos\alpha$ = 0.1763×10^7 m/s

2 $\overrightarrow{Vy}$ = $V_{inh} \cos\beta$ $= V_{CN} \cos \beta =$ 0.3054×10^7 m/s

3 $\overrightarrow{Vz}$ = $V_{inh} \cos y$ = $V_{CN} \cos y$ = 0 m/s

ii Inherited velocity of the each one-half of the reduced mass

$V_{inh} = V_{CN} = 0.3527 \times 10^7$ m/s

Propulsion of the particles

1.. Reduced mass

$\Delta m = [\ m_d + m_{he\text{-}4}\ ] - [\ m_{Li\text{-}6}\ ]$

$\Delta m = [2.01355 + 4.0015] – [\ 6.01347708\ ]$ amu

$\Delta m = [\ 6.01505\ ] – [6.01347708]$ amu

$\Delta m = 0.00157292$ amu

$\Delta m = 0.00157292 \times 1.6605 \times 10^{-27}$ kg

$\Delta m = 0.00261183366 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass .

$E_{inh} = ½\Delta m\, V^2 = ½\Delta m\, V^2_{CN}$

$V^2_{CN} = 0.1244082584 \times 10^{14}\ m^2/s^2$

$E_{inh} = ½ \times 0.00261183366 \times 10^{-27} \times 0.1244082584 \times 10^{14}$ J

$E_{inh} = 0.00016246683 \times 10^{-13}$ J

$E_{inh} = 0.000101$ Mev

$E_{Released} = \Delta mC^2$

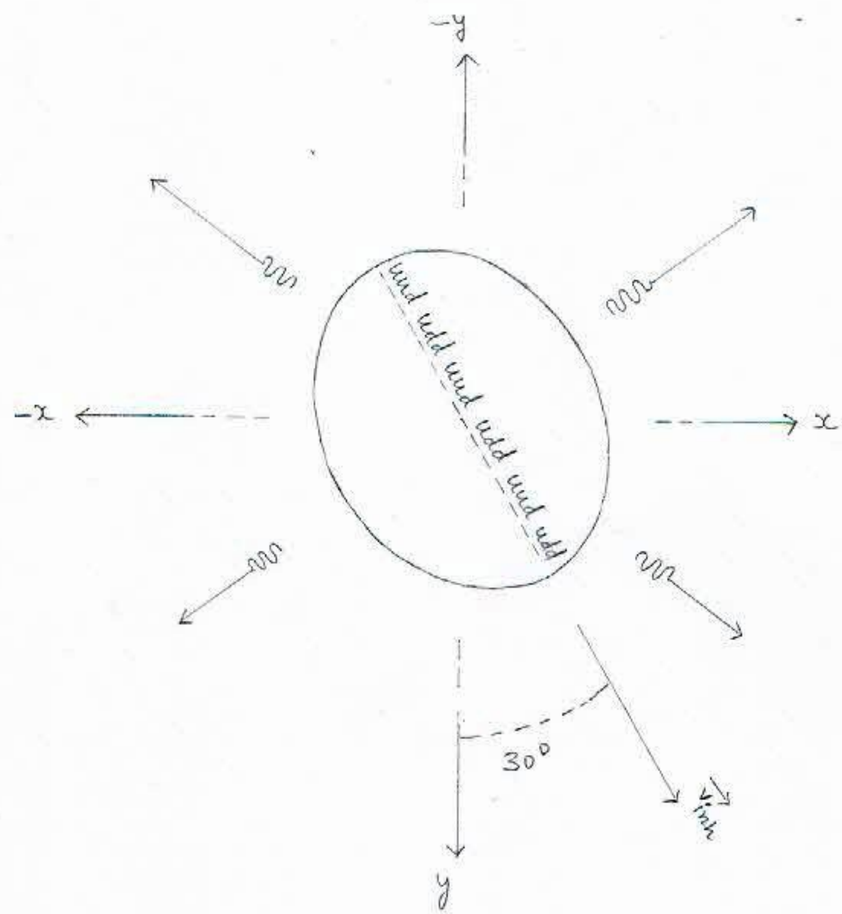
$= 0.00157292 \times 931$ Mev

$= 1.4643$ Mev

$E_{Total} = E_{Inherited} + E_{Released}$

$= [0.000101] + [1.4643\ ]$Mev

$= 1.464401$ Mev


-y
uud udd uud udd uud udd
-x
x
30°
y
→v inh

Components of the final velocity(Vf)of lithion-6 nucleus

I Forlithion-6

According to -	Inherited Velocity($\underset{\text{Vinh}}{\longrightarrow}$)	Increased Velocity($\underset{\text{Vinc}}{\longrightarrow}$)	Final velocity ($\overrightarrow{Vf}$) =($\underset{\text{Vinh}}{\longrightarrow}$+($\underset{\text{Vinc}}{\longrightarrow}$)
X – axis	$\underset{Vx}{\rightarrow}$= 0.1763 x$10^7$m/s	$\underset{Vx}{\rightarrow}$ = 0 m/s	$\underset{Vx}{\rightarrow}$ =0.1763x10^7m/s
y– axis	$\underset{Vy}{\rightarrow}$ = 0.3054x10^7m/s	$\underset{Vy}{\rightarrow}$= 0 m/s	$\underset{Vy}{\rightarrow}$ = 0.3054x10^7m/s
z – axis	$\underset{Vz}{\rightarrow}$ = 0 m/s	$\underset{Vz}{\rightarrow}$ = 0 m/s	$\underset{Vz}{\rightarrow}$ = 0 m/s

$\overrightarrow{Vf}$ =$\underset{\text{Vinh}}{\longrightarrow}$+$\underset{\text{Vcn}}{\longrightarrow}$ = 0.3527x10^7 m/s

Final velocity (vf) of the lithion-6 nucleus:-

=0.3527 m/s

Final kinetic energy of the lithion-6 nucleus

$E = ½\ m_{Li-6}V_f^2$

$V_f^2 = 0.1244082584x\ 10^{14} m^2/s^2$

$E = ½\ x\ 9.9853x\ 10^{-27}\ x0.1244082584x\ 10^{14} J$

= $0.6211268913\ X10^{-13}$ J

= 0.3882043 Mev

= 388.2043 Kev

$mLi\text{-}6\ V_f^2 = 9.9853x\ 10^{-27}\ x0.1244082584x\ 10^{14}$ J

= $1.2422\ x\ 10^{-13}$ J

Forces acting on thelithion-6 nucleus

1 F_y = q V_x B_z sin θ

$\underset{Vx}{\rightarrow}$= 0.1763 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= -1.001 x 10^{-1} Tesla

q= 3 x 1.6 x 10^{-19} c

sin θ = sin 90° = 1

Fy = 3 x 1.6 x 10^{-19}x0.1763x 10^7x 1.001x10^{-1} x 1 N

= 0.8470 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to(-) y-axis ,

so ,

$\underset{Fy}{\rightarrow}$= - 0.8470 x 10^{-13}N

2 F_z = q V_x B_y sinθ

$\underset{By}{\rightarrow}$= 1.0013x$10^{-1}$ Tesla

sin θ = sin 90° = 1

Fz = 3 x 1.6 x 10^{-19}x 0.1763 x 10^7 x 1.0013x10^{-1} x 1 N

= 0.8473 x 10^{-13} N

Form the right hand palm rule , thedirection of the force $\underset{Fz}{\rightarrow}$ is according to(-) Z- axis ,

so ,

$\underset{Fz}{\rightarrow}$ = - 0.8473 x 10^{-13}N

3 F_x = q V_y B_z sin θ

$\underset{Vy}{\rightarrow}$ =0.3054 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= -1.001x$10^{-1}$Tesla

sin θ = sin 90° = 1

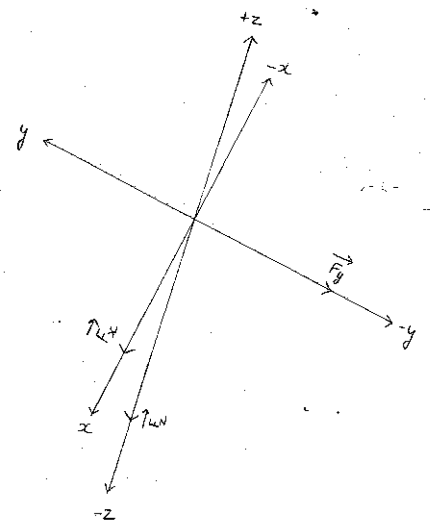
Fx =3 x 1.6 x 10^{-19} x 0.3054 x 10^7x 1.001 x 10^{-1} x 1 N

= 1.4673 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is according to(+) x axis ,

so,$\underset{Fx}{\rightarrow}$ = 1.4673x 10^{-13} N

The forces acting on the lithium - 6



Resultant force acting on the lithium- 6 (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 1.4673 \times 10^{-13}$ N

$F_y = 0.8470 \times 10^{-13}$ N

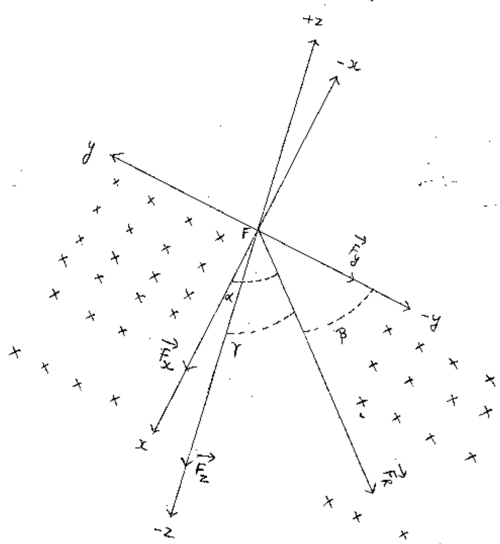
$F_z = 0.8473 \times 10^{-13}$ N

$F_R^2 = (1.4673 \text{ x } 10^{-13})^2 + (0.8470 \text{ x } 10^{-13})^2 + (0.8473 \text{ x } 10^{-13})^2 \quad N^2$

$F_R^2 = (2.15296929 \text{ x } 10^{-26}) + (0.717409 \text{ x } 10^{-26}) + (0.71791729 \text{ x } 10^{-26}) \ N^2$

$F_R^2 = 3.58829558 \text{ x } 10^{-26} \ N^2$

$F_R = 1.8942 \text{ x } 10^{-13} \ N$



The circular orbit followed by the lithion-6lies in the plane made up of positive x-axis, negative y-axis and the negative z-axis.

$\overrightarrow{Fr}$ = The resultant force .

The plane of the circular orbit followed by the lithium -6nucleus makes angles with positive x , y and z-axesas follows :-

1 withx- axis

$\text{Cos}\alpha = \underline{F_R \cos\alpha}\ /Fr = \underset{Fx}{\rightarrow} / F_r$

$\underset{Fx}{\rightarrow} = 1.4673 \times 10^{-13}$ N

$F_r = 1.8942 \times 10^{-13}$ N

Putting values

$\text{Cos}\ \alpha = 0.7746$

$\alpha = 39.23$degree [∴ cos (39.23) = 0.7746]

2 with y- axis

$\text{Cos}\ \beta = \underline{F_R \cos\beta}/ F_r = \underset{Fy}{\rightarrow} / F_r$

$\underset{Fy}{\rightarrow} = - 0.8470 \times 10^{-13}$ N

$F_r = 1.8942 \times 10^{-13}$ N

Putting values

$\text{Cos}\beta = - 0.4471$

$\beta = 243.44$ degree [∴ cos (243.44) = -0.4471]

3 with z- axis

$\text{Cos}\ y = \underline{F_R \cos y}/ F_r = \underset{Fz}{\rightarrow} / F_r$

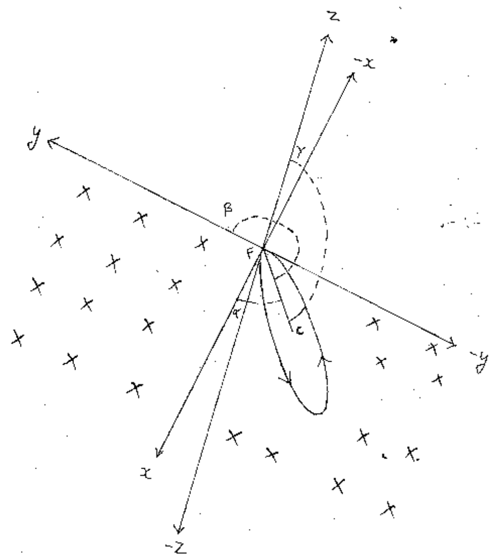
$\underset{Fz}{\rightarrow} = \underline{-0.8473 \times 10^{-13} N}$

$F_r = 1.8942 \times 10^{-13}$ N

Putting values

$\text{Cos}\ y = - 0.4473$

$y = 243.425$ degree



The planeof the circular orbit followed by confined lithium-6 nucleus makes angles with respect to positive x, y and z-axes.

Where,

α = 39.23 degree

β = 243.44 degree

Y = 243.425 degree

Radius of the circular orbit followed by the lithion-6 nucleus :

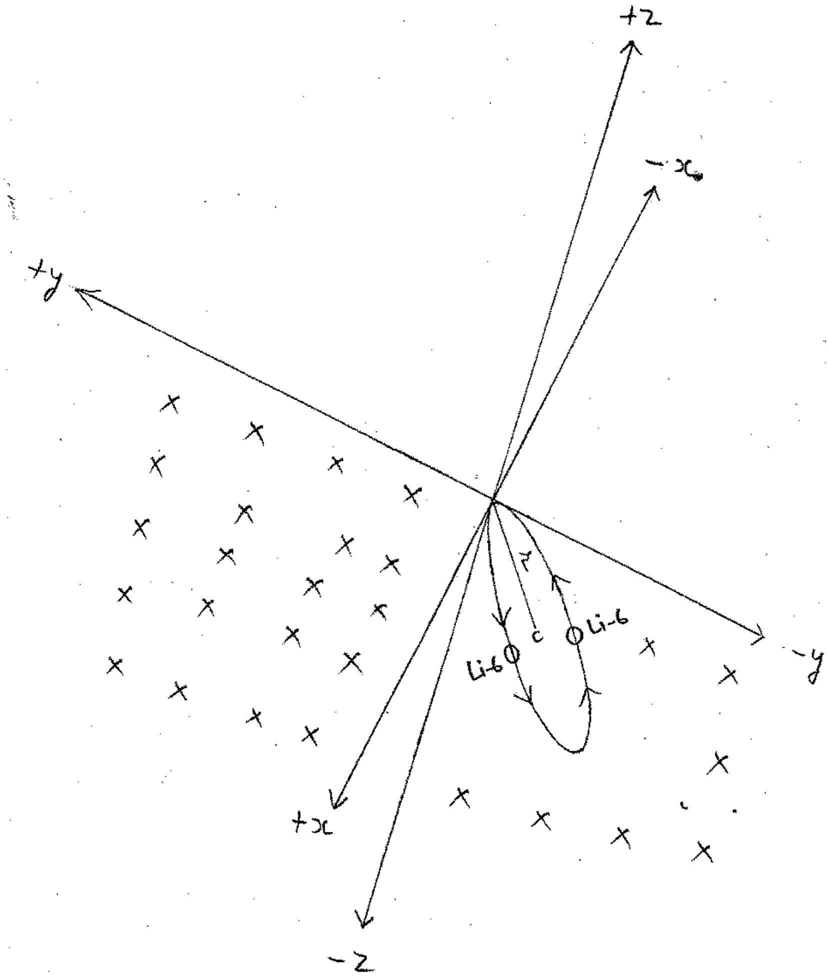
$r = mv^2 / F_R$

$mv^2 = 1.2422 \times 10^{-13}$ J

$F_r = 1.8942 \times 10^{-13}$ N

$$r = \frac{1.2422 \times 10^{-13} \text{ J}}{1.8942 \times 10^{-13} \text{ N}}$$

$r = 0.6557$ m


+z
-x
+y
-y
+x
-z
Li-6
Li-6
c
r

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2, y_2 , z_2) located on the circumference of the circle obtained by the lithium -6 nucleus.

$$\cos\alpha = \frac{x_2 - x_1}{d}$$

$d = 2 \times r$

$= 2 \times 0.6557$ m

$= 1.3114$ m

$\cos\alpha = 0.7746$

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 1.3114 \times 0.7746$ m

$x_2 - x_1 = 1.0158$ m

$x_2 = 1.0158$ m [$\therefore$ $x_1 = 0$]

$$\cos\beta = \frac{y_2 - y_1}{d}$$

$\cos\beta = -0.4472$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 1.3114 \times (-0.4471)$ m

$y_2 - y_1 = -0.5863$m

$y_2 = -0.5863$ m [$\therefore$ $y_1 = 0$]

$$\cos y = \frac{z_2 - z_1}{d}$$

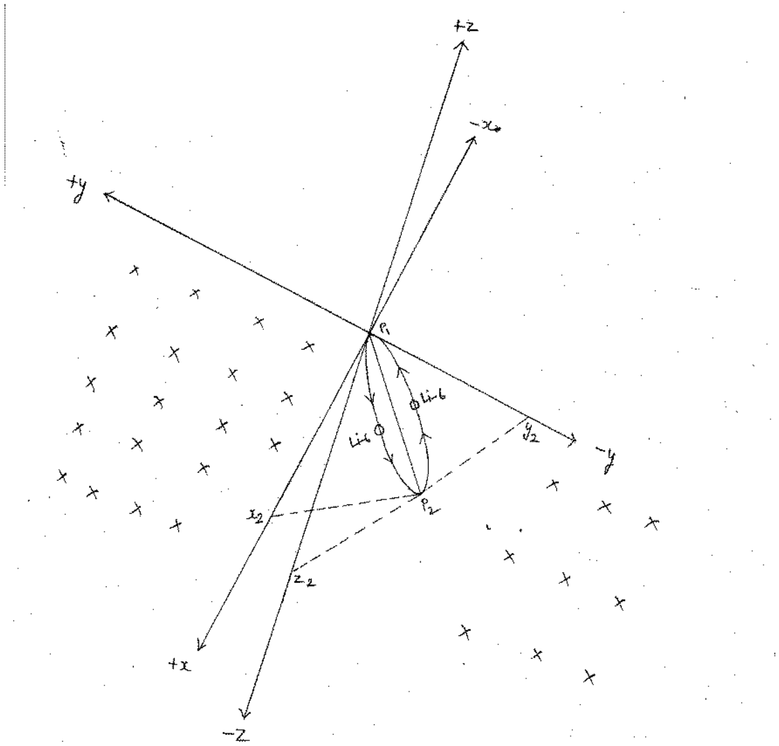
$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 1.3114 \times (-0.4473)$ m

$z_2 - z_1 = -0.5865$ m

$z_2 = -0.5865$ m [$\therefore$ $z_1 = 0$]



The cartesian coordinates of the point $p_1(x_1, y_1, z_1)$ and $p_2(x_2, y_2, z_2)$ located on the circumfrence of the circleobtained by the lithion -6 nucleus are as above shown .

The line ___ is the diameter of the circle .

P_1P_2

Conclusion :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the lithium-6 nucleusare along**+x , -y and -z** axes respectively .

So by seeing the direction ofthe resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit followed by the lithium-6 nucleus lies in the plane made up of positive x- axis, negative y-axisand negative z-axis where the magneticfields areapplied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the lithium-6 nucleus to undergo to a circular orbit of radius of 0.6557 m. It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.0158 m,-0.5863 m, -0.5865 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circle until it fuses with the confined deuteron or deuteron of later injected bunch (that reaches at point "F") at point "F"

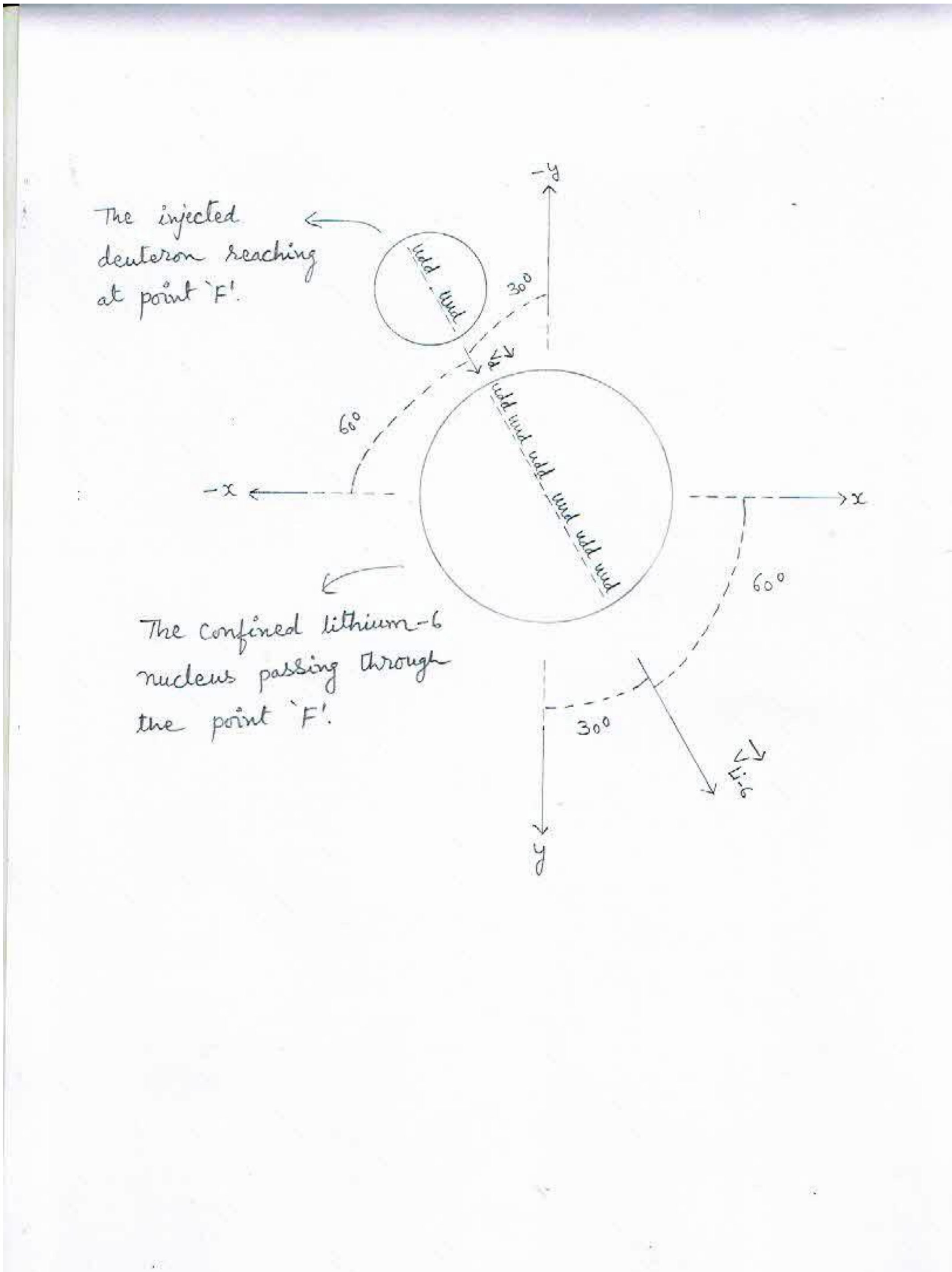
For fusion reaction

$^2{}_1H + {}^6{}_3 Li \rightarrow [{}_4{}^8Be] \rightarrow {}_3{}^7 Li + {}^1{}_1 H$

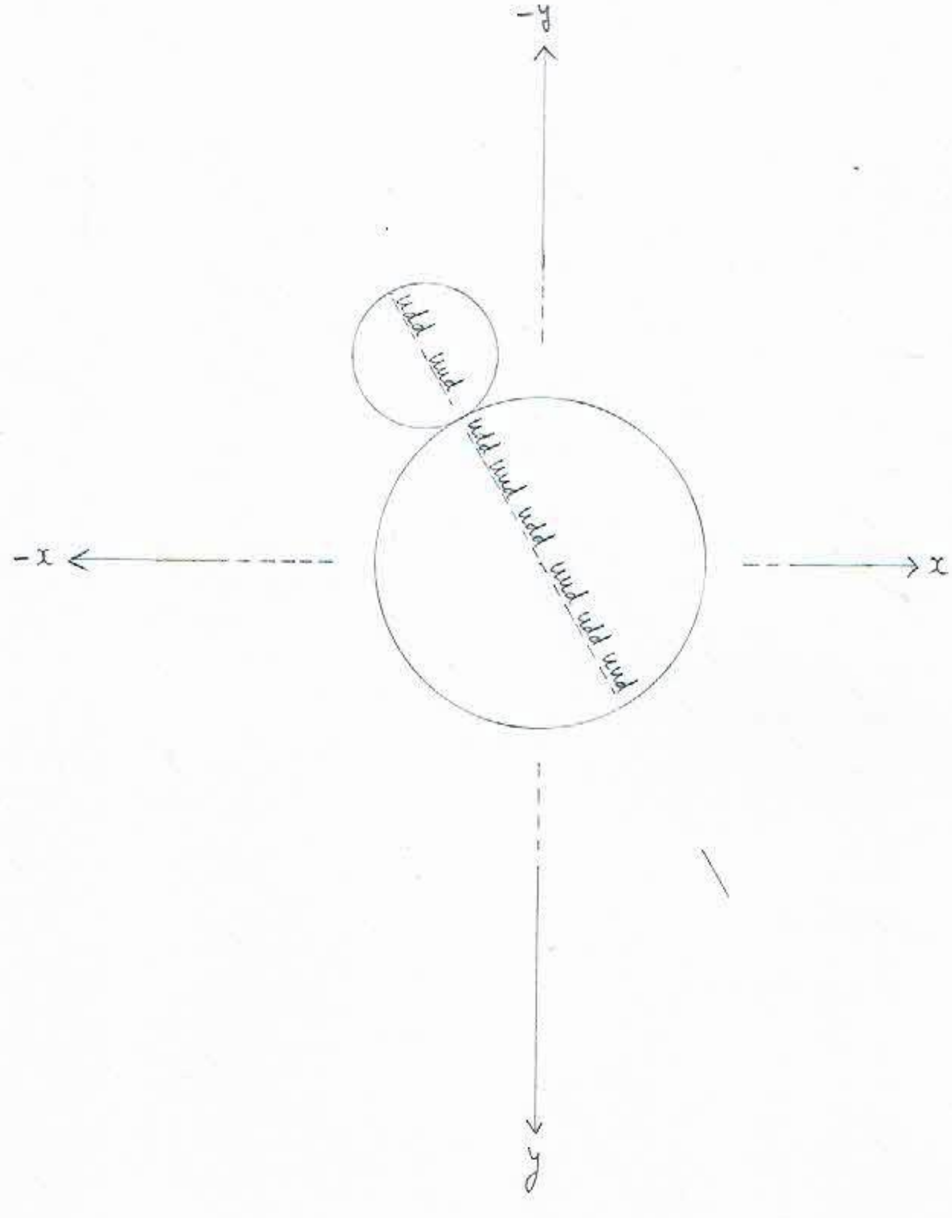
The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6] with the confined lithion-6 passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6.

Interaction of nuclei (1)



Interaction of nuclei (2)

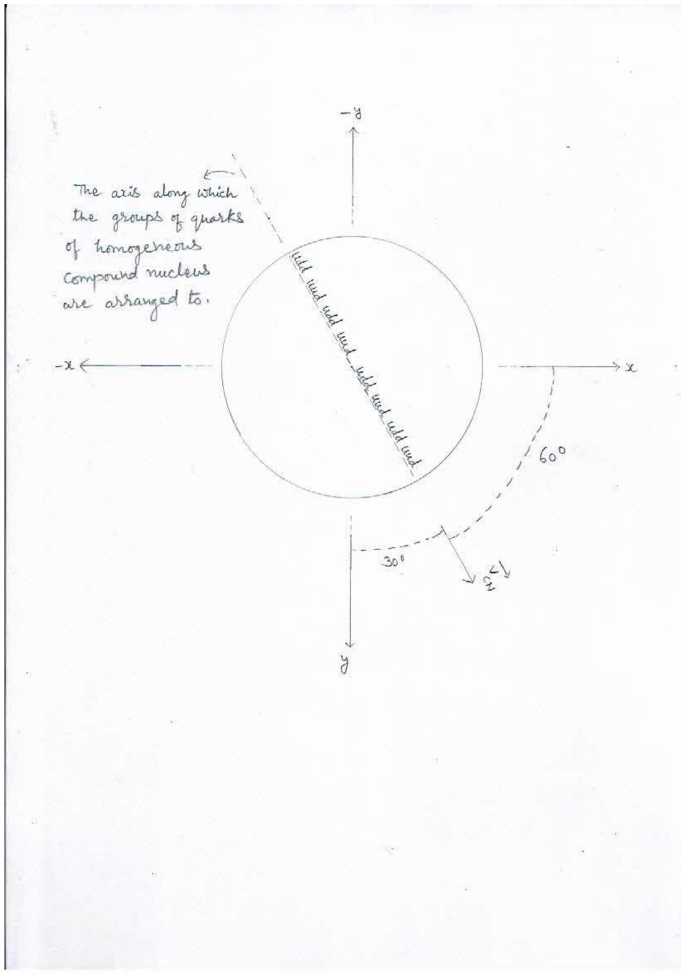

-y
-x
x
y
udd uud
udd uud udd uud udd uud

.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron and the lithion-6 nucleus) behave like a liquid and form a homogeneous compound nucleus . having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 8 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3 . Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the lithion-7) than the reactant one (the lithion-6) includes the other three (nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

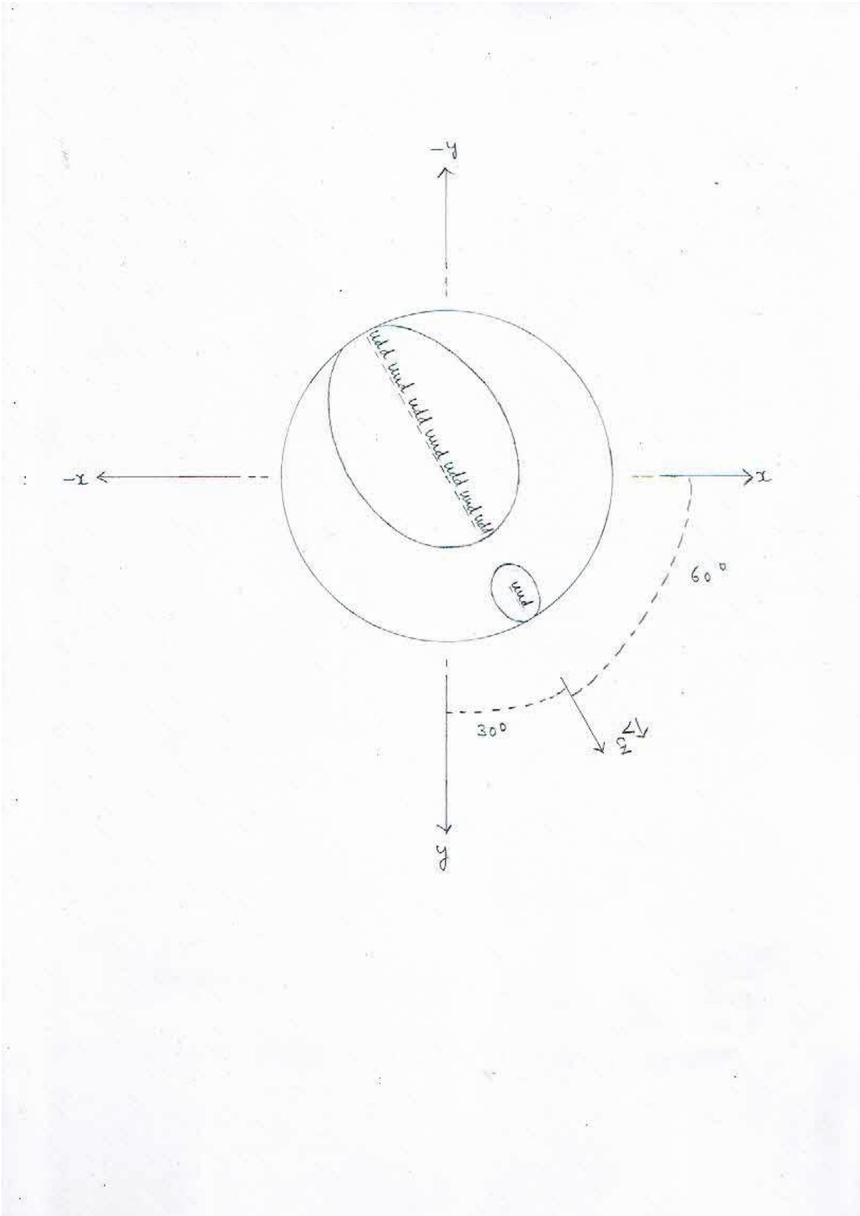
While , the remaing groups of quarks to become a stable nucleus (the proton) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the lithion-7 nucleus and the smaller nucleus is the proton.

The greater nucleus is the lobe ‘A ‘ and the smaller nucleus is the lobe ‘B’ while the remainigh space represent the remaining gluons .



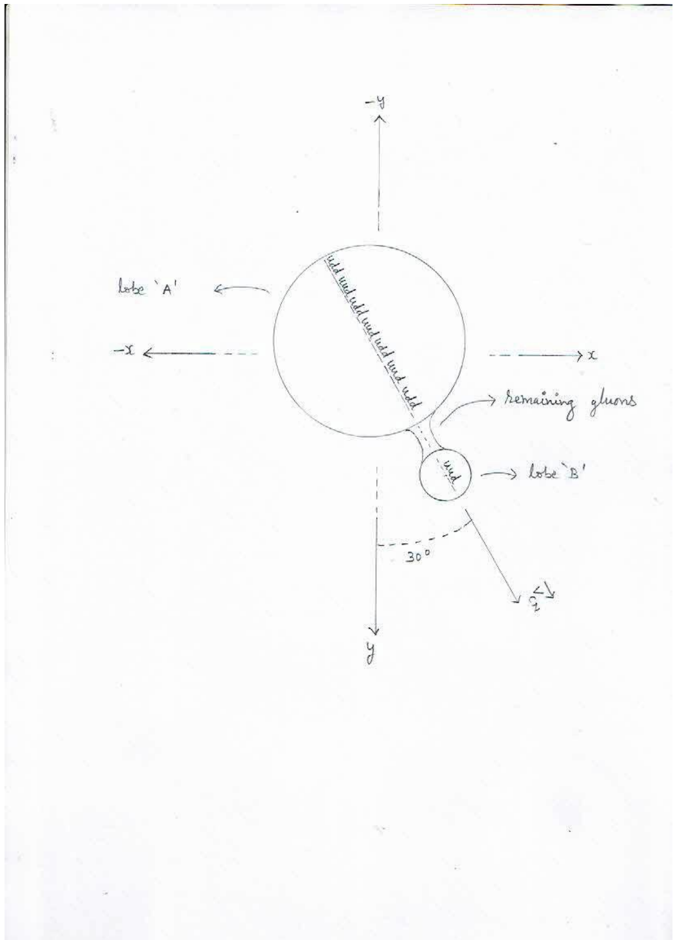
Formaton of lobes

4..Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

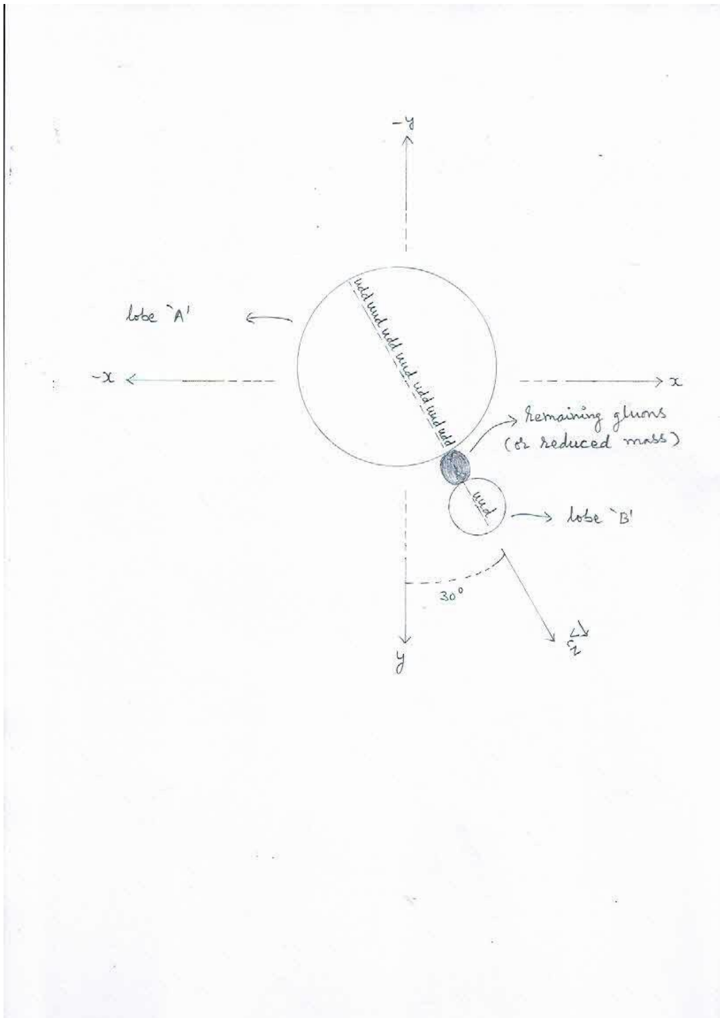
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degrees

β = 30 degrees



Final stage of the heterogenous compound nucleus

where, α = 60 degrees

β = 30 degrees

Formation of compound nucleus :

As the deuteron of n^{th} bunch reaches at point F , it fuses with the confined lithion-6 to form a compund nucleus .

1.Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 45.5598 kev

= 108.0402 kev

= 0.1080402 Mev

2.Just before fusion, to overcome the electrostatic repulsive force exerted by the deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves its energy equal to 136.0700kev.

so, just before fusion,
the kinetic energy of hellion-4 is –
E_b = 388.2043 kev – 136.0700 kev
= 252.1343 kev
= 0.2521343 Mev
Kinetic energy of the compound nucleus :-

K.E. =[E_b of deuteron] + [E_b of lithion-6]

= [108.0402Kev] +[252.1343 Kev]

= 360.1745 Kev.

= 0.3601745 Mev

Mass of the compound nucleus

$M = m_d + m_{Li-6}$

= [3.3434x10^{-27} Kg] +[9.9853 x 10^{-27} Kg]

= 13.3287 x 10^{-27} Kg

Velocity of compound nucleus
K.E. = ½ MV^2_{CN} = 0.3601745Mev

$$V_{CN} = \left[\frac{2 \times 0.3601745 \times 1.6 \times 10^{-13}}{13.3287 \times 10^{-27}\ \text{kg}}\right]^{1/2} \text{ m/s}$$

$$V_{CN} = \left(\frac{1.1525584 \times 10^{-13}}{13.3287 \times 10^{-27}} \right)^{½} m/s$$

V_{CN}= [0.08647192899 x 10^{14}] ^{½} m/s

V_{CN} = 0.2940 x 10^{7}m/s

Components of velocity of compound nucleus

$\overrightarrow{Vx}$ = V_{CN}cos α

=0.2940 X 10^{7}X0.5 m/s

= 0.1470 X 10^{7} m/s

$\overrightarrow{Vy}$ = V_{CN} cos β

= 0.2940X 10^{7}X0.866 m/s

= 0.2546 m/s

$\overrightarrow{Vz}$ = V_{CN} cosy

= 0.2940 X 10^{7}X0 m/s

= 0 m/s

The splitting of the heterogeneous compound nucleus : -

Theheterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – lithion-7 the proton and the reducedmass (Δm) .

Out of them , the two particles (the lithion-7 and protron) are stable while the third one (reduced mass) is unstable .

According to the law of inertia ,each particle that is produced due to splitting of the compound nucleus , has an inherited velocity ($\underrightarrow{Vinh}$) equal to the velocityof the compoundnucleus($\overrightarrow{Vcn}$) .

So,for conservation of momentum

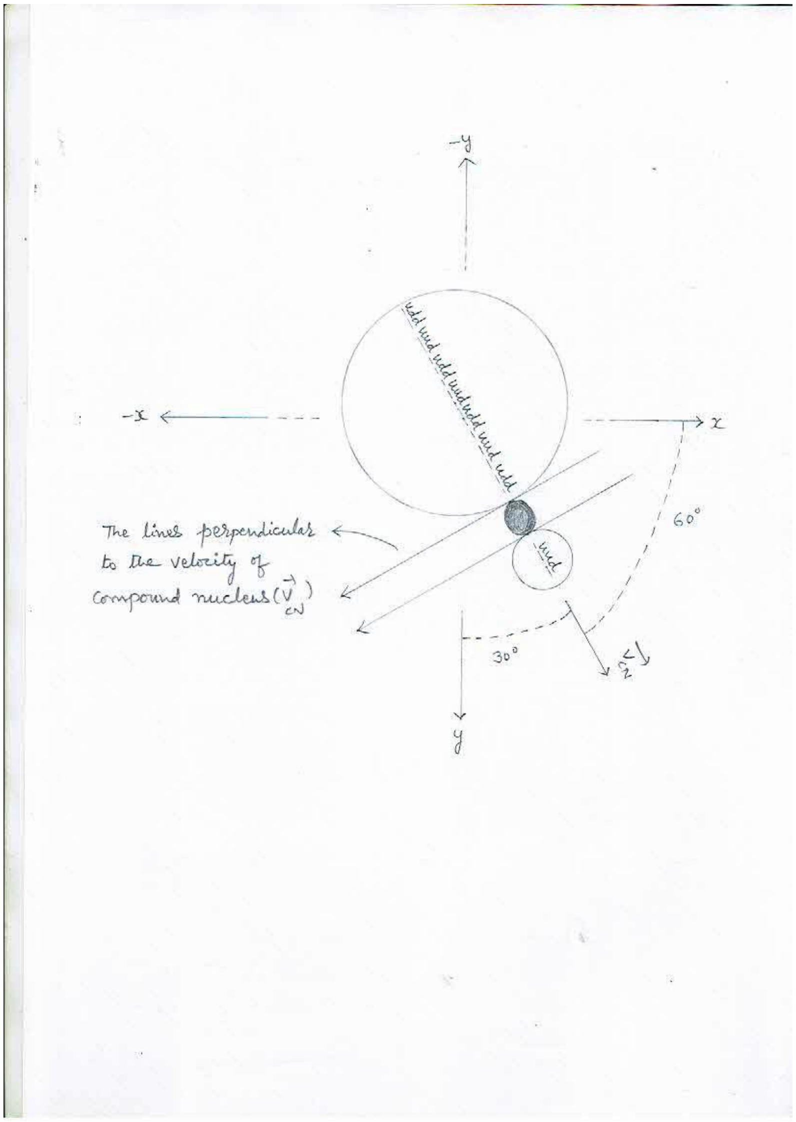
$M\overrightarrow{Vcn} = (m_{Li-7} + \Delta m + m_p)\overrightarrow{Vcn}$

Where ,

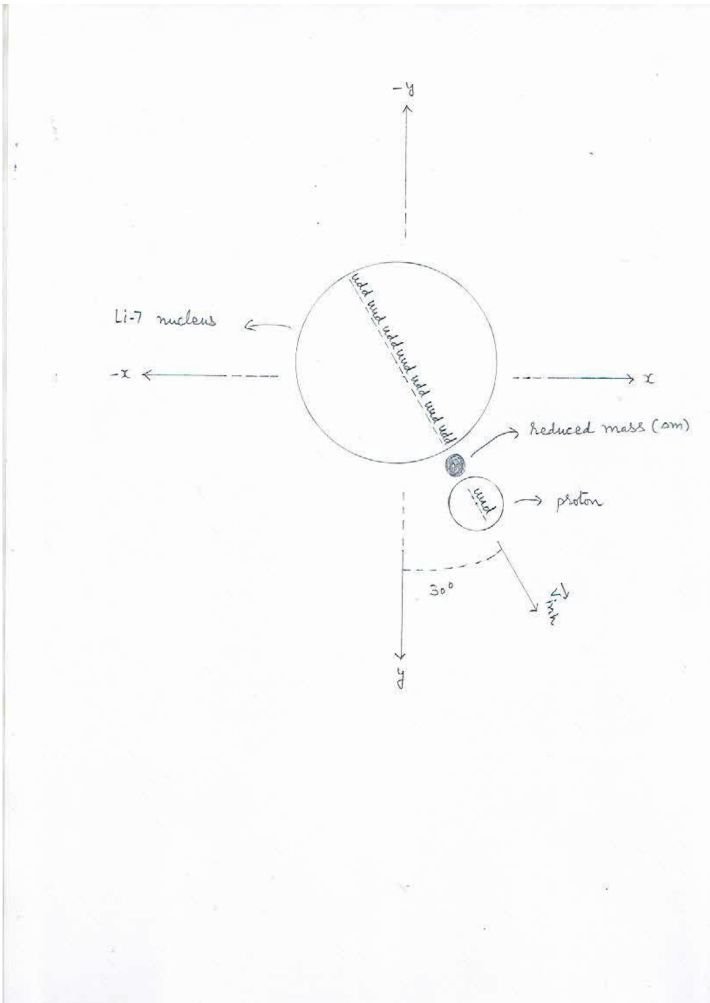
M	= mass ofthe compound nucleus
$\overrightarrow{Vcn}$	= velocity of the compound nucleus
M_{Li-7}	= mass of the lithion-7 nucleus
Δm	= reducedmass
m_p	= mass of the proton

The splitting of the heterogenous compound nucleus

The heterogenous compound nucleus to show the lines perpendicular to the$\overrightarrow{Vcn}$



The splitting of the heterogenous compound nucleus



Inherited velocity of the particles (s) : -

Each particle that isproduced dueto splitting of compound nucleushas an inherited velocity ($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

I . Inhereted velocityof the particle lithion -7

V_{inh} = V_{CN} = 0.2940 x 10^7m/s

Components of the inherited velocity of the particle lithion -7

1 $\overrightarrow{V_x}$ =V_{inh} cos α= V_{CN}cos α= 0.1470x 10^7m/s

2 $\overrightarrow{V_y}$ = V_{inh} cos β = V_{CN}cos β= 0.2546 x 10^7m/s

3 $\overrightarrow{V_z}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

II . Inheritedvelocity of the proton

V_{inh} = V_{CN} = 0.2940 x10^7 m/s

Components ofthe inherited velocity of the proton

1 $\overrightarrow{V_x}$ = V_{inh} cos α= V_{CN}cos α= 0.1470x 10^7m/s

2 $\overrightarrow{V_y}$ = V_{inh} cos β = V_{CN}cos β= 0.2546 x 10^7m/s

3 $\overrightarrow{V_z}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

iii Inherited velocity of the reduced mass

V_{inh} = V_{CN} = 0.2940 x 10^7 m/s

Propulsion of the particles

Reduced mass converts into energy and total energy (E_T) propel both the particles with equal and opposite momentum.

Reduced mass
Δm = [m_d+m_{Li-6}] - [$m_{Li-7+}$$m_p$]
Δm = [2.01355 + 6.01347708]– [7.01435884 + 1.007276] amu
Δm = [8.02702708] – [8.02163484] amu
Δm = 0.00539224 amu
Δm = 0.00539224 x 1.6605 x 10^{-27} kg

The Inherited kinetic energy of reduced mass (Δm) .

$E_{inh} = ½\Delta m\, V^2_{CN}$

$\Delta m = 0.00539224 \times 1.6605 \times 10^{-27}$ kg

$V^2_{CN} = 0.08647192899 \times 10^{14}$

$E_{inh} = ½ \times 0.00539224 \times 1.6605 \times 10^{-27} \times 0.08647192899 \times 10^{14}$ J

$E_{inh} = 0.0003871268 \times 10^{-13}$ J

$E_{inh} = 0.000241$ Mev

Released energy (E_R)

$E_R = \Delta mc^2$

E_R 0.00539224 x 931 Mev

$E_R = 5.020175$ Mev

Total energy (E_T)

$E_T = E_{inh} + E_R$

$E_T = [0.000241 + 5.020175]$ Mev

$E_T = 5.020416$ Mev

Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles ininverse proportion to their masses. so,the increased energy (E_{inc}) of the particles :-

1.. For lithion-7

$$E_{inc} = \frac{m_p}{m_p + m_{Li\text{-}7}} \times E_T$$

$$E_{inc} = \frac{1.007276 \text{ amu}}{[\,1.007276 + 7.01435884\,] \text{ amu}} \times 5.020416 \text{ Mev}$$

$$E_{inc} = \frac{1.007276}{8.02163484} \times 5.020416 \text{ Mev}$$

$$E_{inc} = 0.12556991437 \times 5.020416 \text{ Mev}$$

$$E_{inc} = 0.630413 \text{ Mev}$$

2..increased energy of the proton

E_{inc} = [E_T] - [increased energy of the Li-7]

E_{inc} = [5.020416] - [0.630413] Mev

E_{inc} = 4.390003 Mev

6..Increased velocity of the particles .

(1) For proton

$E_{inc} = {}^{1}/_{2} m_p \; v_{inc}^2$

$V_{inc} = [\, 2 \times E_{inc}/m_p \,]^{1/2}$

$$= \left(\frac{2x\ 4.390003\ x1.6x10^{-13}\ J}{1.6726\ x10^{-27}\ kg} \right)^{1/2} m/s$$

$$= \left(\frac{14.0480096x10^{-13}}{1.6726x10^{-27}} \right)^{1/2} m/s$$

$$= [\ 8.39890565586 \times 10^{14}\ ]^{1/2}\ m/s$$

$$= 2.8980 \times 10^{7}\ m/s$$

(2) For lithium-7

$V_{inc} = [\, 2 \times E_{inc} / m_{He-4} \,]^{1/2}$

$$= \left(\frac{2x\ 0.630413\ x1.6x10^{-13}\ J}{11.6473 \times 10^{-27}\ kg} \right)^{1/2}$$

$$= \left(\frac{2.0173216x\ 10^{-13}}{11.6473\ x10^{-27}} \right)^{1/2} m/s$$

= [$0.17320079331 \times 10^{14}$] ^{½} m/s

= 0.4161×10^{7} m/s

7 Angle of propulsion

1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

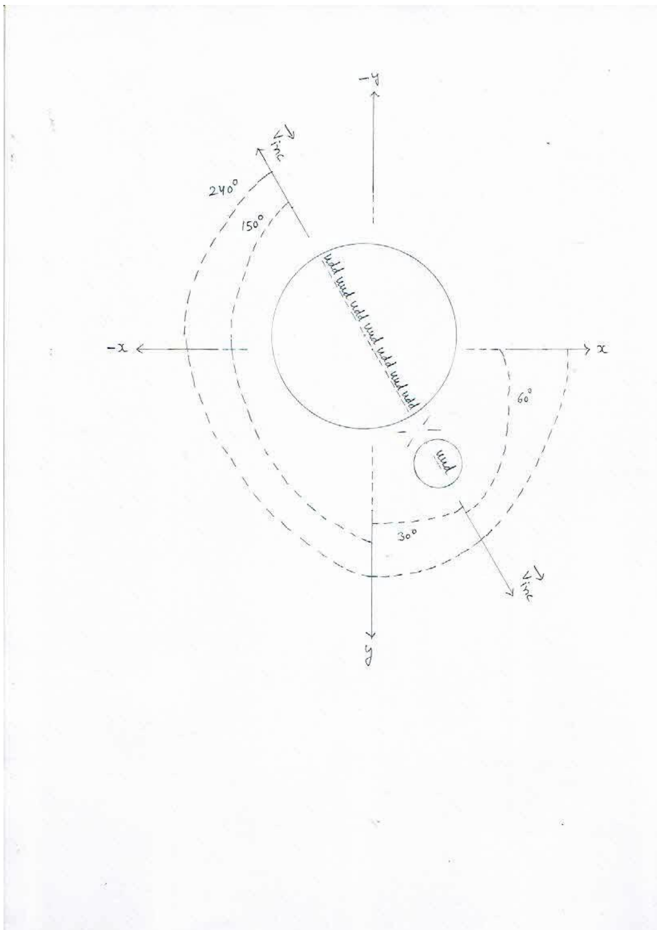
2. We know that when there a fusion processoccurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ' F ' , as V_{CN} makes 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

so, the proton is propelled making 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

While the lithion-7 is propelled making 240° angle with x-axis , 150° angle with y-axis and 90° angle with z-axis .

propulsion of thte particles



Components of the increased velocity (V_{inc}) of the particles.

(i) For lithion-7

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = $0.4161 x 10^7$ m/s

cos α = cos (240) = -0.5

$\underset{Vx}{\rightarrow}$= $0.4161 x 10^7$ x (-0.5) m/s

= $-0.2080 x 10^7$m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β= cos (150) = - 0.866

$\underset{Vy}{\rightarrow}$ = $0.4161 x10^7$ x (- 0.866) m/s

= - $0.3603x 10^7$ m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

Cos y =cos 90^o= 0

$\underset{Vz}{\rightarrow}$ = $0.4161x 10^7$x 0 m/s

= 0 m/s

(II) For proton

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc}= $2.8980x 10^7$ m/s

cos α= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$ = $2.8980x10^7$ x 0.5 m/s

=$1.4490 x 10^7$ m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β = cos (30) = 0.866

$\underset{Vy}{\rightarrow}$= $2.8980 x10^7$ x 0.866m/s

= $2.5096x 10^7$m/s

3 $\underset{Vz}{\rightarrow}$= V_{inc} cosy

cos y= cos (90) = 0

$\underset{Vz}{\rightarrow}$Vz =$2.8980x 10^7$x 0 m/s

= 0 m/s

9.. Components of the finalvelocity (Vf)of the particles

IFor lithion-7

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity ($\overrightarrow{Vf}$) =($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X – axis	$\overrightarrow{Vx}$= 0.1470 x 10^7m/s	$\overrightarrow{Vx}$= -0.2080x 10^7m/s	$\overrightarrow{Vx}$= - 0.061x10^7m/s
y – axis	$\overrightarrow{Vy}$=0.2546 x 10^7m/s	$\overrightarrow{Vy}$ = - 0.3603x 10^7m/s	$\overrightarrow{Vy}$=- 0.1057x10^7m/s
z –axis	$\overrightarrow{Vz}$ =0m/s	$\overrightarrow{Vz}$ = 0m/s	$\overrightarrow{Vz}$=0 m/s

2..Forproton

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$) =($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)

X –axis	$\vec{V_x}$= 0.1470 x10^7m/s	$\vec{V_x}$ = 1.4490 x10^7m/s	$\vec{V_x}$ =1.5960x10^7m/s
y– axis	$\vec{V_y}$=0.2546 x10^7m/s	$\vec{V_y}$ = 2.5096 x10^7m/s	$\vec{V_y}$=2.7642 x10^7m/s
z –axis	$\vec{V_z}$= 0 m/s	$\vec{V_z}$ = 0 m/s	$\vec{V_z}$ =0 m/s

10.. Final velocity (vf) of thelithion-7

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.061 X10^7$ m/s

$V_y = 0.1057X10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.061X10^7)^2 + (0.1057X10^7)^2 + (0)^2$ m^2/s^2

$V_f^2 = (0.003721 X10^{14}) + (0.01117249X10^{14}) + 0$ m^2/s^2

$V_f^2 = 0.01489349 X10^{14}$ m^2/s^2

$V_f = 0.1220x10^7$ m/s

Final kinetic energy of the lithion-7

$E = ½ m_{Li-7}V_f^2$

$E = ½ x 11.6473x 10^{-27} x 0.01489349 X10^{14}$ J

$= 0.08673447303 X 10^{-13}$ J

= 0.054209 Mev

$m_{Li-7}V_f^2 = 11.6473x 10^{-27} x 0.01489349 X10^{14}$ J

$= 0.1734 x 10^{-13}$ J

10.. Final velocity (vf) of the proton

$V_f^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 1.5960 \text{ X } 10^7 m/s$

$V_y = 2.7642 \text{X } 10^7 \text{ m/s}$

$V_z = 0 \text{ m/s}$

$V_f^2 = (1.5960 \text{ X } 10^7)^2 + (2.7642 \text{X } 10^7)^2 + (0)^2 \text{ m}^2/s^2$
$V_f^2 = (2.547216 \text{ X } 10^{14}) + (7.64080164 \text{ X } 10^{14}) + 0 \text{ m}^2/s^2$
$V_f^2 = 10.18801764 \text{ X } 10^{14} \text{ m}^2/s^2$
$V_f = 3.1918 \text{ x} 10^7 \text{ m/s}$

Final kinetic energy of the proton

$E = ½ \, m_p V_f^2$

$V_f^2 = 10.18801764 \text{X } 10^{14} \text{ m}^2/s^2$

$E = ½ \text{ x } 1.6726 \text{x } 10^{-27} \text{ x } 10.18801764 \text{ X } 10^{14} \text{ J}$

$= 8.5202391523 \text{ X} 10^{-13} \text{J}$

= 5.3251 Mev

$M_p V_f^2 = 1.6726 \text{x } 10^{-27} \text{ x } 10.18801764 \text{ X } 10^{14} \text{J}$

$= 17.0404 \text{ x } 10^{-13} \text{ J}$

Forces acting on the lithion-7 nucleus

1 F_y = q V_x $B_z$sin θ

$\underset{Vx}{\rightarrow}$ = -0.061 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= -1.001 x$10^{-1}$ Tesla

q= 3 x 1.6 x 10^{-19} c

sin θ = sin 90^o = 1

Fy = 3x1.6 x 10^{-19}x 0.061 x 10^7 x 1.001x10^{-1}x 1 N
= 0.2930x 10^{-13} N

Form the right hand palmrule , thedirection of the force$\underset{Fy}{\rightarrow}$ is according to (+) y-axis ,

so ,
$\underset{Fy}{\rightarrow}$= 0.2930 x$10^{-13}$ N

2 F_z = q V_x B_y sin θ

$\underset{By}{\rightarrow}$= 1.0013 x$10^{-1}$Tesla

sin θ = sin 90^o = 1

Fz = 3 x 1.6 x 10^{-19} x 0.061 x 10^7 x 1.0013 x10^{-1} x 1 N
= 0.2931 x 10^{-13} N

Form the right hand palm rule, thedirection ofthe force$\underset{Fz}{\rightarrow}$ is according to(+) Z- axis ,

so ,
$\underset{Fz}{\rightarrow}$ = 0.2931 x 10^{-13}N

3 F_x = q V_y B_z sin θ

$\underset{Vy}{\rightarrow}$ = -0.1057 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= 1.001x$10^{-1}$ Tesla

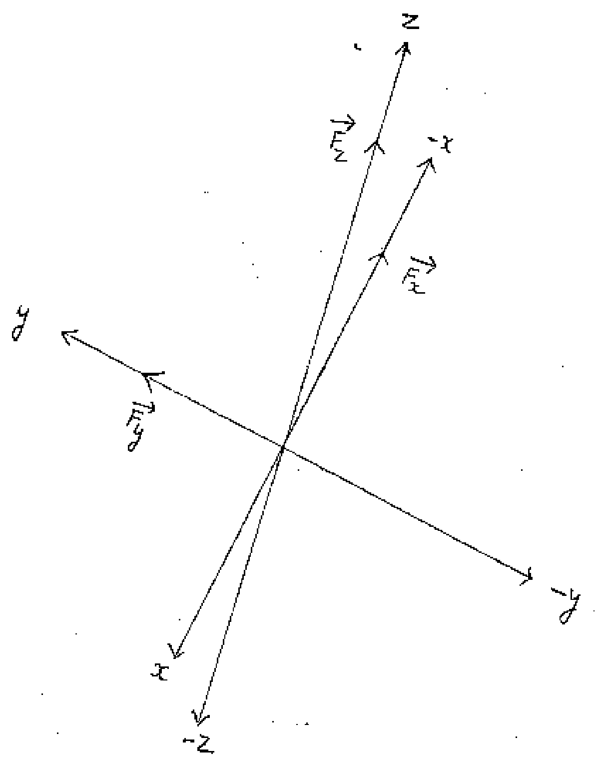
sin θ = sin 90^o = 1

Fx = 3x1.6 x 10^{-19}x 0.1057 x 10^7x 1.001x10^{-1} x 1 N
= 0.5078 x 10^{-13} N

Form the right hand palm rule , the direction of the force$\underset{Fx}{\rightarrow}$ is according to (-) x axis ,

so ,$\underset{Fx}{\rightarrow}$ = - 0.5078 x 10^{-13}N

Forces acting on the lithion-7



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 0.5078 \times 10^{-13}$ N

$F_y = 0.2930$

$F_z = 0.2931 \times 10^{-13}$ N

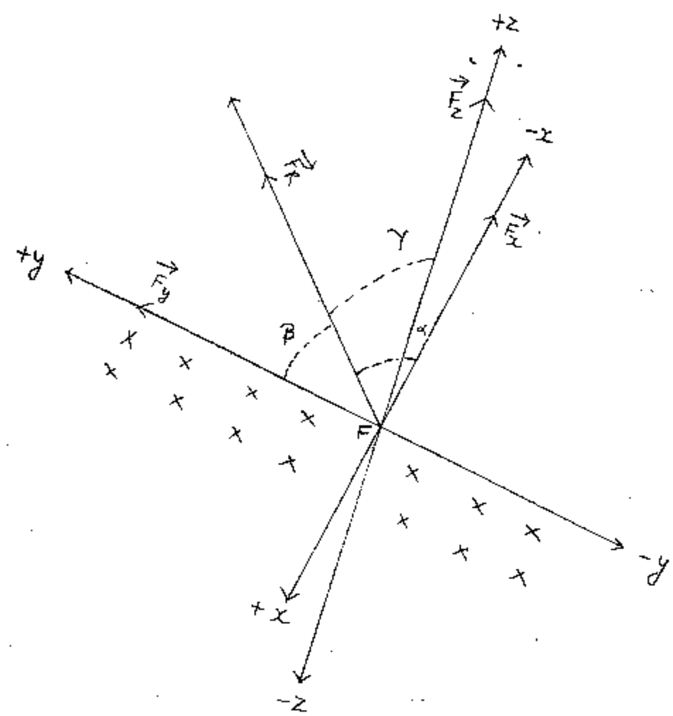
$F_R^2 = (0.5078 \times 10^{-13})^2 + (0.2930 \times 10^{-13})^2 + (0.2931)$ N^2

$F_R^2 = (0.25786084 \times 10^{-26}) + (0.085849 \times 10^{-26}) + (0.08590761)$ N^2

$F_R^2 = 0.42961745 \times 10^{-26}$ N^2

$F_R = 0.6554 \times 10^{-13}$ N

Resultant force acting on the lithium-7



Radius of the circular orbitto be followed by the lithion-7 :

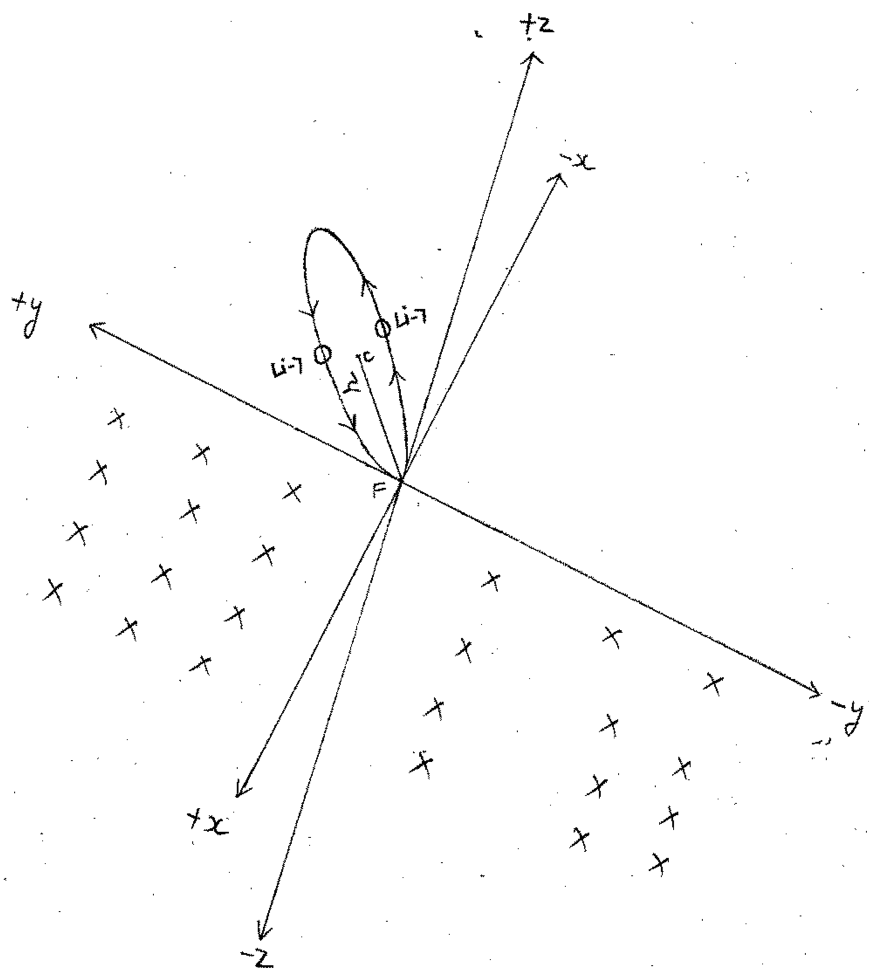
$r = mv^2 / F_R$

$mv^2 = 0.1734 \times 10^{-13}$ J

$F_r = 0.6554 \times 10^{-13}$ N

$$r = \frac{0.1734 \times 10^{-13} J}{0.6554 \times 10^{-13} N}$$

$r = 0.2645$ m


+z
-x
+y
Li-7
Li-7
F
-y
+x
-z

The circular orbit to be followed by the lithion -7lies in the plane made up of negative x-axis, pisitive y-axis and the positive z-axis.

The plane of the circular orbit to be followed by the lithion -7 makes angles with positive x , y and z-axesas follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr = $\vec{F_x}$ / F_r

$\vec{F_x}$ = -0.5078x 10^{-13} N

F_r= 0.6554 x 10^{-13} N

Puttingvalues

Cosα = - 0.7747

α= 219.22 degree [∴ cos (219.22) = -0.7747]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / F_r= $\vec{F_y}$ /F_r

$\vec{F_y}$ = 0.2930 x 10^{-13} N

F_r = 0.6554 x 10^{-13}N

Putting values

Cos β = 0.4470

β = degree [∴ cos ( ) =]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ F_r= $\vec{F_z}$ / F_r

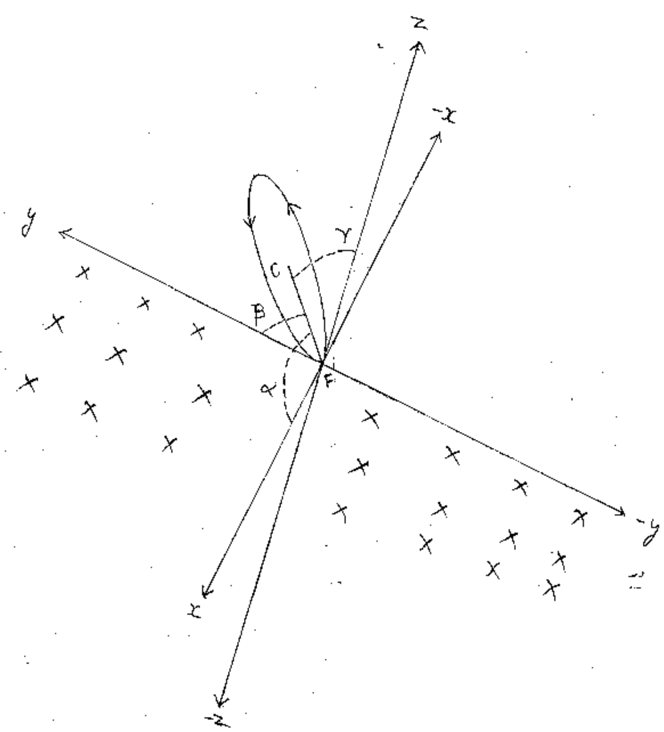
$\vec{F_z}$ = $\underline{0.2931 \times 10^{-13} N}$

F_r = = 0.6554 x 10^{-13} N

Putting values

Cos y = 0.4472
y = 63.43 degree

Plane of the circular orbit to be followed by the lithium -7 nucleus makes angleswith positive x , y , and z axes are as follows :-



Where,

α = 219.22 degree

β =degree

Y = 63.43 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2, y_2 , z_2) located on the circumference of the circle to be obtained by the lithion-7.

$\cos\alpha = \frac{x_2 - x_1}{d}$

$d = 2 \times r$

$= 2 \times 0.2645$ m

$= 0.529$ m

$\cos\alpha = -0.7747$

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 0.529 \times (-0.7747)$ m

$x_2 - x_1 = -0.4098$ m

$x_2 = -0.4098$m $[\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = 0.4470$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 0.529 \times 0.4470$m

$y_2 - y_1 = 0.2364$m

$y_2 = 0.2364$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = 0.4472$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 0.529 \times 0.4472$m

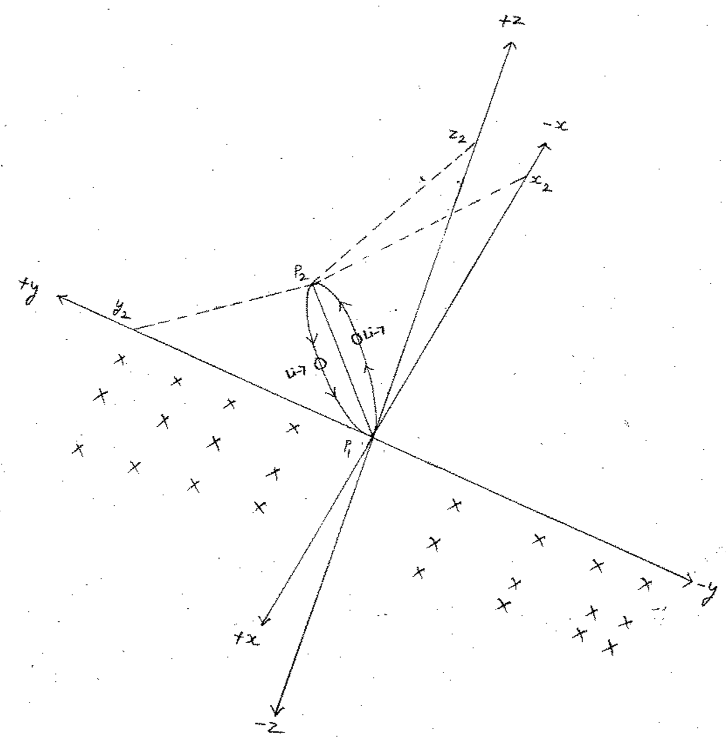
$z_2 - z_1 = 0.2365$ m

$z_2 = 0.2365$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point $p_1 (x_1, y_1, z_1)$ and $p_2 (x_2, y_2, z_2)$ located on the circumfrence of the circle to beobtainedby the lithion -7 are as shown below.

The line ___ is the diameter of the circle .

P_1P_2



Conclusion :-

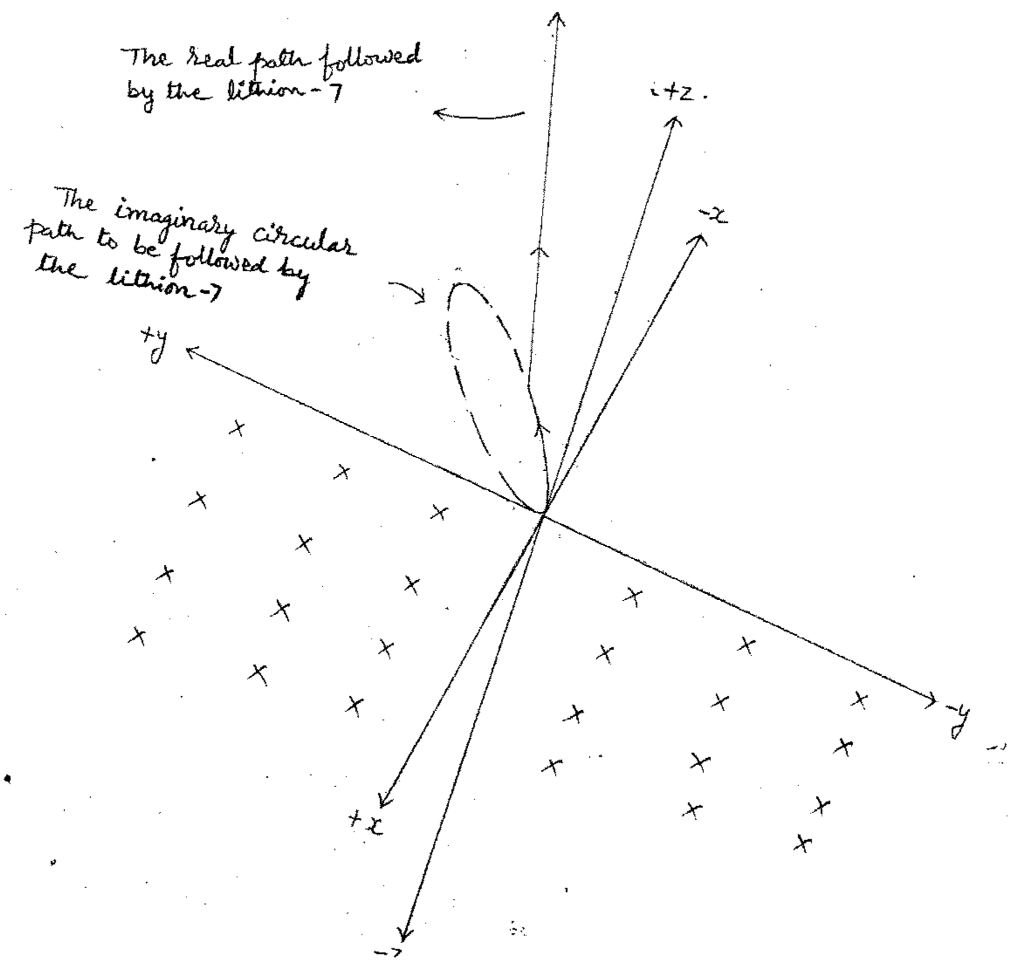
Thedirections components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ ofthe resultant force$(\underset{Fr}{\rightarrow})$that are acting on the lithium-7 nucleus are along **-x , +y and +z** axes respectively .

So by seeing the direction ofthe resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the lithium-7 nucleus to undergo to a circular orbit of radius 0.2645 m. It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.4098 m,0.2364 m,0.2365 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

So the lithium-7 nucleus is not confined.



Forces acting on the proton

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow} = 1.5960 \times 10^{7}$ m/s $\underset{Bz}{\rightarrow} = -1.001 \times 10^{-1}$ Tesla

$q = 1.6 \times 10^{-19}$ c

$\sin\theta = \sin 90^{o} = 1$

$Fy = 1.6 \times 10^{-19} \times 1.5960 \times 10^{7} \times 1.001 \times 10^{-1} \times 1$ N

$= 2.5561 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (-) y-axis ,

so,

$\underset{Fy}{\rightarrow} = -2.5561 \times 10^{-13}$ N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow} = 1.0013 \times 10^{-1}$Tesla

$\sin\theta = \sin 90^{o} = 1$

$Fz = 1.6 \times 10^{-19} \times 1.5960 \times 10^{7} \times 1.0013 \times 10^{-1} \times 1$ N

$= 2.5569 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fz}{\rightarrow}$ is according to (-) Z-axis ,

so ,

$\underset{Fz}{\rightarrow} = -2.5569 \times 10^{-13}$N

3 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow} = 2.7642 \times 10^{7}$ m/s

$\underset{Bz}{\rightarrow} = -1.001 \times 10^{-1}$Tesla

$\sin\theta = \sin 90^{o} = 1$

$Fx = 1.6 \times 10^{-19} \times 2.7642 \times 10^{7} \times 1.001 \times 10^{-1} \times 1$ N

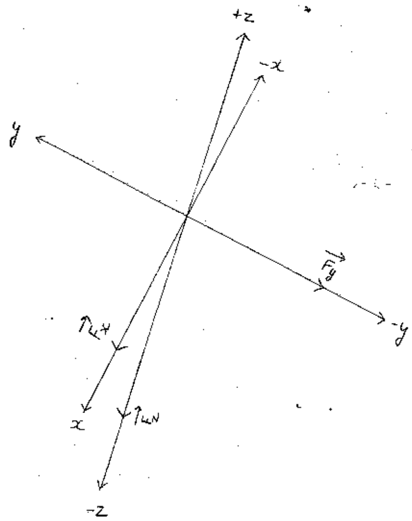
$= 4.4271 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is according to (+) x axis ,

so ,

$\underset{Fx}{\rightarrow} = 4.4271 \times 10^{-13}$ N

The forces acting on the proton



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 4.4271 \times 10^{-13}$ N

$F_y = 2.5561 x 10^{-13}$ N

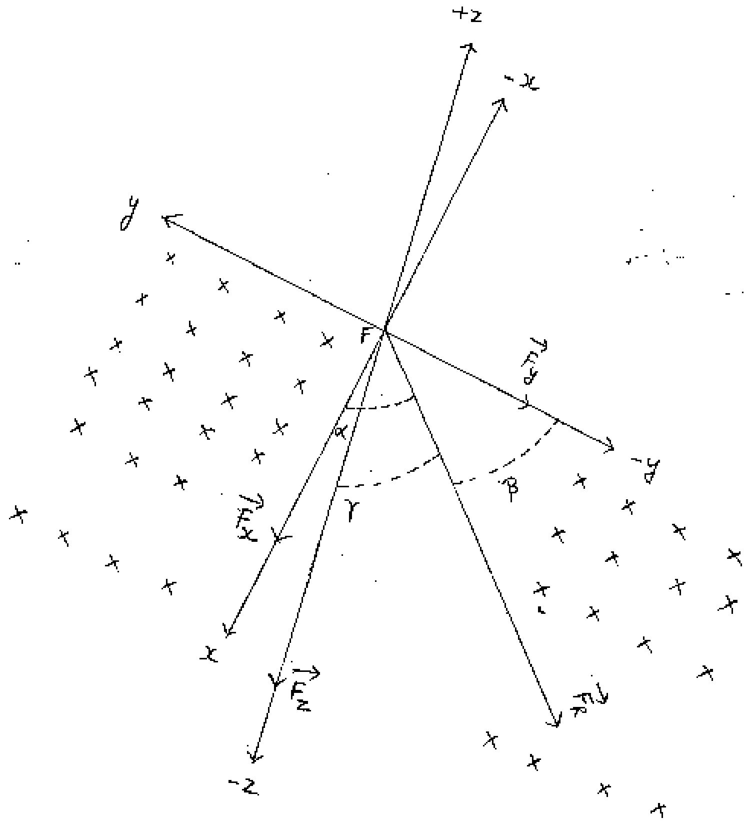
$F_z = 2.5569 x 10^{-13}$ N

$F_R^2 = (4.4271 x 10^{-13})^2 + (2.5561 x 10^{-13})^2 + (2.5569 x 10^{-13})^2$ N^2

$F_R^2 = (19.59921441 x 10^{-26}) + (6.53364721 x 10^{-26}) + (6.53773761 x 10^{-26}) N^2$

$F_R^2 = 32.67059923 x 10^{-26}$ N^2

$F_R = 5.7158 x 10^{-13}$ N


+z
-x
y
F
α
γ
β
-y
-z

.

Radius of the circular orbit to befollowed by the proton :

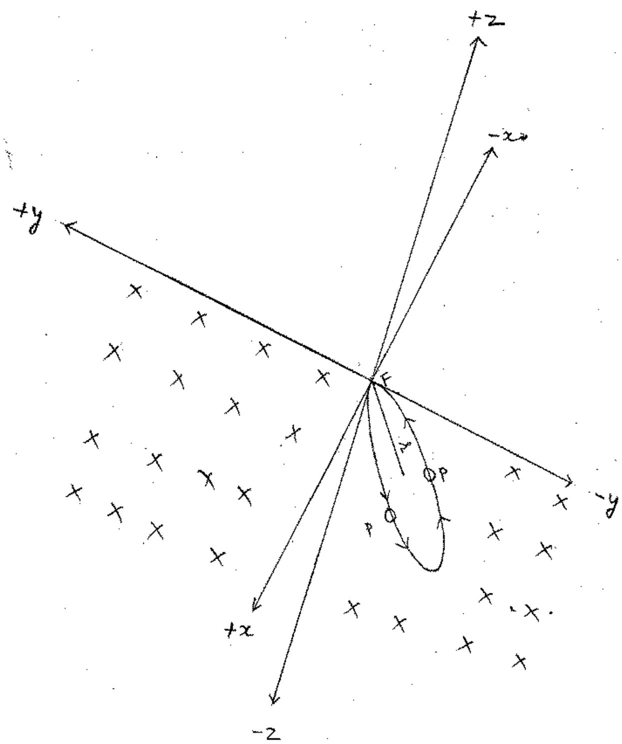
$r = mv^2 / F_R$

$mv^2 = 17.0404 \times 10^{-13}$ J

$F_r = 5.7158 \times 10^{-13}$ N

$$r = \frac{17.0404 \times 10^{-13} J}{5.7158 \times 10^{-13} N}$$

$r = 2.9812 m$



The circular orbit to be followed by the proton lies in theplanemade up of positive x-axis, negative y-axis and the negative z-axis.
C= center of the circleto be followed by the proton.

The plane of the circular orbit to be followed by the proton makes angles with positive x , y and z-axesas follows :-

1 withx- axis

Cos α= $\underline{F_R \cos\alpha}$ /Fr $= \overrightarrow{F_x} / F_r$

$\overrightarrow{F_x}$ = 4.4271 x 10^{-13} N

F_r = 5.7158 x 10^{-13} N

Puttingvalues

Cosα = 0.7745

α =39.24 degree [∴ cos (39.24) = 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / $F_r = \overrightarrow{F_y} / F_r$

$\overrightarrow{F_y}$ = -2.5561 x 10^{-13} N

F_r = 5.7158 x 10^{-13} N

Putting values

Cos β= -0.4471

β=243.44 degree [∴ cos (243.44) = -0.4471]

3with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \overrightarrow{F_z} / F_r$

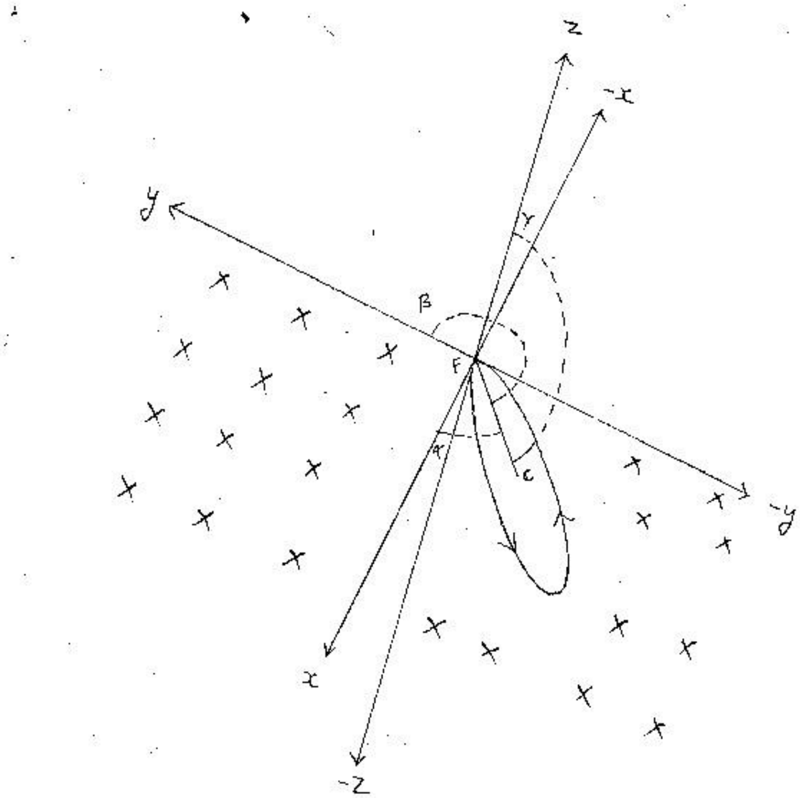
$\overrightarrow{F_z}$ = $\underline{-2.5569 \times 10^{-13} N}$

F_r= 5.7158 x 10^{-13} N

Putting values

Cos y = - 0.4473
y = 243.425 degree

The plane of the circular orbit to be followed by the proton makes angles Angles withpositive x, y , and z axes as follows :-



Where,
α= 39.24 degree

β = 243.44 degree

Y = 243.425 degree

The cartesian coordinates of the points P_1 (x_1, y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to beobtained by the proton .

$\cos \alpha = \frac{x_2 - x_1}{d}$

d = 2 x r

= 2x 2.9812 m

= 5.9624m

Cos α = 0.7745

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 5.9624 \times 0.7745$m

$x_2 - x_1 = 4.6178$ m

$x_2 = 4.6178$ m[$\therefore$ $x_1 = 0$]

$\cos \beta = \frac{y_2 - y_1}{d}$

$\cos \beta = -0.4471$

$y_2 - y_1 = d \times \cos \beta$

$y_2 - y_1 = 5.9624 \times (-0.4471)$ m

$y_2 - y_1 = -2.6657$m

$y_2 = -2.6657$ m [$\therefore$ $y_1 = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 5.9624 \times (-0.4473)$ m

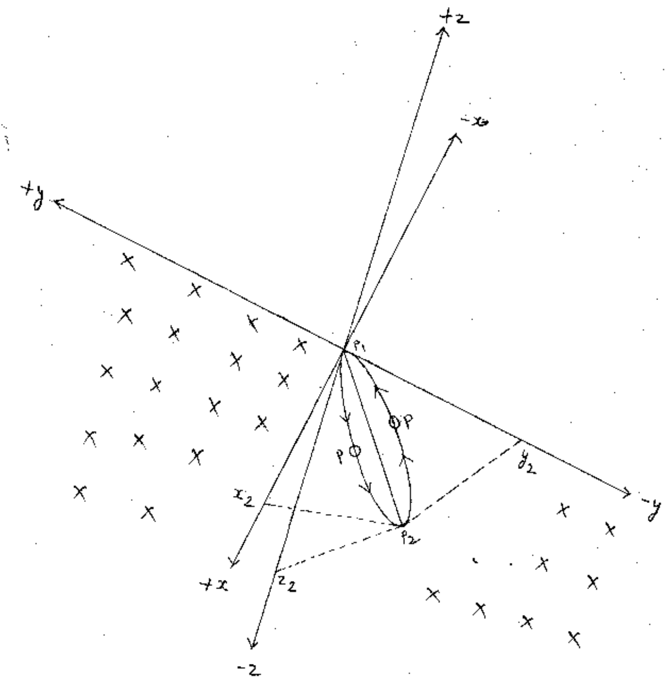
$z_2 - z_1 = -2.6669$m

$z_2 = -2.6669$ m [$\therefore$ $z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2)

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2, y_2 , z_2) located on the circle to be followed by theproton are as shownabove.

The line P_1P_2 is the diameter of the circle .



Conclusion :-

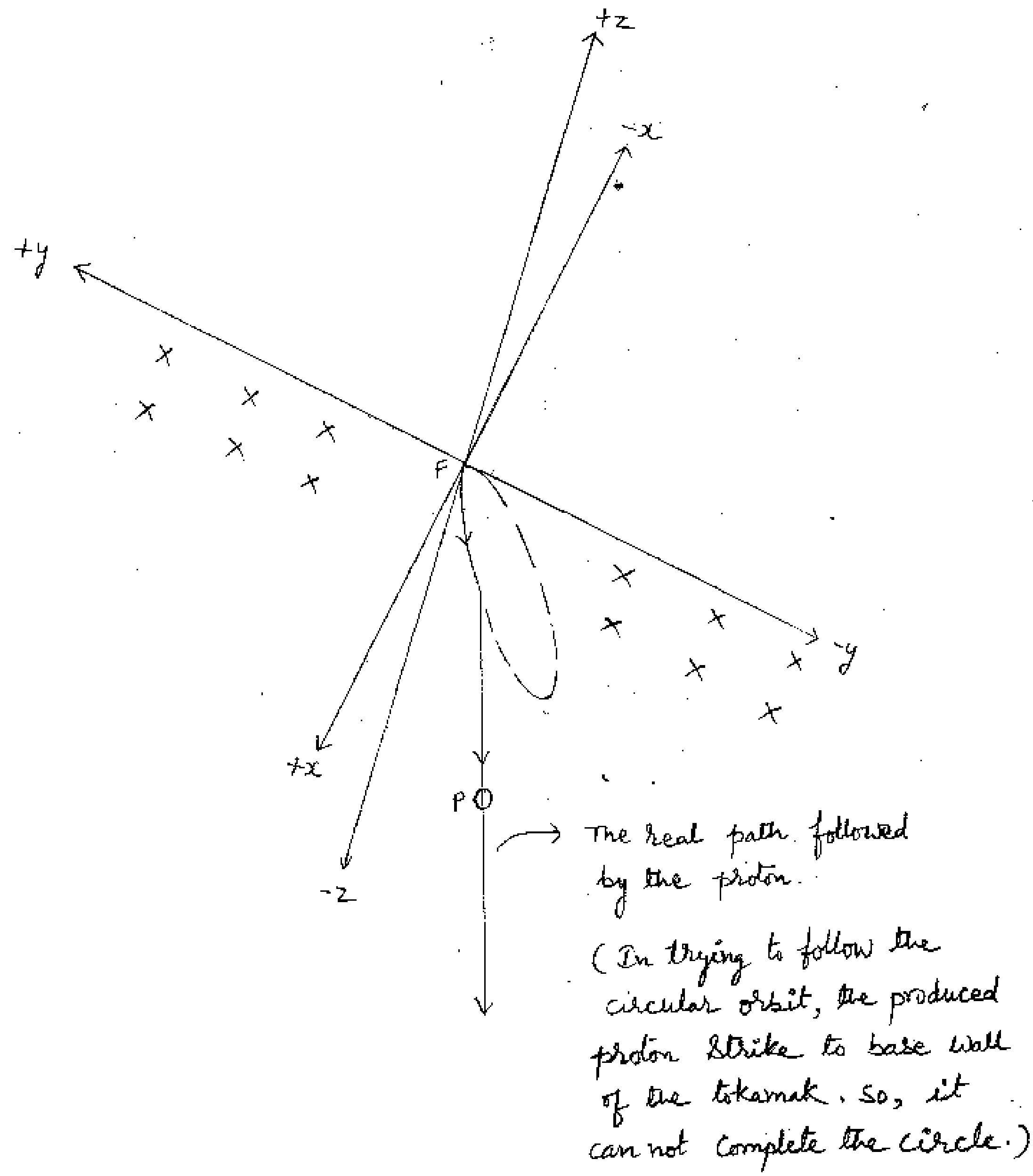
The directions components[$\vec{F_x}$,$\vec{F_y}$,and$\vec{F_z}$] ofthe resultant force($\vec{F_r}$)that are acting on the protonare along**+x , -y and -z**axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis where the magnetic fields are applied.

The resultant force$(\underset{Fr}{\rightarrow}$) tends the proton to undergo to a circular orbit of radius2.9812 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.6178 m,- 2.6657 m ,-2.6669 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.


+z
-x
+y
F
-y
+x
P
-z
The real path followed by the proton.
(In trying to follow the circular orbit, the produced proton strike to base wall of the tokamak. so, it can not complete the circle.)

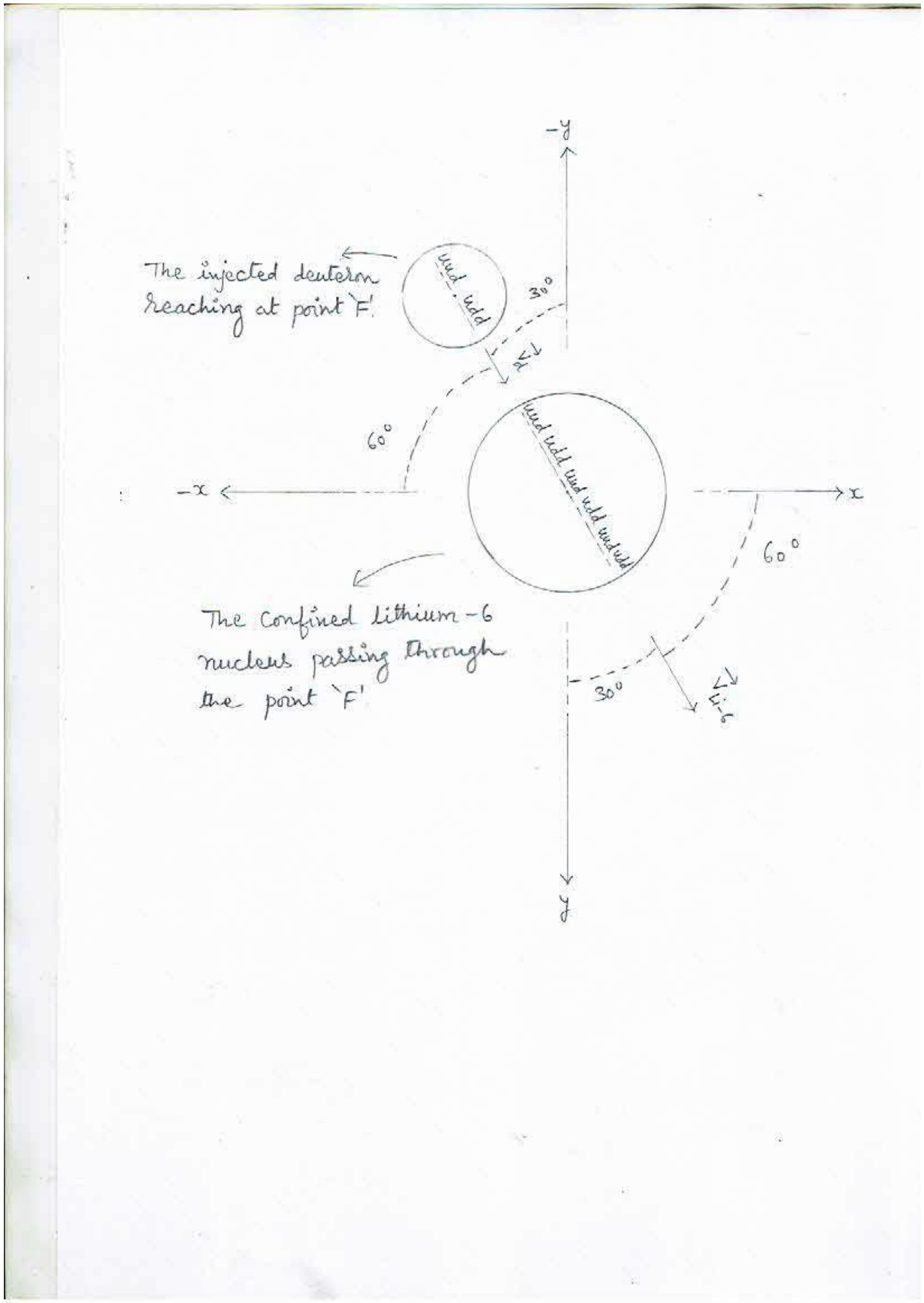
For fusionreaction

$^{2}_{1}H$ + $^{6}_{3}Li$→ [$_{4}^{8}$ Be] →$_{4}^{7}$ Be + $^{1}_{0}$ n

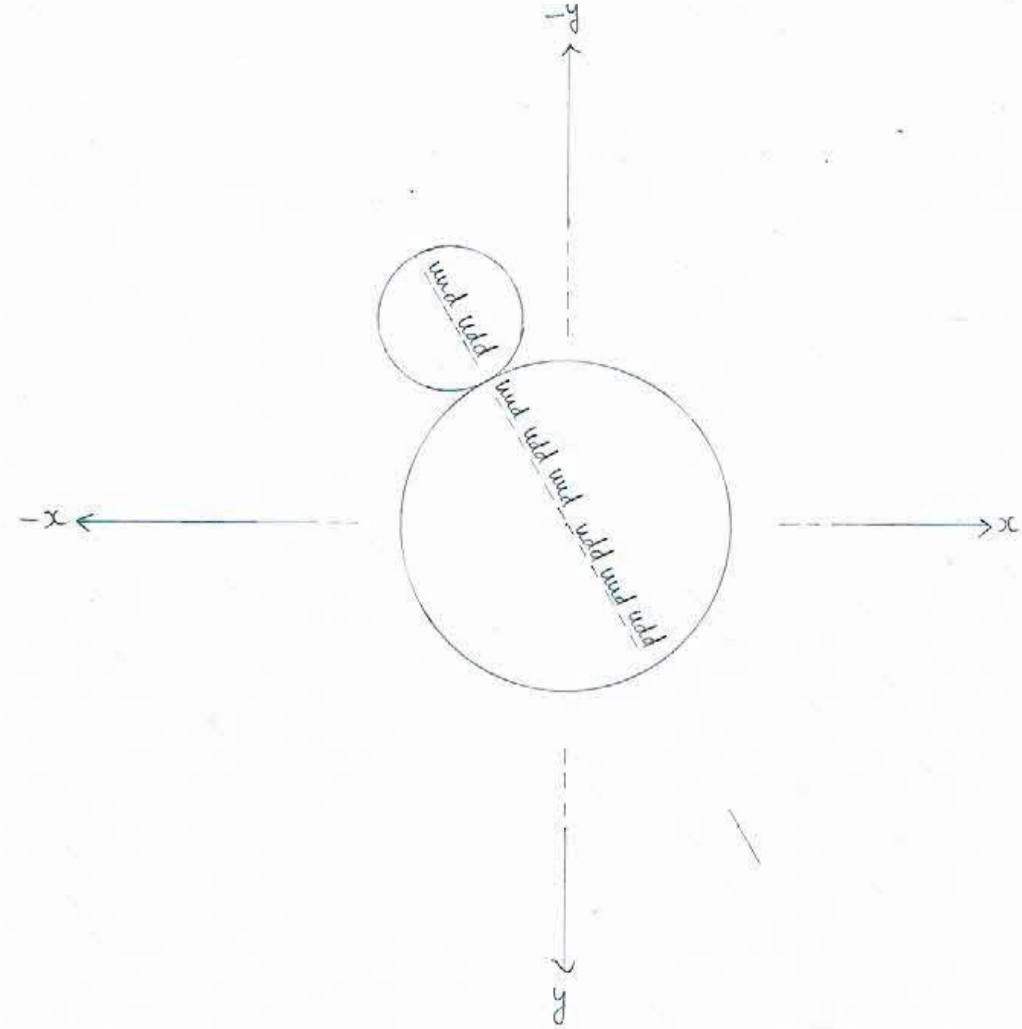
The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6] with the confined lithion-6 passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuterondissimilarly joinswith the confined lithion-6.

Interaction of nuclei (1)



Interaction of nuclei (2)

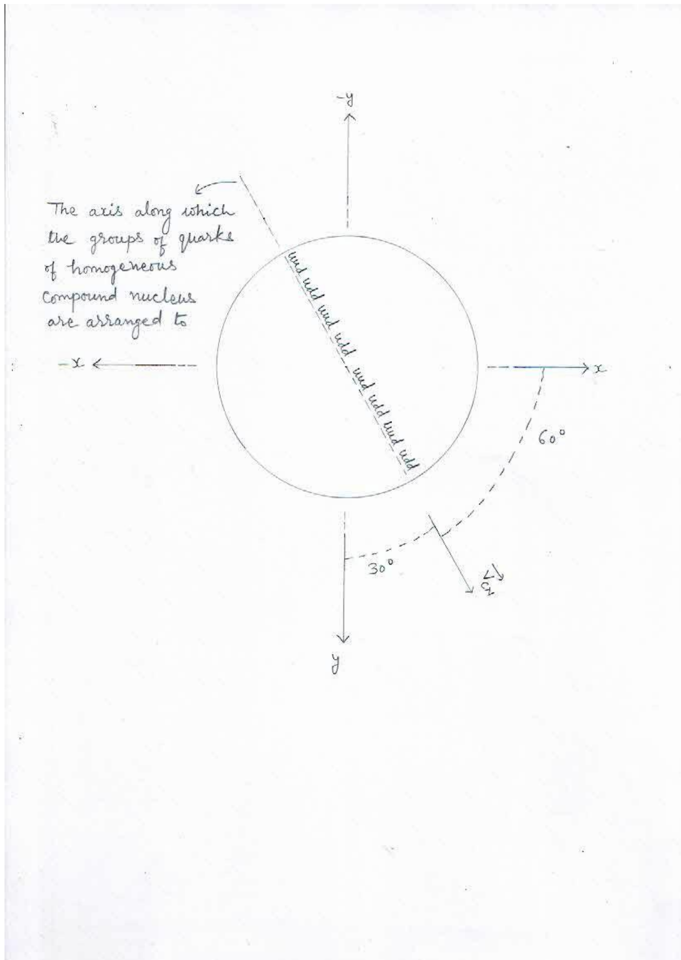

-y
-x
x
y
uud udd
uud udd uud udd uud udd

2.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron and the lithion-6 nucleus) behave like a liquid and form a homogeneous compound nucleus . having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 8 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3. Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the beryllium - 7) than the reactant one (the lithion-6) includes the other seven (nearby located) groups of quarks with their surrounding gluons and rearrange to form the ' A ' lobe of the heterogeneous compound nucleus.

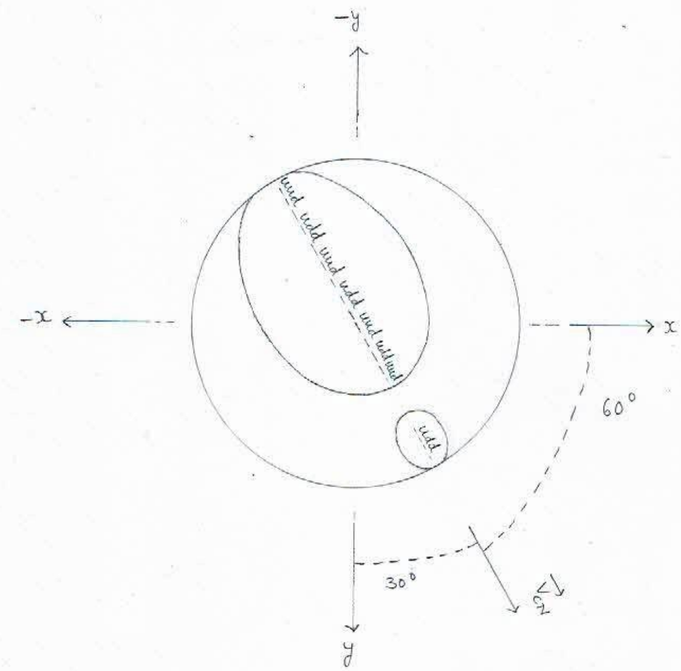
While , the remaing groups of quarks to become a stable nucleus (the neutron) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ' A '] and rearrange to form the 'B' lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the beryllium – 7 nucleus and the smaller nucleus is the neutron.

The greater nucleus is the lobe 'A ' and the smaller nucleus is the lobe 'B' while the remainigh space represent the remaining gluons .



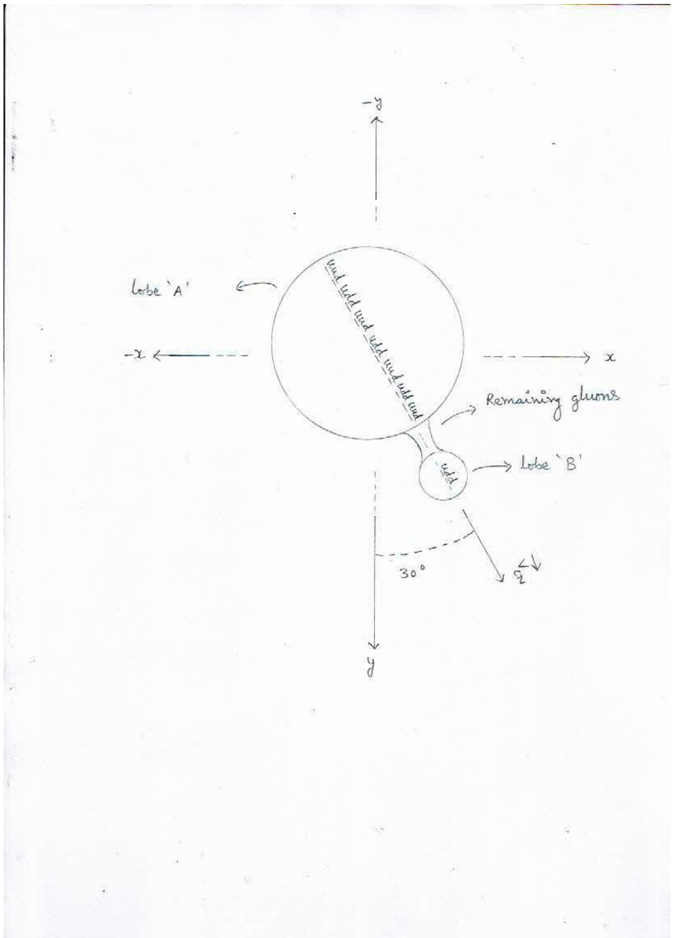
Formaton of lobes

4..Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

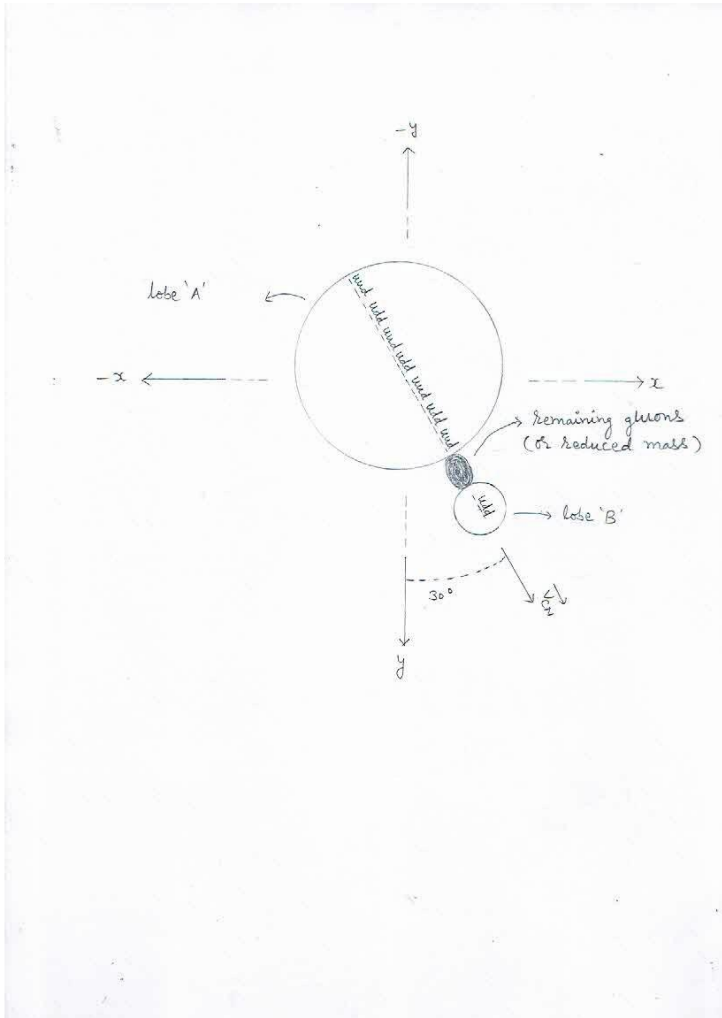
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degrees

β = 30 degrees



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

As the deuteron of n^{th} bunch reaches at point F , it fuses with the confined lithion-6 to form a compund nucleus .

1.Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 45.5598 kev

= 108.0402 kev

= 0.1080402 Mev

2.Just before fusion, to overcome the electrostatic repulsive force exerted by the deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves its energy equal to 136.0700kev.

so, just before fusion,

the kinetic energy of hellion-4 is –

E_b = 388.2043 kev – 136.0700 kev

= 252.1343 kev

= 0.2521343 Mev

Kinetic energy of the compound nucleus :-

K.E. =[E_b of deuteron] + [E_b of lithion-6]

= [108.0402Kev] +[252.1343 Kev]

= 360.1745 Kev.

= 0.3601745 Mev

Mass of the compound nucleus

M= $m_d + m_{Li-6}$

= [3.3434x10^{-27} Kg] +[9.9853 x 10^{-27} Kg]

= 13.3287 x 10^{-27} Kg

Velocity of compound nucleus

K.E. = ½ MV^2_{CN} = 0.3601745Mev

$$V_{CN} = \left(\frac{[\,2x\ 0.3601745x\ 1.6 \times 10^{-13}]}{13.3287 \times 10^{-27}\ kg} \right)^{½} \quad m/s$$

$$V_{CN} = \left(\frac{1.1525584 \times 10^{-13}}{13.3287 \times 10^{-27}} \right)^{½} m/s$$

V_{CN}= [0.08647192899 x 10^{14}] ^{½} m/s

V_{CN} = 0.2940 x 10^{7}m/s

Components of velocity of compound nucleus

$\vec{Vx}$ = V_{CN}cos α

=0.2940 X 10^{7}X0.5 m/s

= 0.1470 X 10^{7} m/s

$\vec{Vy}$ = V_{CN} cos β

= 0.2940X 10^{7}X0.866 m/s

= 0.2546 m/s

$\vec{Vz}$ = V_{CN} cosy

= 0.2940 X 10^{7}X0 m/s

= 0 m/s

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – beryllium – 7, the neutron and the reduced mass (Δm) .

Out of them , the two particles (the beryllium – 7 and neutron) are stablewhile the third one (reduced mass) is unstable .

According to thelaw of inertia, each particle thatis produced due tosplitting of the compound nucleus, has an inherited velocity ($\overrightarrow{Vinh}$) equal tothe velocityof the compound nucleus($\overrightarrow{Vcn}$) .

So,for conservation of momentum

$M\overrightarrow{Vcn} = (m_{be-7} + \Delta m + m_n)\overrightarrow{Vcn}$

Where ,

M = mass ofthe compound nucleus

$\overrightarrow{Vcn}$ = velocity of the compound nucleus

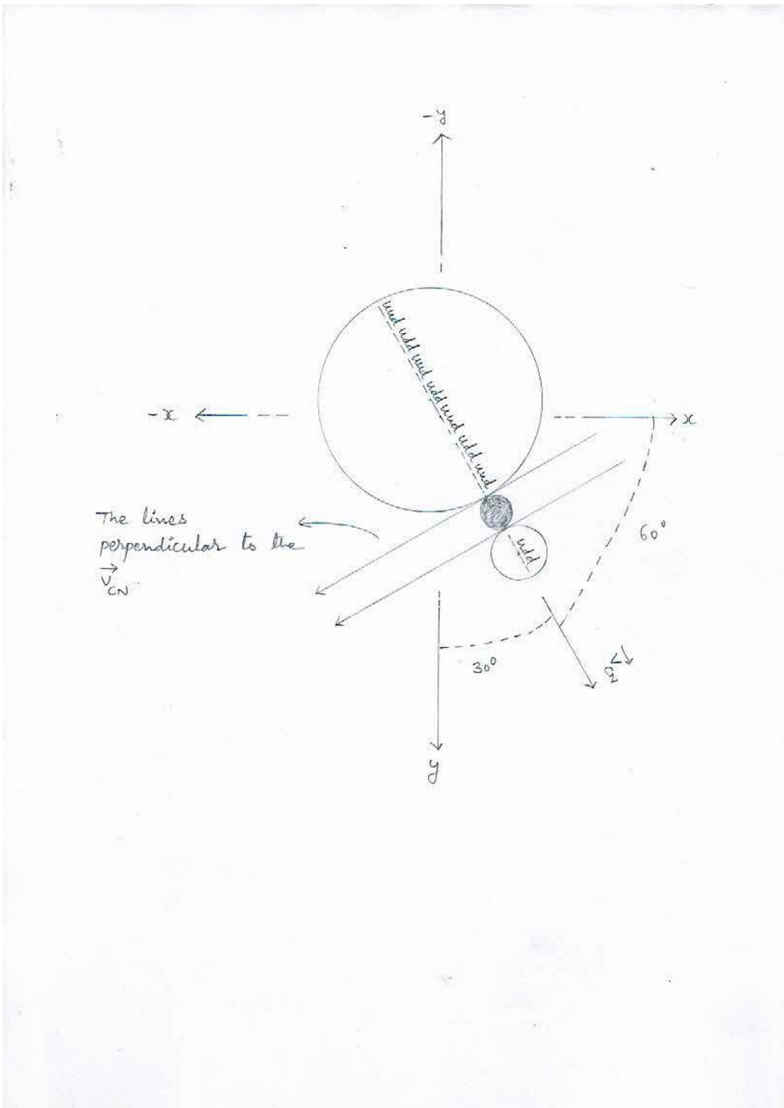
m_{Be-7} = mass of the beryllium – 7 nucleus

Δm = reduced mass

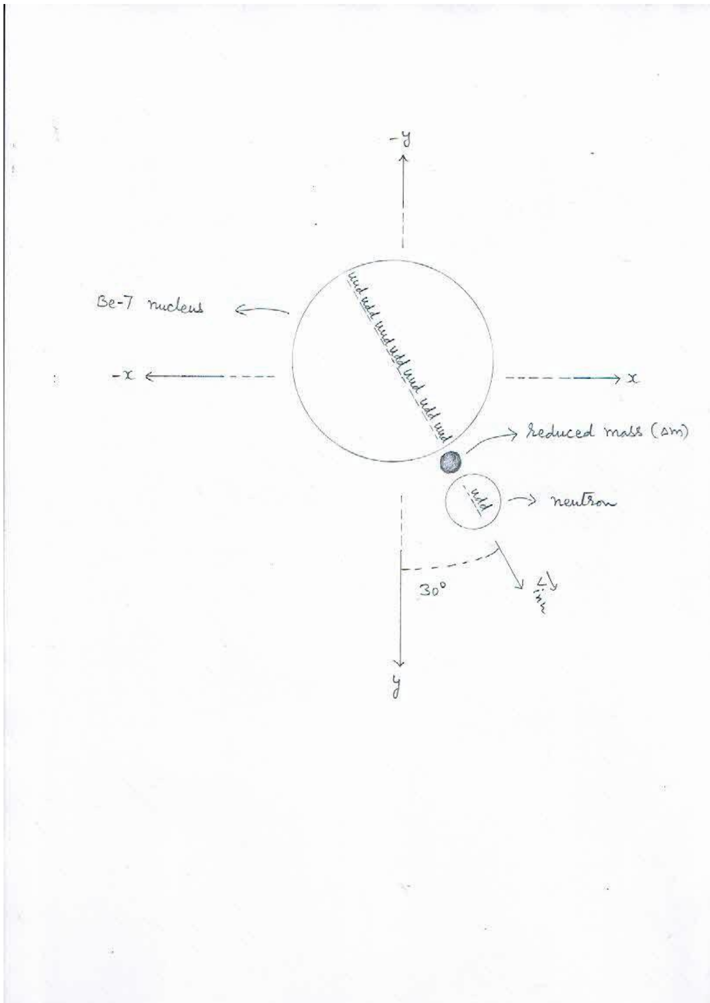
m_n = mass of the neutron

The splitting of the heterogenous compound nucleus

The heterogenous compound nucleus to show the lines perpendicular to the$\overrightarrow{Vcn}$



The splitting of the heterogenous compound nucleus



Inherited velocityof theparticles (s) : -

Each particlehas inherited velocity($\underset{Vinh}{\longrightarrow}$) equal to the velocity of the compound nucleus($\underset{Vcn}{\longrightarrow}$) .

(I). Inherited velocity of the particle $_4{}^7Be$

V_{inh} = V_{CN}= 0.2940x 10^7 m/s

Components of the inherited velocity of the particle beryllium -7

1. $\underset{Vx}{\rightarrow}$ = V_{inh} cos α= V_{CN}cos α= 0.1470x 10^7m/s

2 . $\underset{Vy}{\rightarrow}$ = V_{inh} cos β = V_{CN}cosβ= 0.2546 x 10^7m/s

3 . $\underset{Vz}{\rightarrow}$ =V_{inh} cos y = V_{CN} cos y = 0 m/s

II . Inheritedvelocity of the neutron

V_{inh} = V_{CN}= 0.2940 x 10^7 m/s

Components of the inherited velocityof the neutron

1. $\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cos α = 0.1470 x 10^7 m/s

2. $\underset{Vy}{\rightarrow}$ = V_{inh} cos β=V_{CN}cos β= 0.2546 x 10^7m/s

3 . $\underset{Vz}{\rightarrow}$ =V_{inh} cos y = V_{CN} cos y = 0 m/s

(iii) Inherited velocity of the reduced mass

V_{inh} = V_{CN} = 0.2940 x 10^7 m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propel both the particles with equal and opposite momentum.

Reduced mass

Δm = [m_d+$m_{Li\text{-}6}$] - [$m_{Be\text{-}7}$+ m_n]

Δm = [2.01355 + 6.01347708]– [7.01473555 + 1.00866] amu

Δm = [8.02702708] – [8.02339555] amu

Δm = 0.00363153 amu

Δm = 0.00363153 x 1.6605 x 10^{-27} kg

The Inherited kinetic energy of reduced mass (Δm) .

E_{inh} = ½Δm V^2_{CN}

Δm 0.00363153 x 1.6605 x 10^{-27} kg

V^2_{CN} = 0.08647192899x 10^{14}

E_{inh} = ½ x 0.00363153 x 1.6605 x 10^{-27} x 0.08647192899 x 10^{14} J

E_{inh} = 0.00026071959 x 10^{-13} J

E_{inh} = 0.000162 Mev

Released energy (E_R)

$E_R = \Delta mc^2$

E_R = 0.00363153 x 931 Mev

E_R = 3.380954 Mev

Total energy (E_T)

E_T = E_{inh} + E_R

E_T = [0.000162 + 3.380954] Mev

E_T = 3.381116 Mev

Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses . so,the increased energy (E_{inc}) of the particles are :-

1.. For beryllium – 7

$$E_{inc} = \frac{m_n}{m_n + m_{Be-7}} \times E_T$$

$$E_{inc} = \frac{1.00866 \text{ amu}}{[1.00866 + 7.01473555] \text{ amu}} \times 3.381116 \text{ Mev}$$

$$E_{inc} = \frac{1.00866}{8.02339555} \times 3.381116 \text{ Mev}$$

E_{inc} = 0.12571485398 x 3.381116 Mev

E_{inc} = 0.425056 Mev

2..increased energy of the neutron

E_{inc} = [E_T] - [increased energy of the Be-7]

E_{inc} = [3.381116] - [0.425056] Mev

E_{inc} = 2.95606 Mev

6..Increased velocity of the particles .

(1) For neutron

$E_{inc} = {}^{1}/_{2} m_n \ v_{inc}^2$

$V_{inc} = [2 \times E_{inc}/m_n]^{½}$

$$= \left[\frac{2x\ 2.95606 x\ 1.6x10^{-13}\ J}{1.6749x10^{-27}\ kg}\right]^{½} m/s$$

$$\left(\frac{9.459392\ x10^{-13}}{1.6749\ x10^{-27}}\right)^{½}$$

$= [\ 5.64773538718 \times 10^{14}\ ]^{½}$ m/s

$= 2.3764 \times 10^{7}$ m/s

For beryllium-7

$V_{inc} = [2 \times E_{inc} / m_{Be-7}]^{½}$

$$= \left(\frac{2x0.425056x1.6x10^{-13}\ J}{11.6479 \times 10^{-27}\ kg}\right)^{½}$$

$$= \left(\frac{1.3601792x\ 10^{-13}}{11.6479\ x10^{-27}}\right)^{½} m/s$$

$= [\ 0.1167746289x\ 10^{14}\ ]^{½}$ m/s

$= 0.3417 \times 10^{7}$ m/s

7 Angle of propulsion

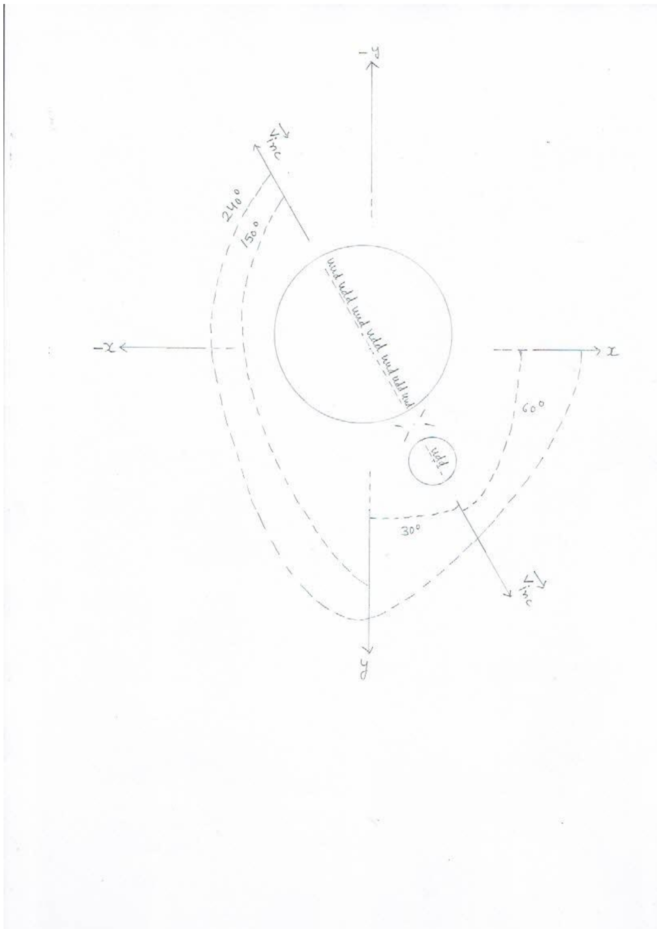
1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ' F ' , as V_{CN} makes 60^o angle with x-axis , 30^o angle with y-axis and 90^o angle with z-axis .

so, the neutron is propelled making 60^o angle with x-axis , 30^o angle with y-axis and 90^oangle with z-axis . While the beryllium-7 is propelled making 240^o angle with x-axis , 150^o angle with y-axis and 90^oangle with z-axis .

Propulsion of the particles



Components of the increased velocity (V_{inc}) ofthe particles.

(i) For beryllium- 7

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.3417 x 10^7 m/s

cosα = cos (240) = -0.5

$\underset{Vx}{\rightarrow}$= 0.3417 x 10^7x (-0.5) m/s

= -0.1708 x 10^7m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc}cosβ

cos β= cos(150) = - 0.866

$\underset{Vy}{\rightarrow}$= 0.3417x 10^7x (- 0.866) m/s

= - 0.2959x 10^7 m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

Cos y = cos 90^o= 0

$\underset{Vz}{\rightarrow}$ =0.3417 x 10^7x 0

= 0 m/s

For neutron

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 2.3764 x 10^7m/s

cos α= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$ =2.3764x 10^7 x 0.5m/s

= 1.1882 x10^7 m/s

2 $\underset{Vy}{\rightarrow}$ =V_{inc}cos β

cos β = cos (30) = 0.866

$\underset{Vy}{\rightarrow}$=2.3764x 10^7 x 0.866m/s

= 2.0579x 10^7 m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

cos y= cos (90) = 0

$\underset{Vz}{\rightarrow}$= 2.3764 x 10^7 x0 m/s

= 0 m/s

9.. Componentsof the final velocity(Vf)of theparticles

IFor beryllium-7

According to-	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity ($\vec{Vf}$) =($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X –axis	$\underset{Vx}{\rightarrow}$= 0.1470 x$10^7$m/s	$\underset{Vx}{\rightarrow}$ =-0.1708 x10^7m/s	$\underset{Vx}{\rightarrow}$ = -0.0238 x10^7m/s
y –axis	$\underset{Vy}{\rightarrow}$=0.2546x$10^7$m/s	$\underset{Vy}{\rightarrow}$ = - 0.2959 x 10^7m/s	$\underset{Vy}{\rightarrow}$ =- 0.0413x10^7m/s
z –axis	$\underset{Vz}{\rightarrow}$= 0 m/s	$\underset{Vz}{\rightarrow}$= 0m/s	$\underset{Vz}{\rightarrow}$=0 m/s

2..For neutron

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity ($\vec{Vf}$)=($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X–axis	$\underset{Vx}{\rightarrow}$= 0.1470 x$10^7$m/s	$\underset{Vx}{\rightarrow}$ = 1.1882 x10^7m/s	$\underset{Vx}{\rightarrow}$ =1.3352 x10^7m/s
y– axis	$\underset{Vy}{\rightarrow}$= 0.2546 x$10^7$m/s	$\underset{Vy}{\rightarrow}$ = 2.0579 x10^7m/s	$\underset{Vy}{\rightarrow}$=2.3125 x$10^7$m/s
z –axis	$\underset{Vz}{\rightarrow}$= 0 m/s	$\underset{Vz}{\rightarrow}$ = 0 m/s	$\underset{Vz}{\rightarrow}$ =0 m/s

10.. Final velocity (vf) of theberyllium-7

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.0238 \times 10^7$ m/s

$V_y = 0.0413 \times 10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.0238X10^7)^2 + (0.0413\ X10^7)^2 + (0)^2\ m^2/s^2$

$V_f^2 = (0.00056644X10^{14}) + (0.00170569\ X10^{14}) + 0\ m^2/s^2$

$V_f^2 = 0.00227213 \times 10^{14} m^2/s^2$
$V_f = 0.0476 \times 10^7 m/s$

Final kinetic energy of the beryllium-7

$E = ½\ m_{Be-7} V_f^2$

$E = ½ \times 11.6479 \times 10^{-27} \times 0.00227213 \times 10^{14}$ J

$= 0.01323277151 \times 10^{-13}$ J

$= 0.008270$ Mev

$m_{Be-7} V_f^2 = 11.6479 \times 10^{-27} \times 0.00227213 \times 10^{14}$ J

$= 0.0264 \times 10^{-13}$ J

Forces acting on the beryllium-7 nucleus

1 $F_y = q\ V_x\ B_z \sin\theta$

$\underset{Vx}{\rightarrow} = -0.0238 \times 10^7 m/s$ $\underset{Bz}{\rightarrow} = -1.001 \times 10^{-1}$ Tesla

$q = 4 \times 1.6 \times 10^{-19}$ c

$\sin\theta = \sin 90^o = 1$

$Fy = 4 \times 1.6 \times 10^{-19} \times 0.0238 \times 10^7 \times 1.001 \times 10^{-1} \times 1$ N
$= 0.1524 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (+) y-axis ,

so ,
$\underset{Fy}{\rightarrow} = 0.1524 \times 10^{-13}$N

2 $F_z = q\ V_x\ B_y \sin\theta$

$\underset{By}{\rightarrow} = 1.0013 \times 10^{-1}$Tesla

$\sin\theta = \sin 90^o = 1$

$Fz = 4 \times 1.6 \times 10^{-19} \times 0.0238 \times 10^7 \times 1.0013 \times 10^{-1} \times 1$ N
$= 0.1525 \times 10^{-13}$ N

Form the right hand palm rule , thedirection ofthe force $\underset{Fz}{\rightarrow}$ is according to(+) Z- axis ,

so ,

$\vec{F_z}$ = 0.1525 x 10^{-13}N

3 F_x = q V_y $B_z$sin θ

$\vec{V_y}$ = -0.0413 x 10^7 m/s

$\vec{B_z}$ = 1.001x10^{-1} Tesla

sin θ = sin 90° = 1

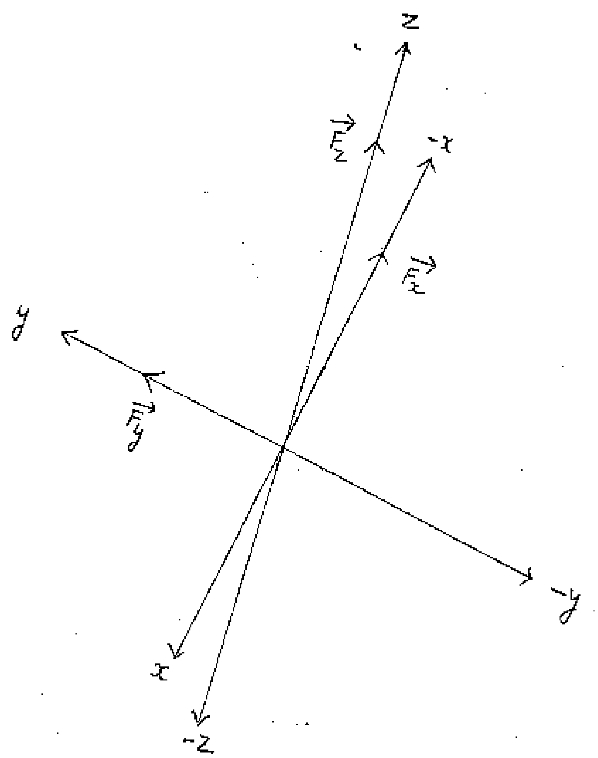
Fx = 4x1.6 x 10^{-19}x 0.0413 x 10^7x 1.001x10^{-1} x 1 N

= 0.2645 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\vec{F_x}$ is according to (-) x axis ,

so , $\vec{F_x}$ = - 0.2645 x 10^{-13}N

Forces acting on the beryllium-7



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 0.2645 \times 10^{-13}$ N

F_y=0.1524

$F_z = 0.1525 \times 10^{-13}$ N

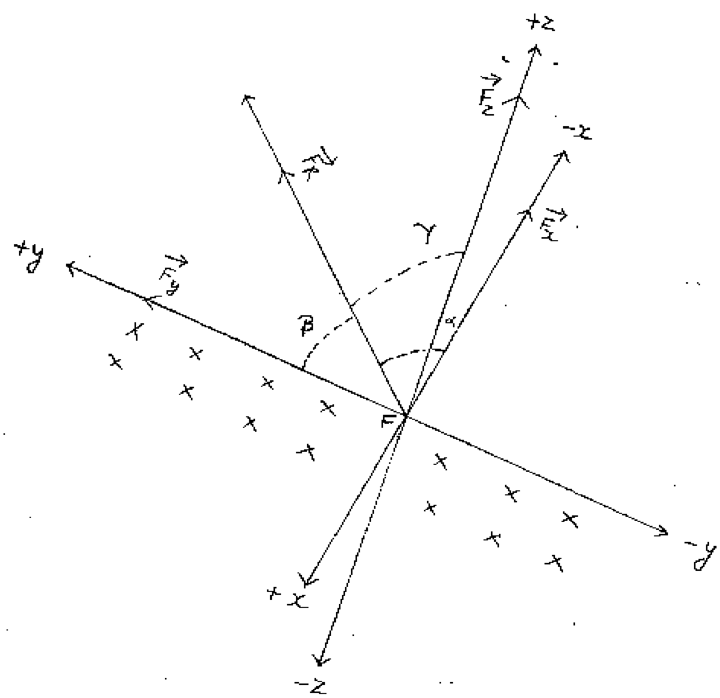
$F_R^2 = (0.2645 \times 10^{-13})^2 + (0.1524 \times 10^{-13})^2 + (0.1525)$ N^2

$F_R^2 = (0.06996025 \times 10^{-26}) + (0.02322576 \times 10^{-26}) + (0.02325625)$ N^2

$F_R^2 = 0.11644226 \times 10^{-26}$ N^2

$F_R = 0.3412 \times 10^{-13}$ N

Resultant force acting on the beryllium -7



Radius of the circular orbit to be followed by the beryllium-7:

$r = mv^2 / F_R$

$mv^2 = 0.0264 \times 10^{-13}$ J

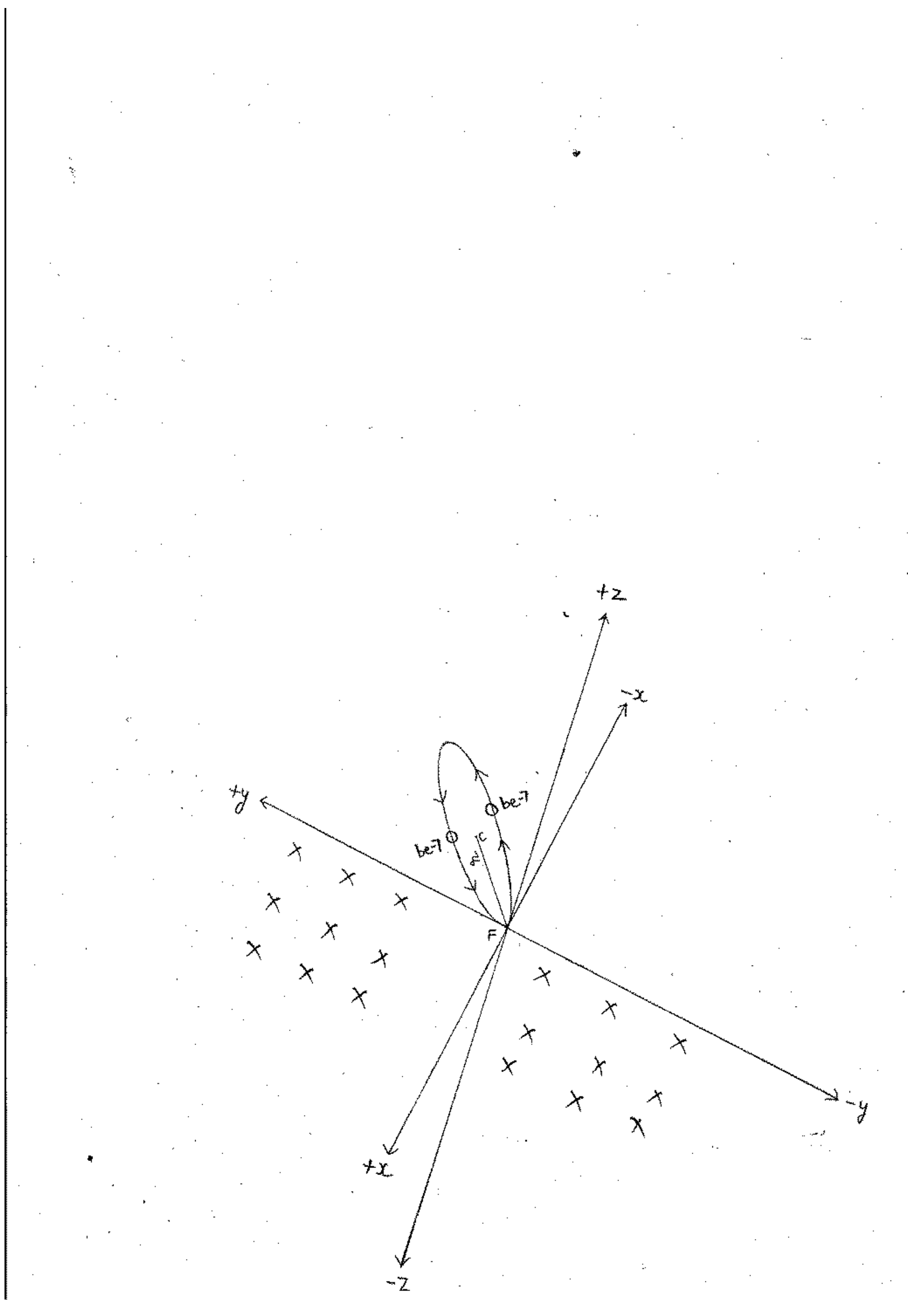
$F_r = 0.3412 \times 10^{-13}$ N

$$r = \frac{0.0264 \times 10^{-13} \text{ J}}{0.3412 \times 10^{-13} \text{ N}}$$

$r = 0.0773$ m

The circular orbitto be followed by the beryllium -7 lies in the plane made up of negativex-axis,pisitive y-axis and the positive z-axis.

C= center of the circular orbit to be followed by the beryllium -7.



The plane of the circular orbit to be followed by the beryllium -7 nucleus makes angles with positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr $= \overrightarrow{F_x} / F_r$

$\underset{Fx}{\rightarrow}$ = -0.2645 x 10^{-13} N

F_r= 0.3412 x 10^{-13} N

Puttingvalues

Cos α = - 0.7752

α= 219.17 degree [∴cos (219.17) = - 0.7752]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / F_r=$\underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ = 0.1524 x 10^{-13} N

F_r = 0.3412x 10^{-13}N

Putting values

Cosβ = 0.4466

β = 63.47 degree [∴ cos(63.47) = 0.4466]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ F_r=$\underset{Fz}{\rightarrow}$ / F_r

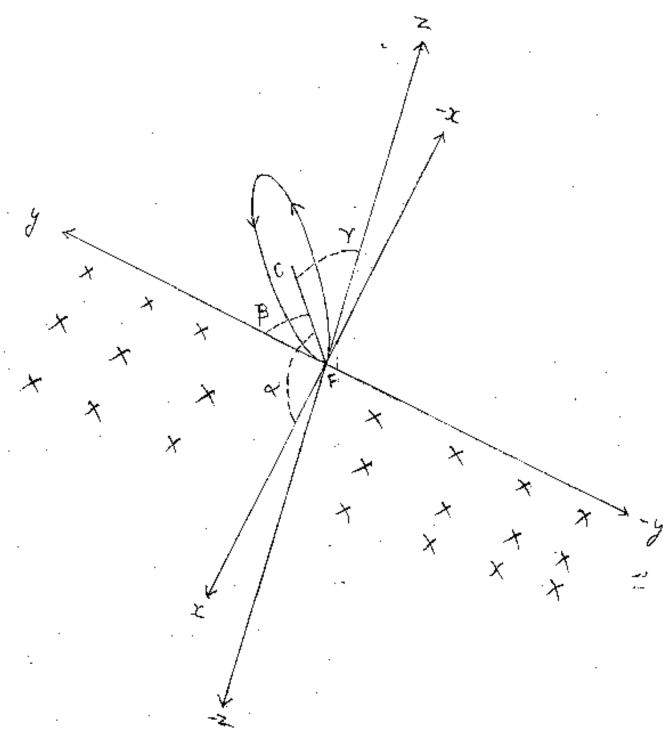
$\underset{Fz}{\rightarrow}$ = $\underline{0.1525\text{x } 10^{-13}\text{N}}$

F_r = = 0.3412 x 10^{-13} N

Puttingvalues

Cos y = 0.4469
y = 63.45 degree

The plane of the circular orbit to be followed by the beryllium -7 nucleus makes angles with positive x, y , and z axes as follows :-



Where,

α =219.17 degree

β= 63.47 degree

Y = 63.45 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2(x_2 , y_2 , z_2) located on the circumference of the circleto be obtained by the beryllium -7.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

$= 2x\ 0.0773$ m

$= 0.1546$ m

$\cos\alpha = -0.7752$

$x_2 - x_1 = d\ x\cos\alpha$

$x_2 - x_1 = 0.1546\ x\ (-0.7752)$ m

$x_2 - x_1 = -0.1198$ m

$x_2 = -0.1198$m$[\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = 0.4466$

$y_2 - y_1 = d\ x\ \cos\beta$

$y_2 - y_1 = 0.1546\ x\ 0.4466$m

$y_2 - y_1 = 0.0690$m

$y_2 = 0.0690$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = 0.4469$

$z_2 - z_1 = d\ x\cos y$

$z_2 - z_1 = 0.1546\ x\ 0.4469$m

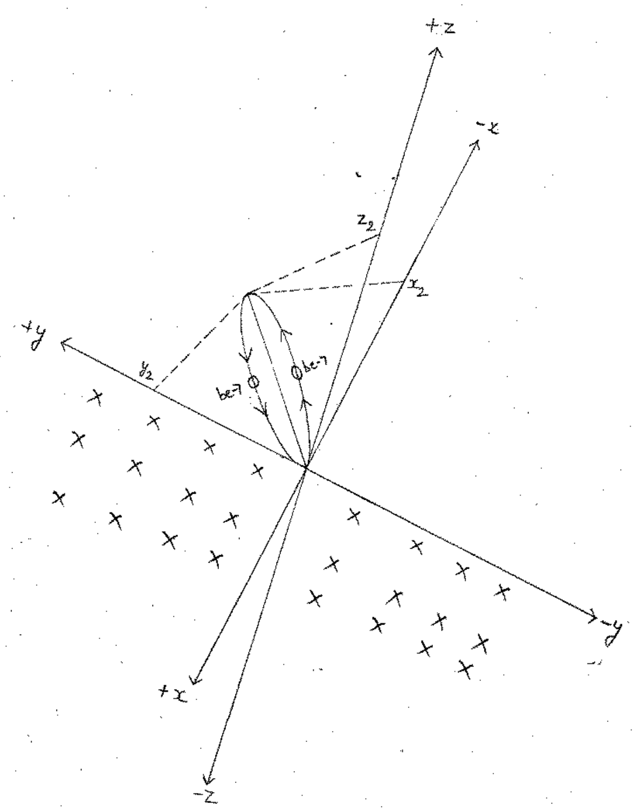
$z_2 - z_1 = 0.0690$ m

$z_2 = 0.0690$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point $p_1 (x_1, y_1, z_1)$ and $p_2 (x_2, y_2, z_2)$ located on the circumfrence of the circle to be obtained by the beryllium-7 are as shown below.

The line ___is the diameter of the circle .

P_1P_2


+z
-x
z_2
x_2
+y
y_2
be-7
be-7
-y
+x
-z

Conclusion :-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the beryllium-7 nucleusare along **-x , +y and +z** axes respectively .

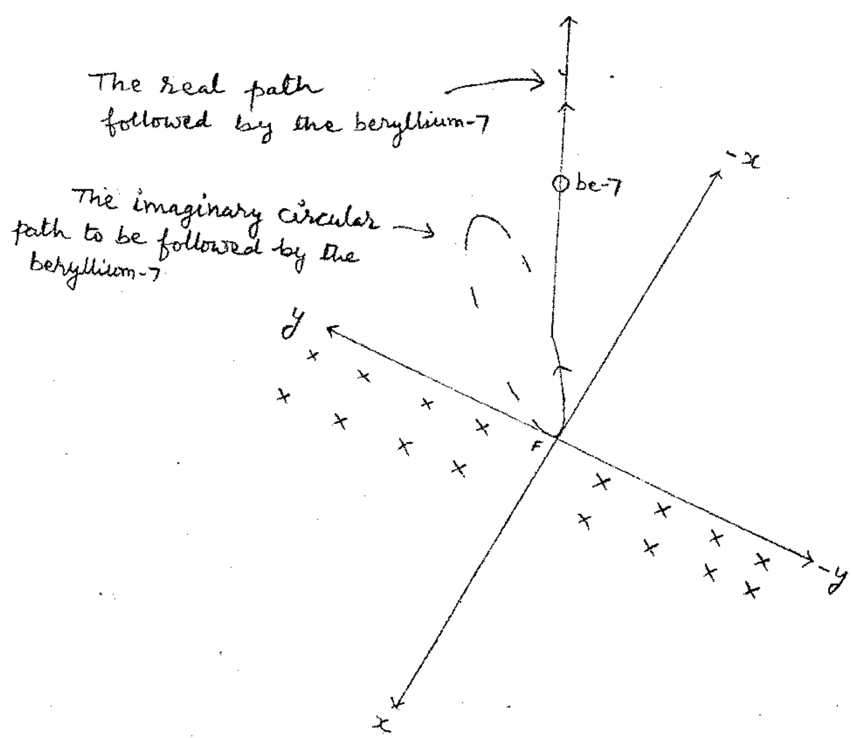
So by seeing the direction ofthe resultantforce($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the beryllium-7 nucleus to undergo to a circular orbit of radius 0.0773 m .

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-0.1198 m,0.0690m, 0.0690 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the beryllium-7 nucleus is not confined.



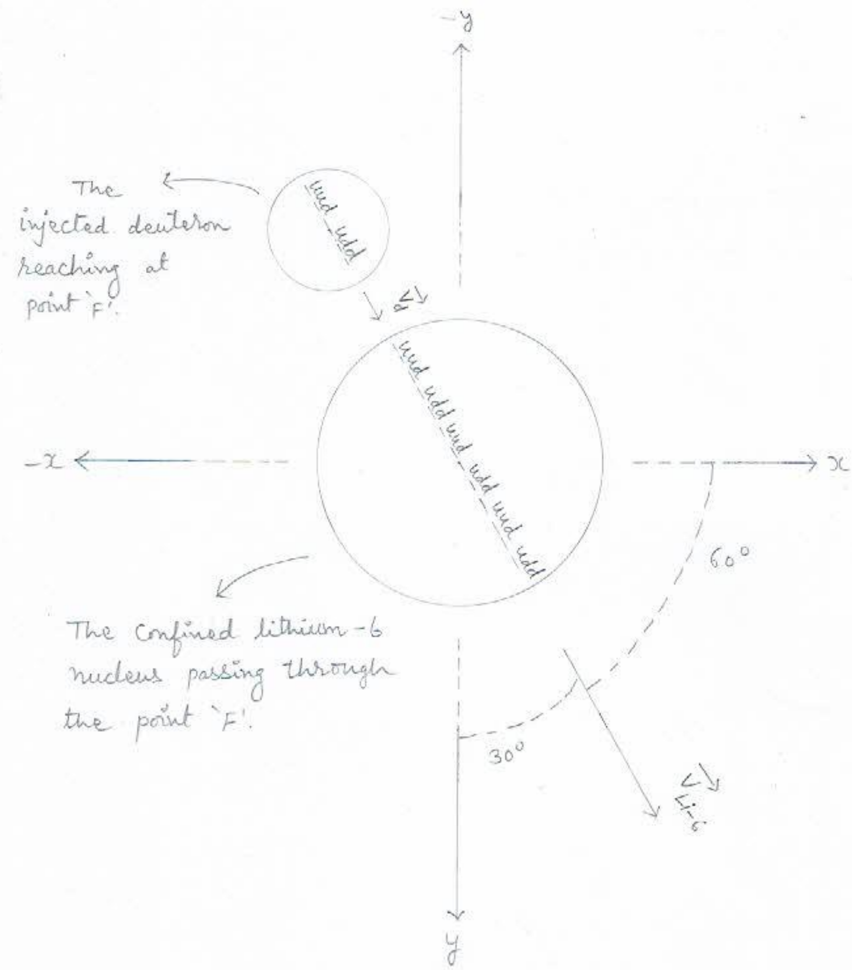
For fusion reaction

$^{2}_{1}H + ^{6}_{3}Li \rightarrow [^{8}_{4}Be] \rightarrow ^{4}_{2}He + ^{4}_{2}He$

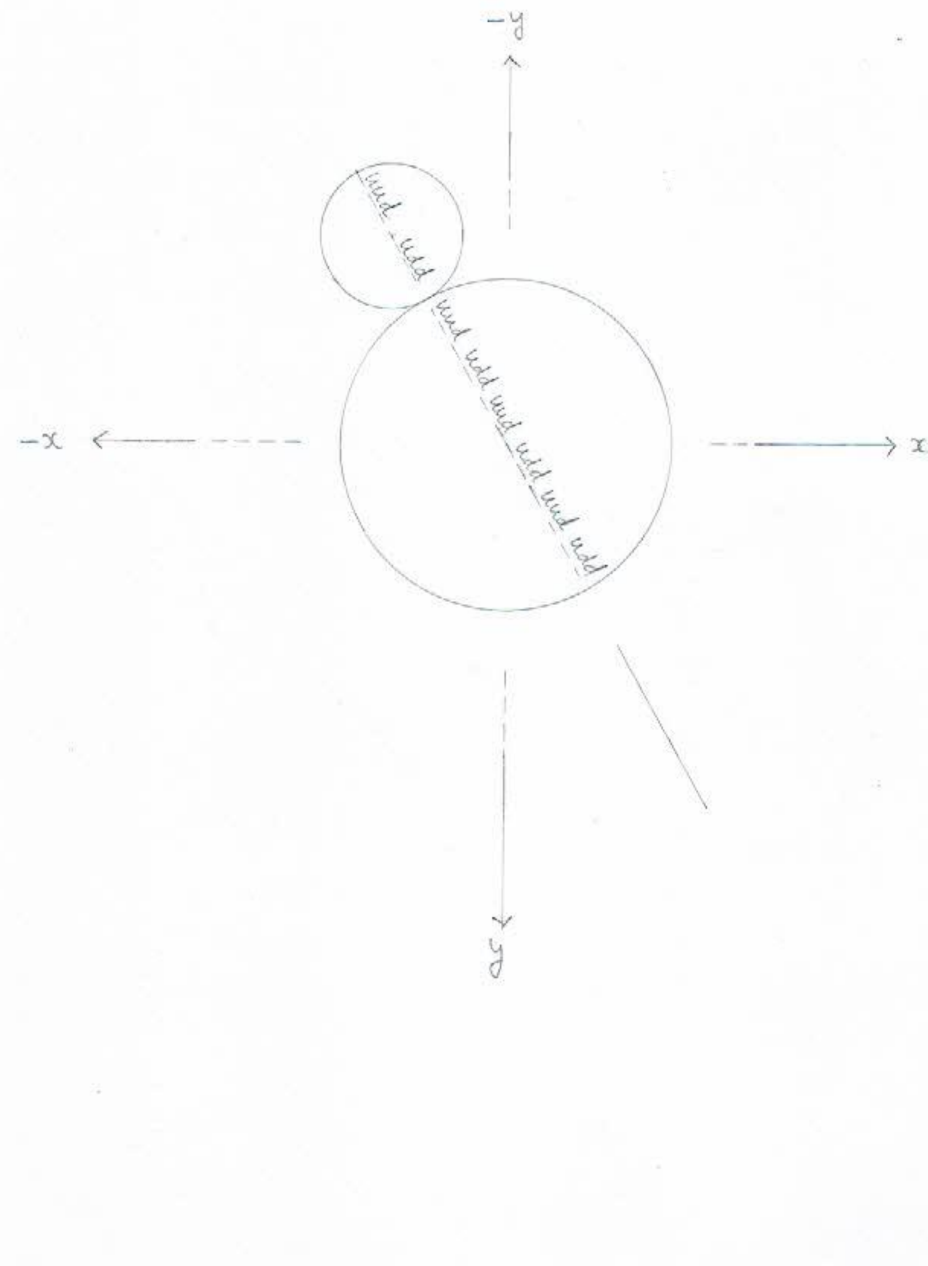
The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6] with the confined lithion-6 passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6.

Interaction of nuclei (1)



Interaction of nuclei (2)

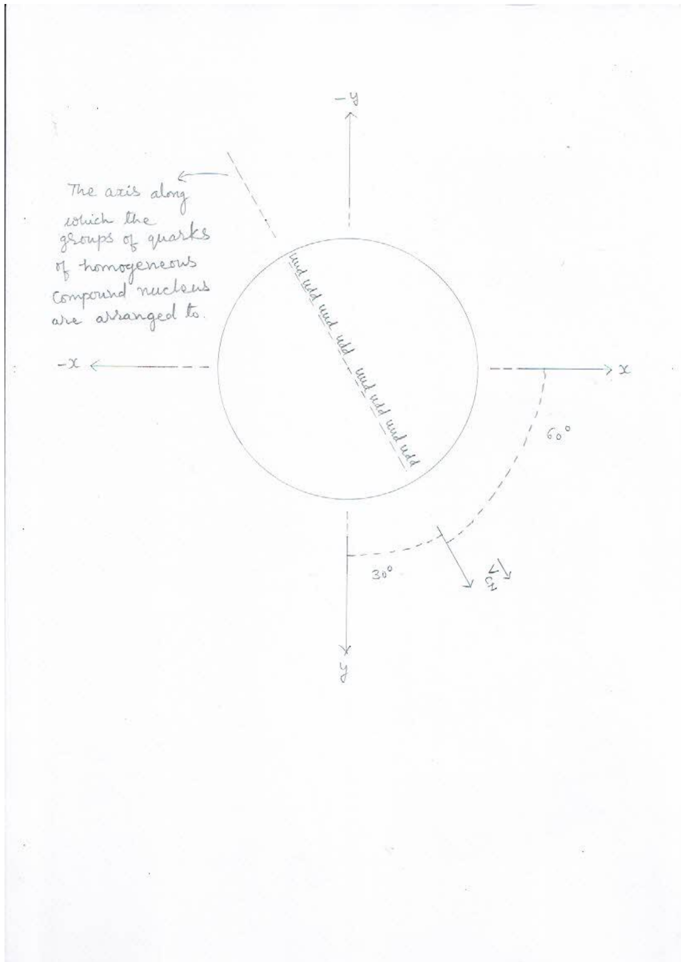

-y
uud udd
uud udd uud udd uud udd
-x
x
y

2.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron and the lithion-6 nucleus) behave like a liquid and form a homogeneous compound nucleus . having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 8 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3 . Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the just lower nucleus (the hellion-4) than the reactant one (the lithion-6) includes the other three (nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

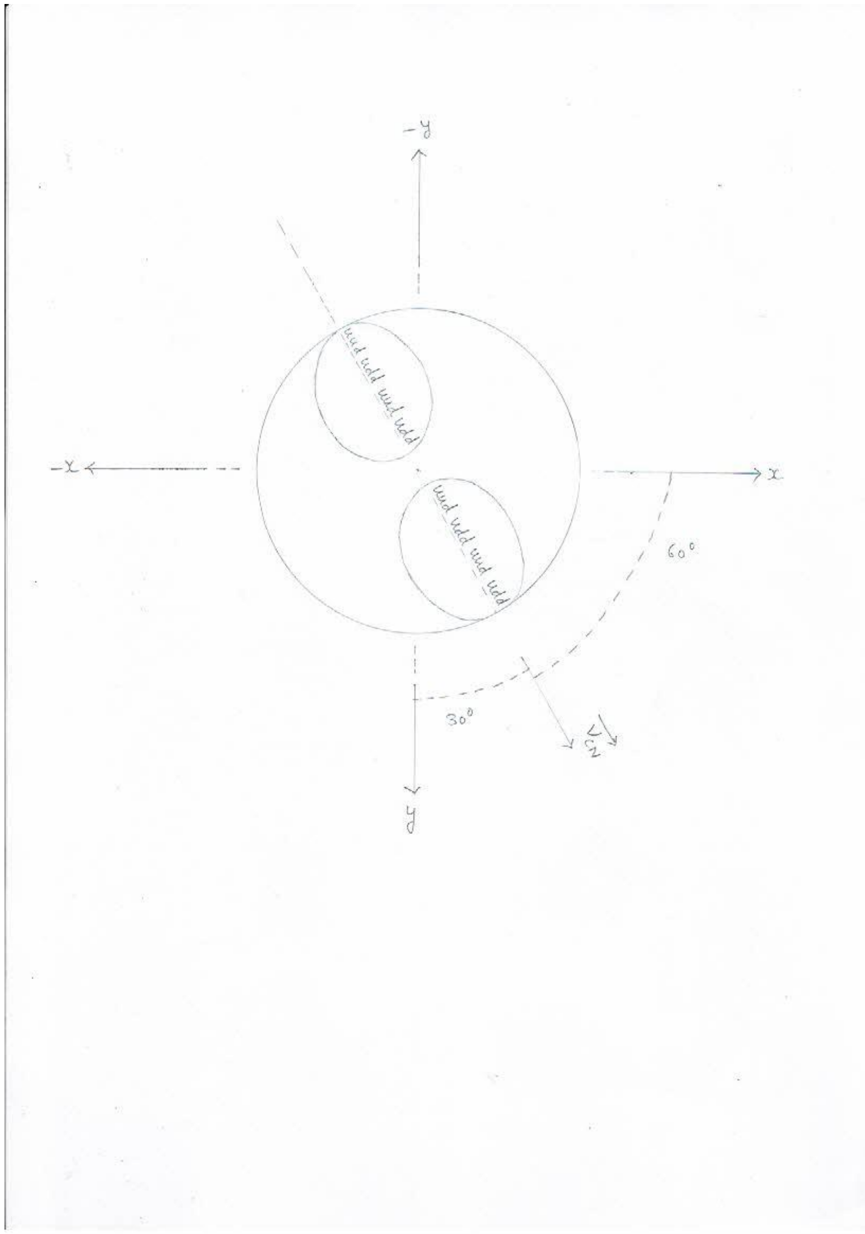
While , the remaining groups of quarks to become a stable nucleus (the hellion-4) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the one nucleus is the hellion-4 nucleus and the other nucleus is the hellion-4.

The one nucleus is the lobe ‘A ‘ and the other nucleus is the lobe ‘B’ while the remaining space represent the remaining gluons .



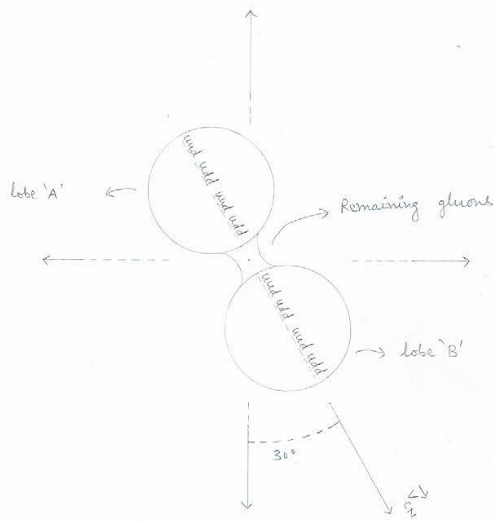
Formaton of lobes

4..Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

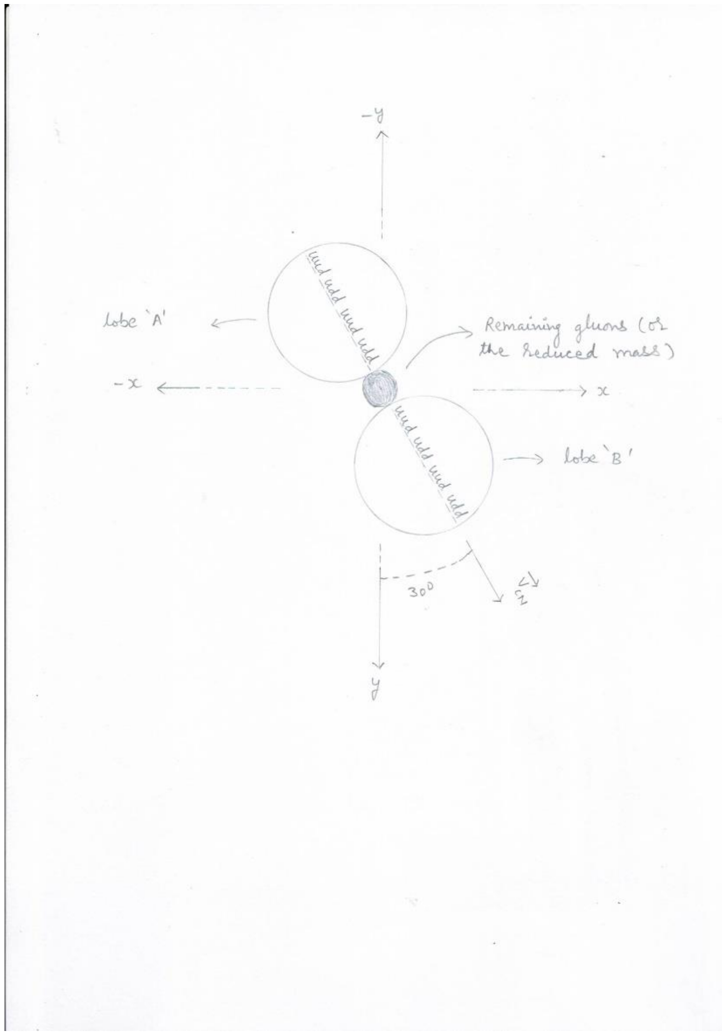
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degree

β = 30 degree



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

As the deuteron (of n^{th} bunch reaches at point F), it fuses with the confined lithion-6 to form a compund nucleus .

1.Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 45.5598 kev

= 108.0402 kev

= 0.1080402 Mev

2.Just before fusion, to overcome the electrostatic repulsive force exerted by the deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves its energy equal to 136.0700kev.

so, just before fusion,

the kinetic energy of hellion-4 is –

E_b = 388.2043 kev – 136.0700 kev

= 252.1343 kev

= 0.2521343 Mev

Kinetic energy of the compound nucleus :-

K.E. =[E_b of deuteron] + [E_b of lithion-6]

= [108.0402Kev] +[252.1343 Kev]

= 360.1745 Kev.

= 0.3601745 Mev

Mass of the compound nucleus

M= m_d +m_{Li-6}

= [3.3434x10^{-27} Kg] +[9.9853 x 10^{-27} Kg]

= 13.3287 x 10^{-27} Kg

Velocity of compound nucleus

K.E. = ½ MV^2_{CN} = 0.3601745Mev

$$V_{CN} = \left(\frac{2\text{x } 0.3601745\text{x } 1.6 \text{ x } 10^{-13}}{13.3287 \text{ x } 10^{-27} \text{ kg}} \right)^{½} \text{m/s}$$

$$V_{CN} = \left(1.1525584 \text{ x } 10^{-13} \right)^{½} \text{m/s}$$

13.3287×10^{-27}

V_{CN}= [0.08647192899 x 10^{14}] ^{½} m/s

V_{CN} = 0.2940 x 10^{7}m/s

Components of velocity of compound nucleus

$\overrightarrow{Vx}$ = V_{CN}cos α
=0.2940 X 10^{7}X0.5 m/s
= 0.1470 X 10^{7} m/s

$\overrightarrow{Vy}$ = V_{CN} cos β

= 0.2940X 10^{7}X0.866 m/s
= 0.2546 m/s

$\overrightarrow{Vz}$ = V_{CN} cosy
= 0.2940 X 10^{7}X0 m/s
= 0 m/s

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocityof the compound nucleus($\overrightarrow{Vcn}$) into the three particles – hellion-4,the hellion-4 and the reduced mass (Δm) .

Out of them , the two particles (the helion-4, and helion-4) are stable while the third one (reduced mass) isunstable .

According to the law of inertia , each particle that is produced due to splitting of the compound nucleus , hasan inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

So, for conservation of momentum

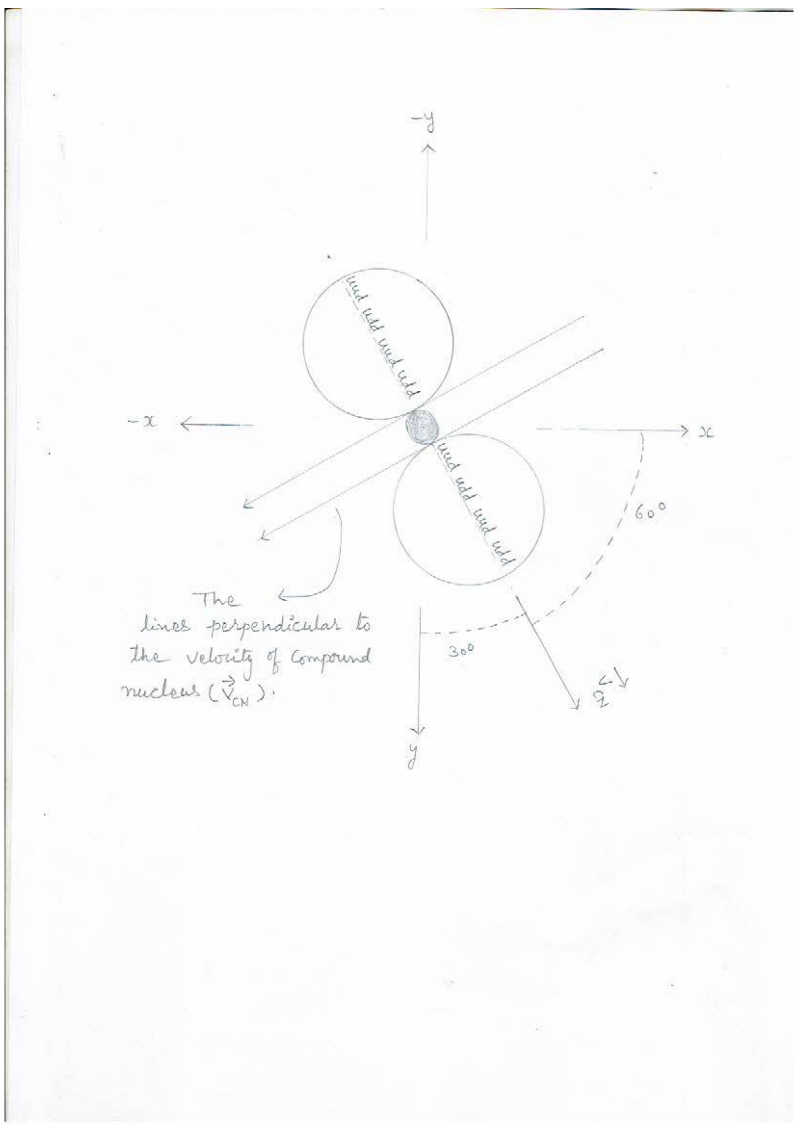
$M\overrightarrow{Vcn} = (m_{He-4} + \Delta m + m_{He-4})\overrightarrow{Vcn}$

Where ,

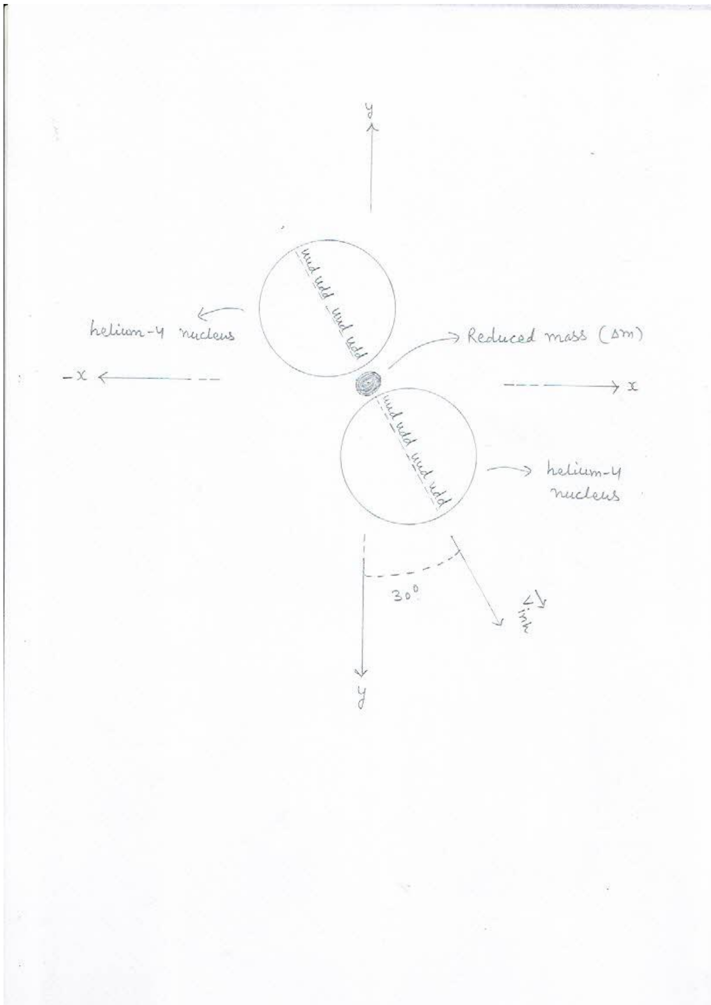
M	= massof the compound nucleus
$\overrightarrow{Vcn}$	= velocity of the compound nucleus
M_{He-4}	= mass of thehellion-4 nucleus
Δm	= reduced mass

The splitting of the heterogenous compound nucleus

The heterogenous compound nucleus to show the lines perpendicular tothe$\overrightarrow{Vcn}$



The splitting of the heterogenous compound nucleus



Inherited velocity of the particles (s) : -

Each particles has inherited velocity ($\underset{Vinh}{\longrightarrow}$) equal to the velocity of the compound nucleus($\underset{Vcn}{\longrightarrow}$) .There, due to splitting, two helium -4 nuclei are produced.

(I). Inhereted velocity of the each helium -4 nucleus

$V_{inh} = V_{CN} = 0.2940 \times 10^7$ m/s

Components of the inherited velocity of theeach helium -4 nucleus

1. $\overrightarrow{V_x} = V_{inh} \cos\alpha = V_{CN} \cos\alpha = 0.1470 \times 10^7$ m/s

2. $\overrightarrow{V_y} = V_{inh} \cos\beta = V_{CN} \cos\beta = 0.2546 \times 10^7$ m/s

3. $\overrightarrow{V_z} = V_{inh} \cos y = V_{CN} \cos y = 0$ m/s

(ii)Inherited velocity of the reduced mass

$V_{inh} = V_{CN} = 0.2940 \times 10^7$ m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propelboth the particles with equal and opposite momentum.

Reduced mass

$\Delta m = [m_d + m_{Li-6}] - [m_{He-4+} m_{He-4}]$

$= [m_d + m_{Li-6}] - 2[m_{He-4}]$

$\Delta m = [2.01355 + 6.01347708] - 2 [4.0015]$ amu

$\Delta m = [8.02702708] - [8.003]$ amu

$\Delta m = 0.02402708$ amu

$\Delta m = 0.02402708 \times 1.6605 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass (Δm) .

$E_{inh} = \frac{1}{2} \Delta m V^2_{CN}$

$\Delta m = 0.02402708 \times 1.6605 \times 10^{-27}$ kg

V^2_{CN} = 0.08647192899 x 10^{14}

E_{inh} = ½ x 0.02402708 x 1.6605 x 10^{-27} x 0.08647192899 x 10^{14} J

E_{inh} = 0.00172498382 x 10^{-13} J

E_{inh} = 0.001078 Mev

Released energy (E_R)

E_R = Δmc^2

E_R = 0.02402708 x 931 Mev

E_R = 22.369211 Mev

Total energy (E_T)

E_T = E_{inh} + E_R

E_T = [0.001078 + 22.369211] Mev

E_T 22.370289 Mev

Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses . so,the increased energy (E_{inc}) of the particles are :-

1.Increased kinetic energy of each hellion-4 nucleus

$$E_{inc} = \frac{m_{He-4}}{m_{He-4} + m_{He-4}} \times E_T$$

$E_{inc} = E_T/2$

$E_{inc} = 22.370289 /2$ Mev

$E_{inc} = 11.185144$ Mev

6..Increased velocity of each of the helium-4 nucleus .

(1) For helium-4 nucleus

$E_{inc} = {}^{1}/{}_{2} m_{He-4} \; v_{inc}^2$

$V_{inc} = [\, 2 \times E_{inc}/m_{He-4} \,]^{½}$

$$= \left(\frac{2x11.185144 \; x1.6x10^{-13} \; J}{6.64449 \; x10^{-27} \; kg} \right)^{½} \; m/s$$

$$= \left(\frac{35.7924608 \; x10^{-13}}{} \right)^{½} \; m/s$$

6.64449×10^{-27}

$= [\ 5.38678827118 \times 10^{14}\ ]^{½}$ m/s

$= 2.3209 \times 10^{7}$m/s

7 Angle of propulsion

1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

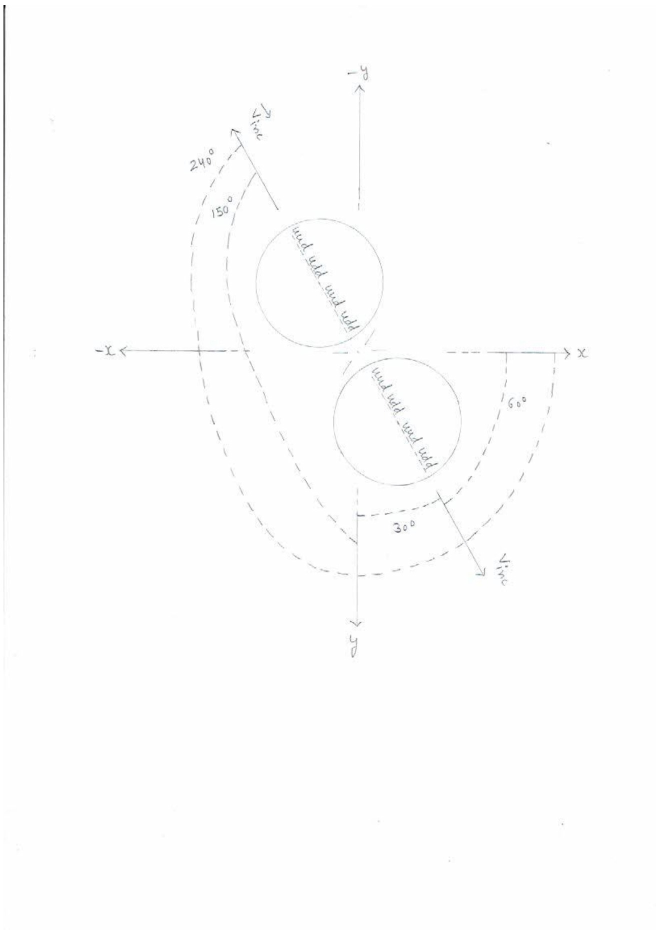
2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ' F ' , as V_{CN} makes 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

so, the one hellion-4is propelled making 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

While the other hellion-4 is propelled making 240° angle with x-axis , 150° angle withy-axis and 90° angle with z-axis .

Propulsion of the particles



Components of the increased velocity (V_{inc}) of the particles.

(i) Forleft hand side propelled helion-4

1 $\vec{V_x} = V_{inc} \cos \alpha$

$V_{inc} = 2.3209 \times 10^7$ m/s

$\cos\alpha = \cos(240) = -0.5$

$\vec{V_x} = 2.3209 \times 10^7 \times (-0.5)$ m/s

$= -1.1604 \times 10^7$ m/s

2 $\vec{V_y} = V_{inc} \cos \beta$

$\cos \beta = \cos (150) = -0.866$

$\vec{V_y} = 2.3209 \times 10^7 \times (-0.866)$ m/s

$= -2.0098 \times 10^7$ m/s

3 $\vec{V_z} = V_{inc} \cos y$

$\cos y = \cos 90^o = 0$

$\vec{V_z} = 2.3209 \times 10^7 \times 0$

$= 0$ m/s

For right hand side propelled helion-4

1 $\vec{V_x} = V_{inc} \cos\alpha$

$V_{inc} = 2.3209 \times 10^7$ m/s

$\cos\alpha = \cos(60) = 0.5$

$\vec{V_x} = 2.3209 \times 10^7 \times 0.5$ m/s

$= 1.1604 \times 10^7$ m/s

2 $\vec{V_y} = V_{inc} \cos \beta$

$\cos \beta = \cos (30) = 0.866$

$\vec{V_y} = 2.3209 \times 10^7 \times 0.866$ m/s

$= 2.0098 \times 10^7$ m/s

3 $\vec{V_z} = V_{inc} \cos y$

$\cos y = \cos (90) = 0$

$\vec{V_z}$ Vz Vz Vz= $2.3209 \times 10^7 \times 0$ m/s

$= 0$ m/s

9.. Componentsof the final velocity(Vf)oftheparticles

1 For right hand side propelled helion-4

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\vec{Vf}$)=($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X – axis	$\overrightarrow{Vx}$ =0.1470x 10^7m/s	$\overrightarrow{Vx}$= 1.1604 x10^7m/s	$\overrightarrow{Vx}$= 1.3074x10^7m/s
y –axis	$\overrightarrow{Vy}$ = 0.2546 x 10^7m/s	$\overrightarrow{Vy}$= 2.0098x 10^7m/s	$\overrightarrow{Vy}$=2.2644 x10^7m/s
z –axis	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$= 0m/s

2.. Forleft hand side propelled helion-4

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity ($\vec{Vf}$)=($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X – axis	$\overrightarrow{Vx}$= 0.1470x 10^7m/s	$\overrightarrow{Vx}$= - 1.1604x10^7m/s	$\overrightarrow{Vx}$ = - 1.0134 x10^7m/s
y –axis	$\overrightarrow{Vy}$=0.2546x10^7m/s	$\overrightarrow{Vy}$ =- 2.0098x10^7m/s	$\overrightarrow{Vy}$ = - 1.7552x10^7m/s
z –axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$=0 m/s

10..Final velocity (vf) of For right hand side propelled helion-4

$V^2= V_x^2 + V_Y^2 + V_Z^2$

$V_x = 1.3074X10^7 m/s$

$V_y = 2.2644X10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (1.3074 X10^7)^2 + (2.2644X10^7)^2 +(0)^2$ m^2/s^2
$V_f^2 = (1.70929476 X10^{14})+(5.12750736 X10^{14})+0$ m^2/s^2
$V_f^2= 6.83680212 X10^{14}$ m^2/s^2
$V_f = 2.6147x10^7 m/s$

Final kinetic energy of right hand side propelled helion-4

$E= ½ m_{He-4}V_f^2$

$E = ½ x 6.64449x 10^{-27} x 6.83680212 X10^{14}$ J

= $22.7135316591 X 10^{-13}$ J

= 14.1959Mev

$m_{He-4}V_f^2 = 6.64449x 10^{-27} x6.83680212X10^{14}$J

= $45.4270 x 10^{-13}$ J

10.. Final velocity (vf) of left hand side propelled helion-4

$V_f^2 = V_x^2+ V_Y^2 +V_Z^2$

$V_x =1.0134X 10^7$ m/s

$V_y = 1.7552 X 10^7$ m/s

$V_z= 0$ m/s

$V_f^2 = (1.0134 \text{ X } 10^7)^2 + (1.7552 \text{ X } 10^7 \ )^2 + (0)^2 \ \ m^2/s^2$
$V_f^2 = (1.02697956 \text{ X } 10^{14}) + (3.08072704 \text{ X } 10^{14}) + 0 \ \ m^2/s^2$
$V_f^2 = 4.1077066 \text{ X } 10^{14} \ m^2/s^2$
$V_f = 2.0267 \text{ x } 10^7 \text{ m/s}$

Final kinetic energy of left hand side propelled helion-4

$E = ½ \ m_{He\text{-}4} V_f^2$

$V_f^2 = 4.1077066 \text{ X } 10^{14} \ m^2/s^2$

$E = ½ \text{ x } 6.64449 \text{x } 10^{-27} \text{ x } 4.1077066 \text{ X } 10^{14} \text{ J}$

$= 13.6468077133 \text{ X } 10^{-13} \text{ J}$

= 8.5292 Mev

$m_{He\text{-}4} V_f^2 = 6.64449 \text{x } 10^{-27} \text{ x } 4.1077066 \text{ X } 10^{14} \text{ J}$

$= 27.2936 \text{ x } 10^{-13} \text{ J}$

Forces acting on the right hand side propelled helion-4

1 $F_y = q \ V_x \ B_z \sin\theta$

$\underset{Vx}{\rightarrow} = 1.3074 \text{ x } 10^7 \text{ m/s}$ $\underset{Bz}{\rightarrow} = -1.001 \text{ x} 10^{-1}$ Tesla

$q = 2 \text{ x } 1.6 \text{ x } 10^{-19} \text{ c}$

$\sin\theta = \sin 90^o = 1$

$Fy = 2 \text{x} 1.6 \text{ x } 10^{-19} \text{x} 1.3074 \text{ x } 10^7 \text{x } 1.001 \text{x} 10^{-1} \text{x } 1 \quad N$
$= 4.1878 \text{ x} 10^{-13} \text{ N}$

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to(-) y-axis ,

so ,
$\underset{Fy}{\rightarrow} = -4.1878 \text{ x } 10^{-13} \text{N}$

2 $F_z = q \ V_x \ B_y \sin\theta$

$\underset{By}{\rightarrow} = 1.0013 \text{ x} 10^{-1}$Tesla

$\sin\theta = \sin 90^o = 1$

$Fz = 2 \text{x } 1.6 \text{ x } 10^{-19} \text{ x } 1.3074 \text{ x } 10^7 \text{ x } 1.0013 \text{ x} 10^{-1} \text{ x } 1 \quad N$
$= 4.1891 \text{ x } 10^{-13} \text{ N}$
Form the right hand palm rule , the direction of theforce $\underset{Fz}{\rightarrow}$ is according to (-) Z- axis ,

so ,

$\overrightarrow{Fz}$ = - 4.1891 x 10^{-13}N

3 F_x = q V_y B_z sin θ

$\overrightarrow{Vy}$=2.2644 x 10^7 m/s

$\overrightarrow{Bz}$= 1.001x10^{-1} Tesla

sin θ = sin 90° = 1

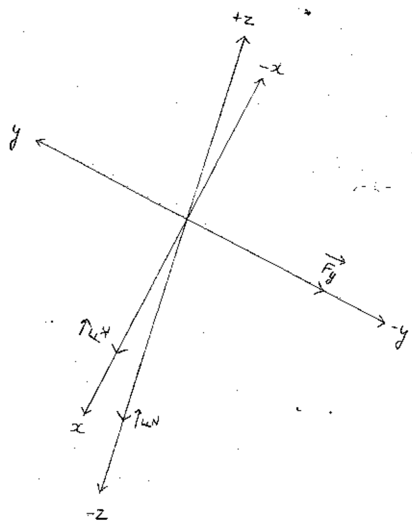
Fx = 2x1.6 x 10^{-19}x 2.2644 x 10^7x 1.001x10^{-1} x 1 N

= 7.2533 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (+) x axis ,

so , $\overrightarrow{Fx}$ = 7.2533 x 10^{-13} N

The forces acting on the right hand side propelled helium – 4 nucleus



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 7.2533 \times 10^{-13}$ N

$F_y = 4.1878 \times 10^{-13}$ N

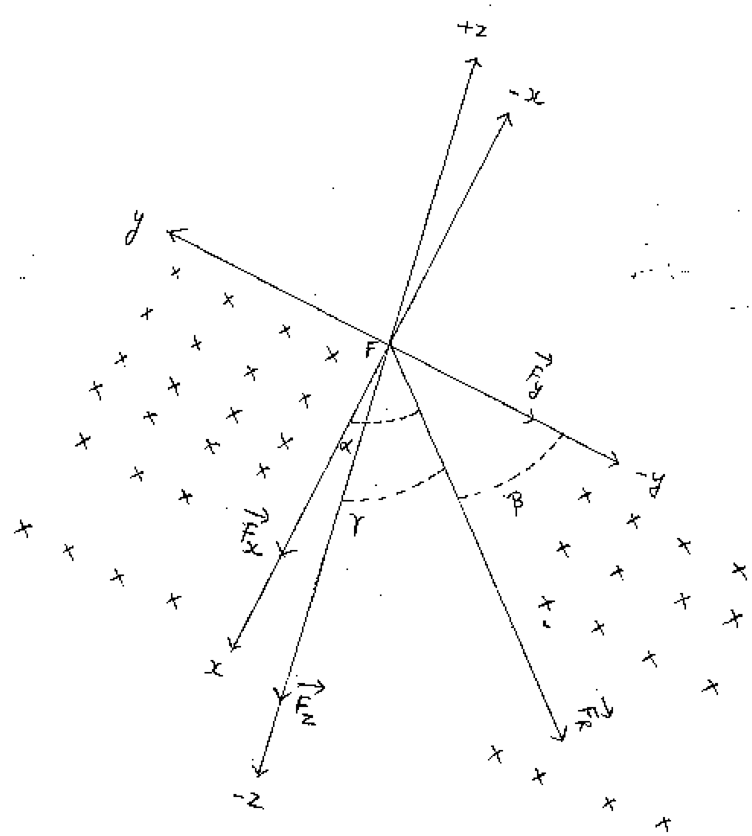
$F_z = 4.1891 \times 10^{-13}$

$F_R^2 = (7.2533 \times 10^{-13})^2 + (4.1878 \times 10^{-13})^2 + (4.1891 \times 10^{-13})^2$ N^2

$F_R^2 = (52.6103 \times 10^{-26}) + (17.53766884 \times 10^{-26}) + (17.54855881 \times 10^{-26})$ N^2

$F_R^2 = 87.69652765 \times 10^{-26} N^2$

$F_R = 9.3646 \times 10^{-13}$ N


+z
-x
y
F
-y
α
β
γ
x
-z

Radius of the circular orbit to be followed by the right hand side propelled helion-4 :

$r = mv^2 / F_R$

$mv^2 = 45.4270 \times 10^{-13}$ J

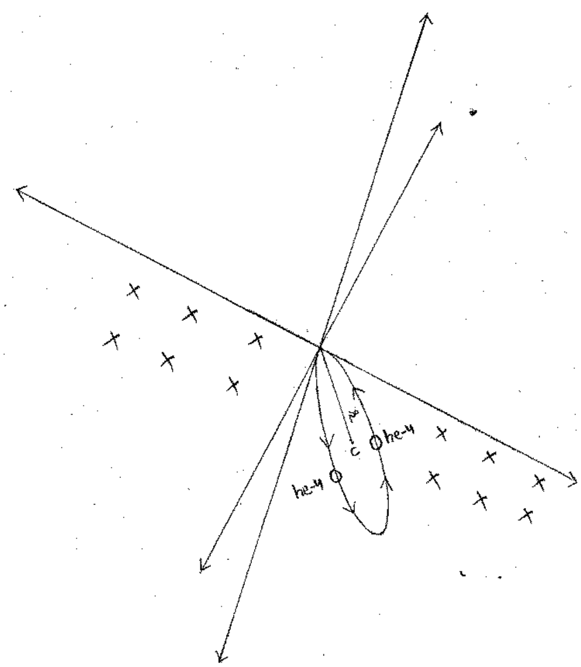
$F_r = 9.3646 \times 10^{-13}$ N

$r = \dfrac{45.4270 \times 10^{-13} \text{ J}}{9.3646 \times 10^{-13} \text{ N}}$

$r = 4.8509$ m

The circular orbit to be followed by theright hand side propelled helion -4 nucleus lies in the plane made up of positive x-axis, negative y-axis and the negative z-axis.

Che-4 = center of the circular orbitto be followed by the right hand side propelled helion -4 nucleus.



Theplane of the circular orbit to be followed by the right hand side propelled helion-4 makes angles with positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow} / F_r$

$\underset{Fx}{\rightarrow}$ = 7.2533 x 10^{-13} N

F_r= 9.3646 x 10^{-13} N

Puttingvalues

Cos α= 0.7745

α= 39.24degree [∴ cos (39.24) = 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$= - 4.1878 x 10^{-13} N

F_r = 9.3646 x 10^{-13} N

Puttingvalues

Cosβ = - 0.4471

β =243.44 degree [∴ cos (243.44)= -0.4471]

3with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow}$/ F_r

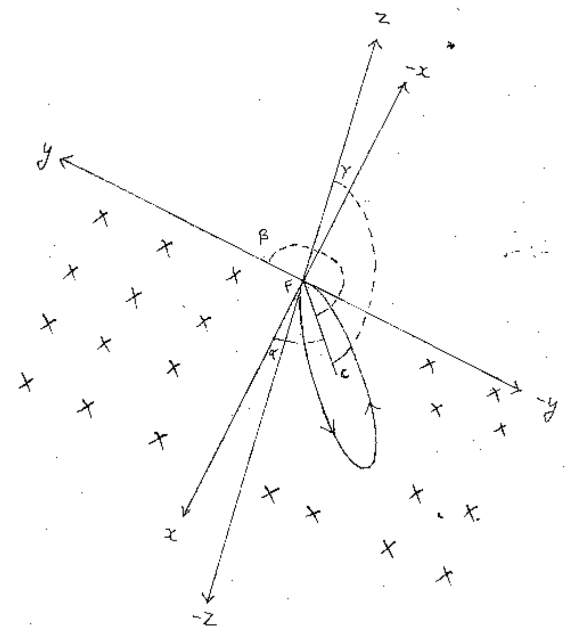
$\underset{Fz}{\rightarrow}$ = - $\underline{4.1891 \text{ x } 10^{-13} N}$

F_r = 9.3646x 10^{-13} N

Putting values

Cos y = - 0.4473
y = 243.425 degree

The plane of the circular orbit to be followed by the right hand side propelled helion -4 makes angles with positive x , y , and z axes as follows :-



Where,

α = 39.24degree

β = 243.44 degree

Y =243.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to beobtained by the right hand side propelled hellion-4 .

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

d = 2 x r

$= 2x\ 4.8509$ m

$= 9.7018$ m

$\cos \alpha = 0.7745$

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 9.7018 \times 0.7745$ m

$x_2 - x_1 = 7.5140$ m

$x_2 = 7.5140$ m $[\therefore x_1 = 0]$

$\cos \beta = \frac{y_2 - y_1}{d}$

$\cos \beta = - 0.4471$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 9.7018 \times (- 0.4471)$ m

$y_2 - y_1 = - 4.3376$ m

$y_2 = - 4.3376$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = - 0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 9.7018 \times (- 0.4473)$m

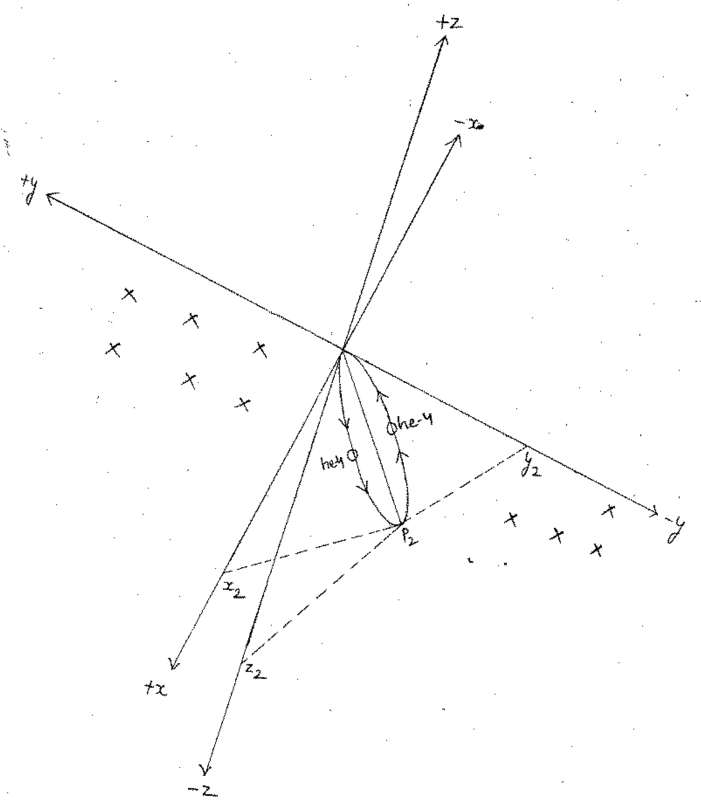
$z_2 - z_1 = - 4.3396$ m

$z_2 = - 4.3396$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumfrence of the circleto be obtained by the right hand sidepropelledhelion-4 are as shown below.

The line ___is the diameter of the circle .

P_1P_2


+z
-x
+y
he-4
he4
y_2
-y
P_2
x_2
z_2
+x
-z

Conclusion :-

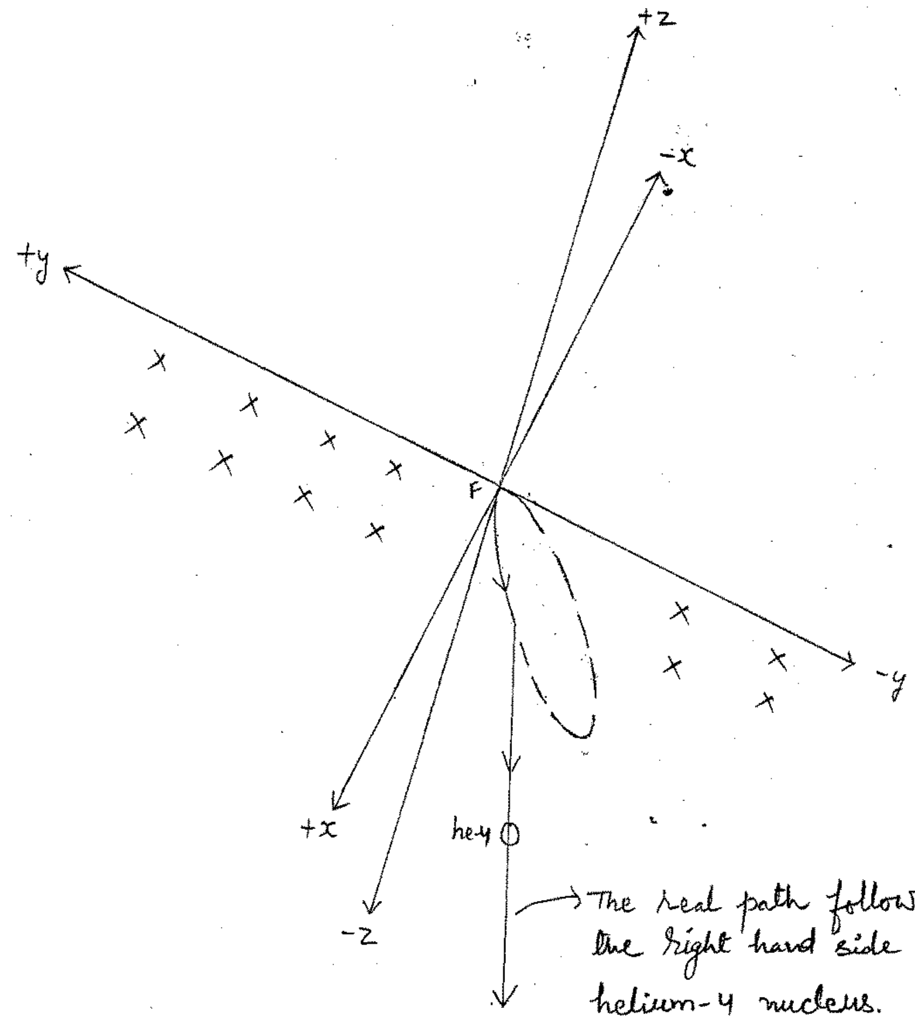
The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on theright hand side propelled hellion-4are along **+x , -y and -z**axes respectively .

So by seeing the direction ofthe resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the right hand side propelled hellion-4 lies in the plane made up of positivex- axis, negative y-axis and negative z-axis where the magnetic fields are applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the right hand side propelled hellion-4 to undergoto a circular orbit of radius 4.8509 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (7.5140 m,- 4.3376 m ,-4.3396 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the right hand side propelled helion-4is not confined.



→ The real path followed by the right hand side propelled helium-4 nucleus.

(In trying to follow the circular orbit, the right hand side propelled helium-4 nucleus strike to the base wall of the tokamak. So, it can't complete the circle.)

forces acting on the left hand side propelled hellion-4

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow}$ =-1.0134x 10^7m/s $\underset{Bz}{\rightarrow}$= - 1.001 x$10^{-1}$ Tesla

q = 2x1.6 x 10^{-19} c

sin θ = sin 90° = 1

Fy = 2x1.6 x 10^{-19} x 1.0134x 10^7x 1.001 x10^{-1}x 1 N
= 3.2461 x10^{-13} N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (-) y-axis ,

so,
$\underset{Fy}{\rightarrow}$ = 3.2461 x 10^{-13} N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow}$= 1.0013x$10^{-1}$Tesla

sin θ = sin 90° = 1

Fz = 2x1.6 x10^{-19} x 1.0134 x 10^7x 1.0013x10^{-1} x 1 N
= 3.2470 x 10^{-13} N

Form the right hand palm rule , the direction ofthe force $\underset{Fz}{\rightarrow}$ is according to (-) Z- axis ,

so ,
$\underset{Fz}{\rightarrow}$ =3.2470 x 10^{-13}N

3 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow}$ = - 1.7552 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= - 1.001 x$10^{-1}$Tesla

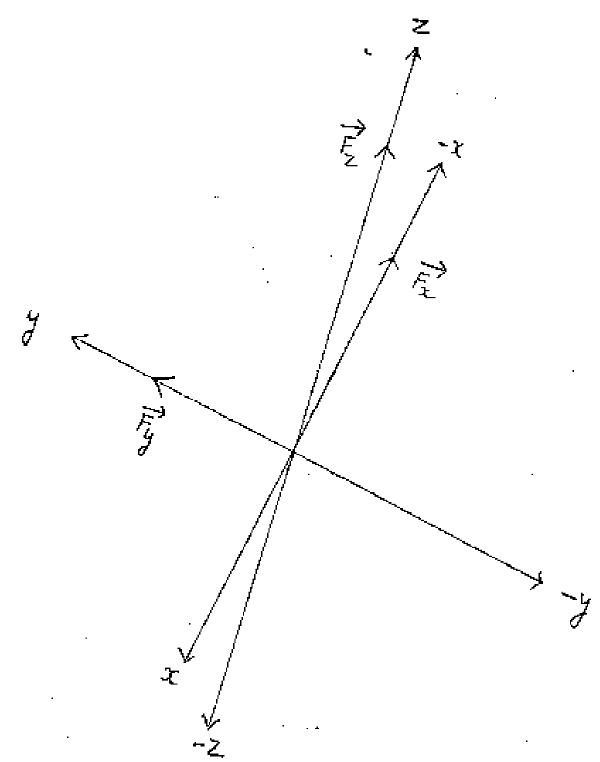
sin θ = sin 90° = 1

Fx = 2x 1.6 x 10^{-19} x 1.7552 x 10^7x1.001 x10^{-1}x 1 N
= 5.6222 x 10^{-13}N

Form the right hand palm rule , thedirection of the force $\underset{Fx}{\rightarrow}$ is according to (+) x axis ,

so , $\underset{Fx}{\rightarrow}$ = - 5.6222 x 10^{-13} N

Forces acting on the left hand side propelled hellion-4



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 5.6222 \times 10^{-13}$ N

$F_y = 3.2461 \times 10^{-13}$ N

$F_z = 3.2470 \times 10^{-13}$ N

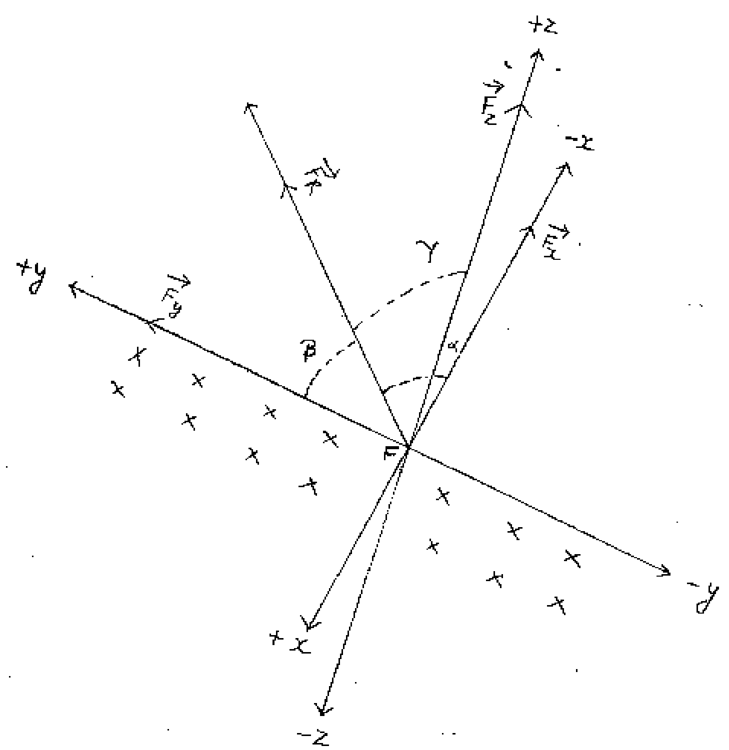
$F_R^2 = (5.6222 \times 10^{-13})^2 + (3.2461 \times 10^{-13})^2 + (3.2470 \times 10^{-13})^2$ N^2

$F_R^2 = (31.60913284 \times 10^{-26}) + (10.53716521 \times 10^{-26}) + (10.543009 \times 10^{-26})$ N^2

$F_R^2 = 52.68930705 \times 10^{-26}$ N^2

$F_R = 7.2587 \times 10^{-13}$ N

Resultant force acting on the left hand side propelled helion-4



Radius of the circular orbit to be followed by the left hand side propelled helion-4 :

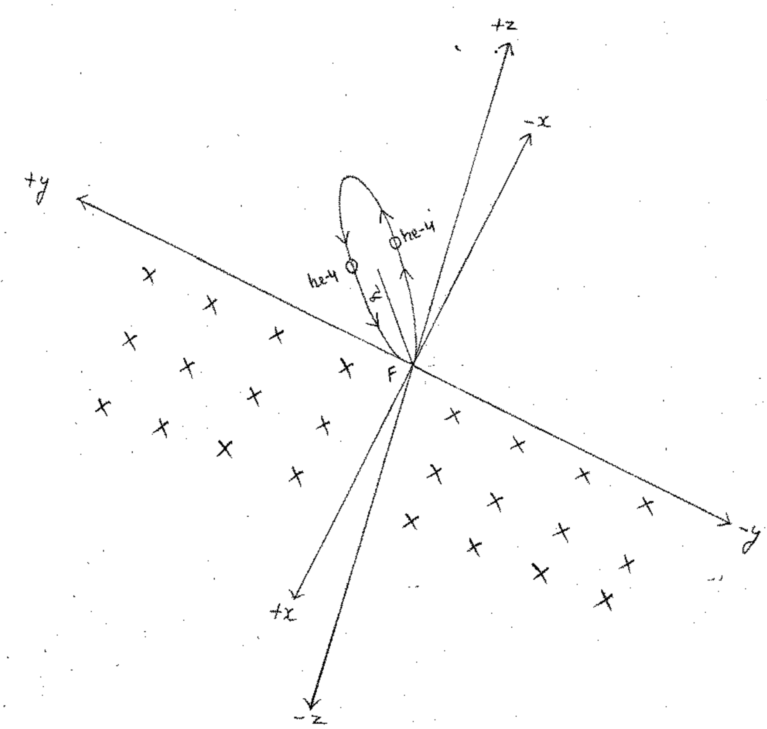
$r = mv^2 / F_R$

$mv^2 = 27.2936 \times 10^{-13} J$

$F_r = 7.2587 \times 10^{-13} N$

$$r = \frac{27.2936 \times 10^{-13} J}{7.2587 \times 10^{-13} N}$$

$r = 3.7601\ m$



The circular orbit to be followed by the left hand side propelled helion-4 lies in the plane made up of negative x-axis, positive y-axis and the positive z-axis.
C= center of the circleto be followed by the left hand side propelled helion-4.

The plane of the circular orbit to be followed by the left hand side propelledhellion-4 makes angles with positive x , y and z-axes as follows :-

1 withx- axis

$\text{Cos } \alpha = \underline{F_R \cos \alpha} / Fr = \underset{Fx}{\rightarrow} / F_r$

$\underset{Fx}{\rightarrow} = - 5.6222 \times 10^{-13}$ N

$F_r = 7.2587 \times 10^{-13}$ N

Puttingvalues

Cos α = - 0.7745

α = 219.24 degree [∴ cos (219.24) = - 0.7745]

2 with y- axis

$\text{Cos } \beta = \underline{F_R \cos \beta} / F_r = \underset{Fy}{\rightarrow} / F_r$

$\underset{Fy}{\rightarrow} = 3.2461 \times 10^{-13}$ N

$F_r = 7.2587 \times 10^{-13}$N

Putting values

Cosβ = 0.4472

β= 63.43degree [∴cos (63.43) = 0.4472]

3 with z- axis

$\text{Cos } y = \underline{F_R \cos y} / F_r = \underset{Fz}{\rightarrow} / F_r$

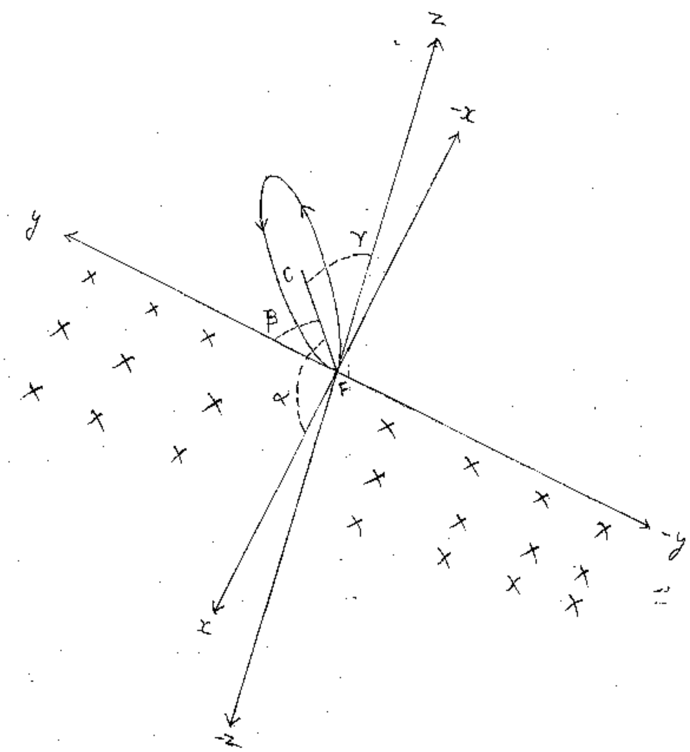
$\underset{Fz}{\rightarrow} = \underline{3.2470 \times 10^{-13} N}$

$F_r = 7.2587 \times 10^{-13}$ N

Putting values

Cos y = 0.4473
y = 63.425 degree

Theplane of the circular orbit To be followed by the left hand side propelled helion -4 makes angles with positive x , y , and z axes as follows :-



Where, α = 219.24 degree

β = 63.43 degree

Y = 63.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the left hand side propelled hellion-4 .

$\cos \alpha = \frac{x_2 - x_1}{d}$

d = 2 x r

= 2x 3.7601 m

$= 7.5202 \text{ m}$

$\cos\alpha = -0.7745$

$x_2 - x_1 = dx \cos\alpha$

$x_2 - x_1 = 7.5202 \times (-0.7745) \text{ m}$

$x_2 - x_1 = -5.8243 \text{ m}$

$x_2 = -5.8243 \text{ m} [\therefore x_1 = 0]$

$\cos\beta = \dfrac{y_2 - y_1}{d}$

$\cos\beta = 0.4472$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 7.5202 \times 0.4472 \text{m}$

$y_2 - y_1 = 3.3630 \text{ m}$

$y_2 = 3.3630 \text{ m} \quad [\therefore y_1 = 0]$

$\cos y = \dfrac{z_2 - z_1}{d}$

$\cos y = 0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 7.5202 \times 0.4473 \text{ m}$

$z_2 - z_1 = 3.3637 \text{m}$

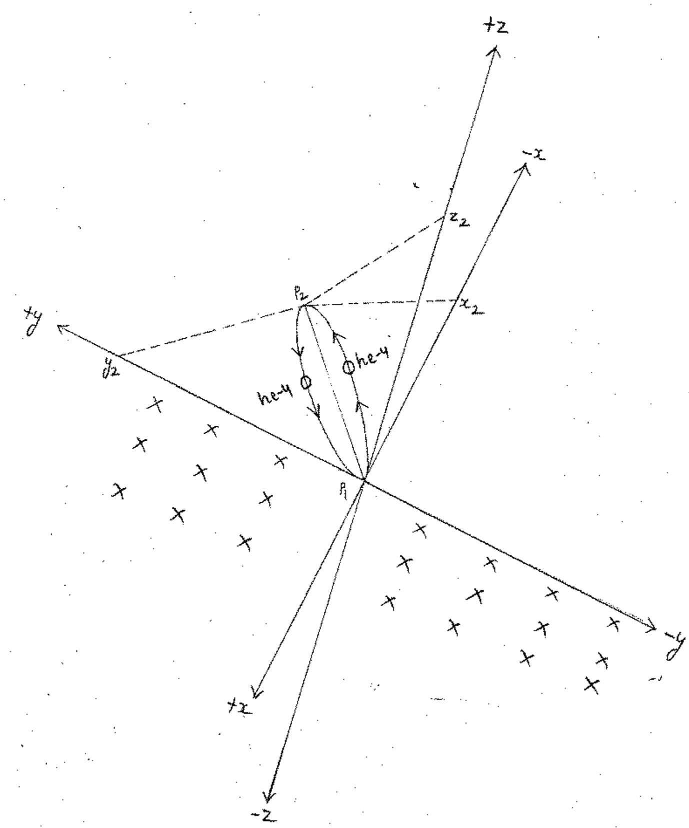
$z_2 = 3.3637 \text{m} \quad [\therefore z_1 = 0]$

The cartesian coordinates of the points p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2)

The cartesian coordinates of the points p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumferenceof the circle to be followed by the left hand side propelled helion -4are as shown above.

The line___ isthe diameter of thecircle .

P1P2


+z
-x
z_2
P_2
x_2
+y
y_2
he-4
he-4
P_1
-y
+x
-z

Conclusion :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$thatare acting on the left hand side propelled helium-4 nucleusare along **-x , +y and +z** axes respectively .

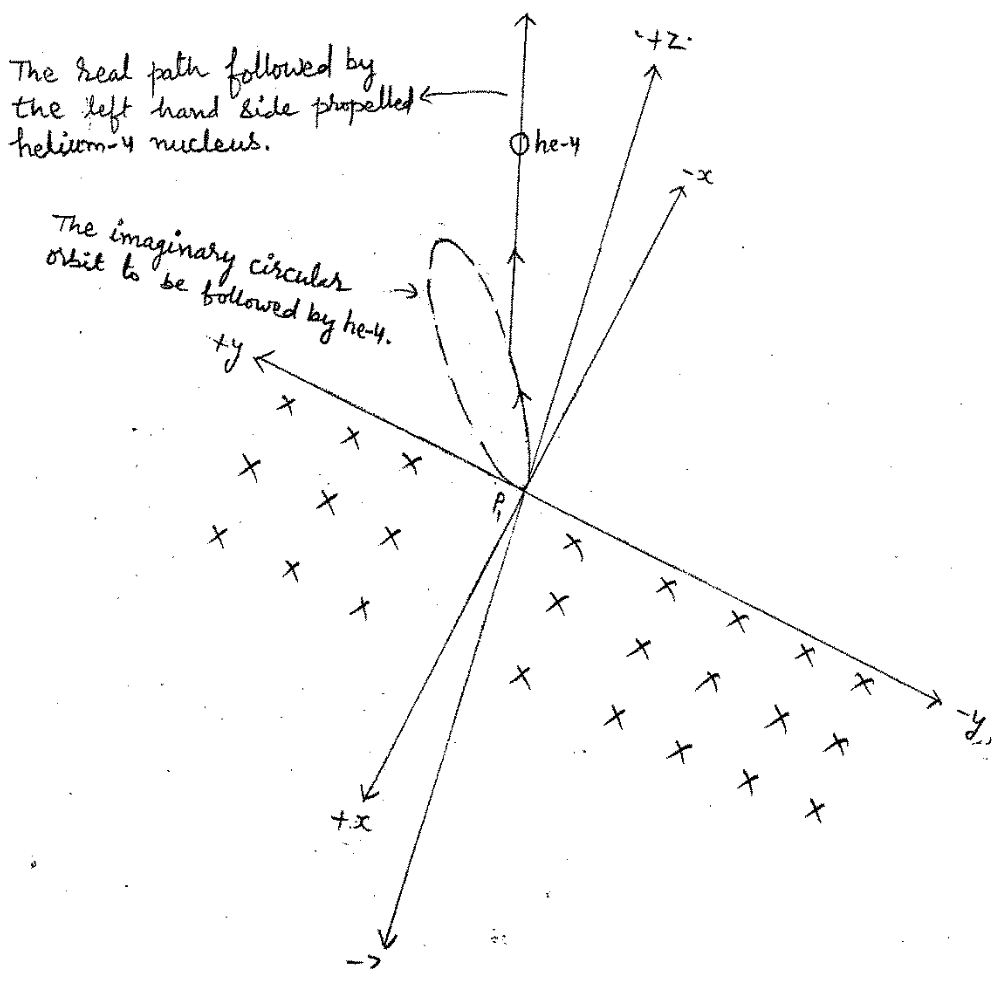
So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the left hand side propelled helium-4 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the left hand side propelled helium-4 nucleus to undergo to a circular orbit of radius 3.7601m

It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2(-5.8243 m , 3.3630 m, 3.3637 m) where the magnetic fields are not applied.

So , It starts its circularmotion from point P_1(0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the left hand side propelled helium-4 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

So the left hand side propelledhelium-4nucleus is not confined


The real path followed by the left hand side propelled helium-4 nucleus.
he-4
+z
-x
The imaginary circular orbit to be followed by he-4.
+y
P1
-y
+x

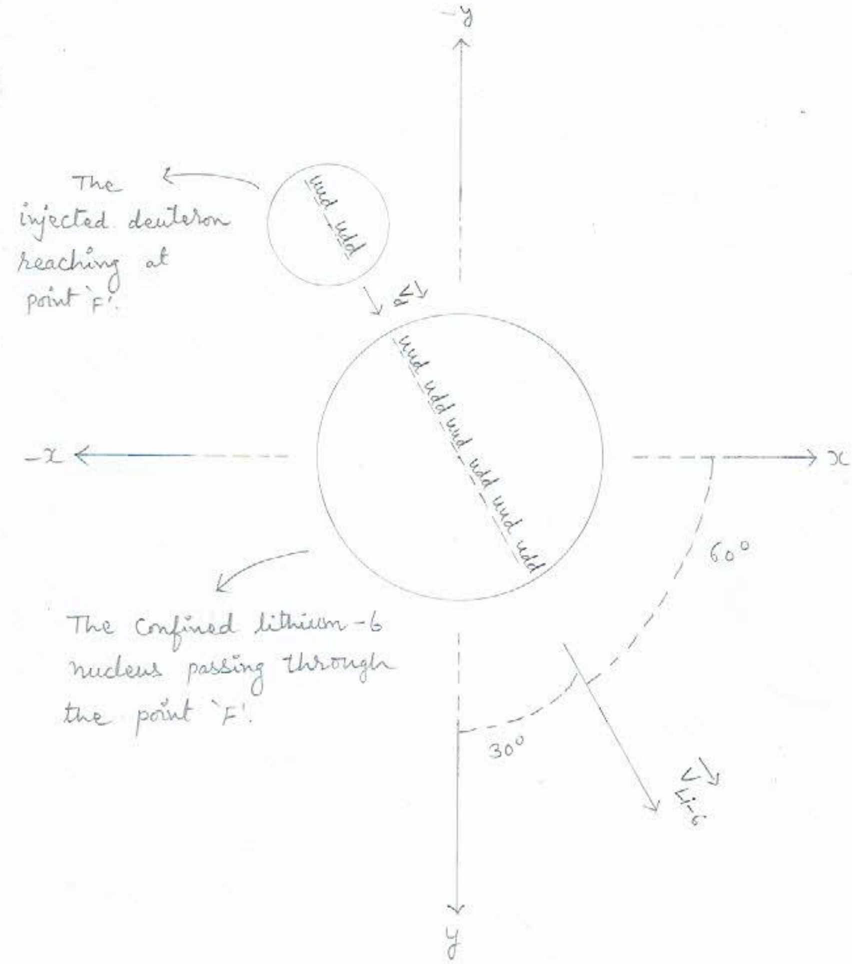
For fusion reaction

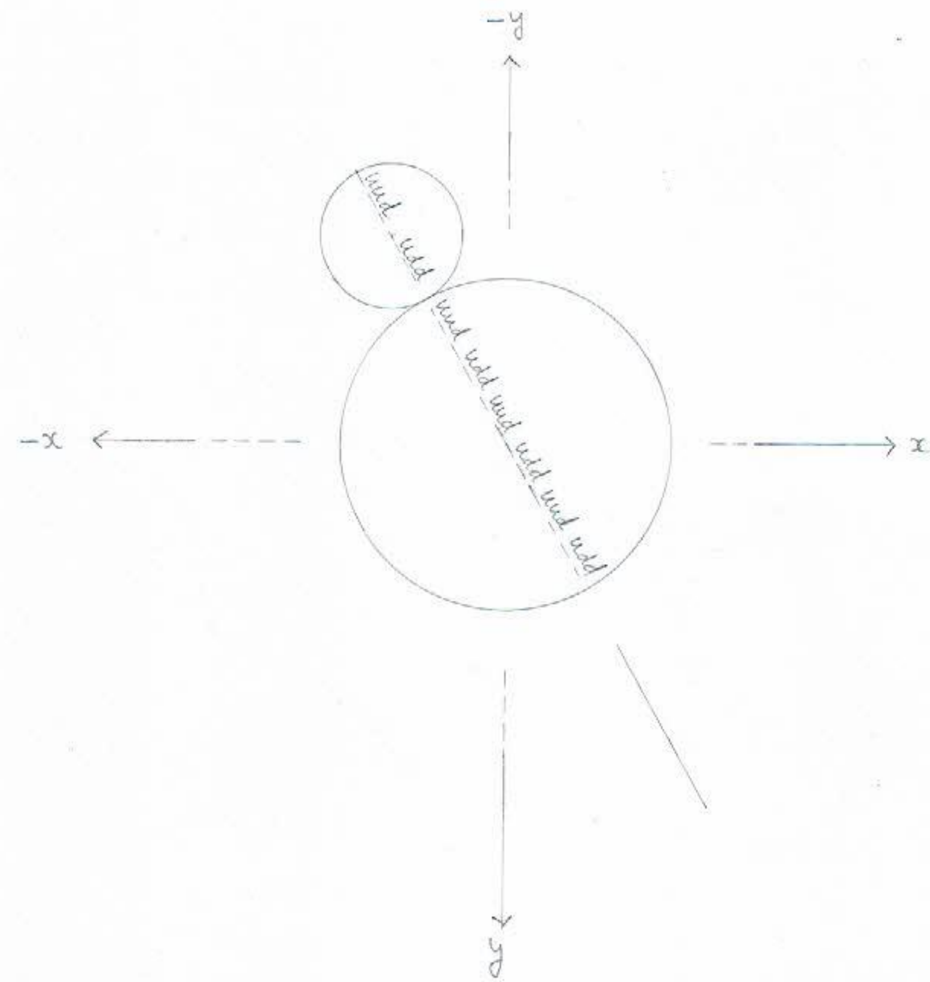
$^{2}_{1}H + ^{6}_{3}Li \rightarrow [_{4}^{8}Be] \rightarrow _{2}^{3}He + _{2}^{4}He + ^{1}_{0}n$

The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6] with the confined lithion-6 passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6.

Interaction of nuclei (1)


-y
The injected deuteron reaching at point `F'.
uud udd
-x
uud udd uud udd uud udd
x
60°
The confined lithium-6 nucleus passing through the point `F'.
30°
y

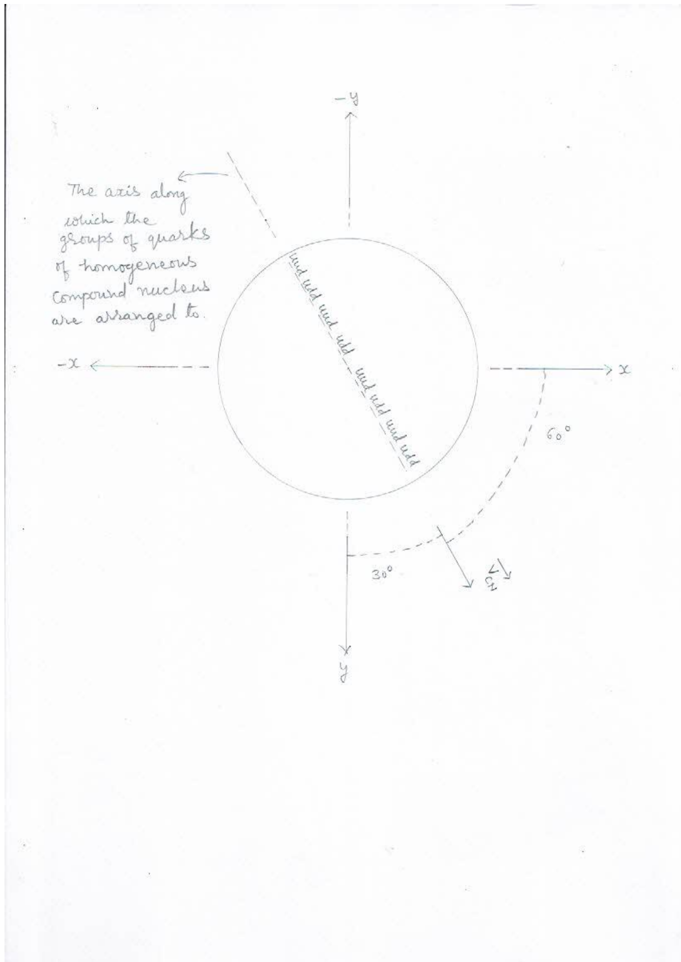

-y
uud udd
uud udd uud udd uud udd
-x
x
y

2.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (deuteron and the lithion-6 nucleus) behave like a liquid and form a homogeneous compound nucleus . having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 8 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3. Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the beryllium - 7) than the reactant one (the lithion-6) includes the other seven (nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

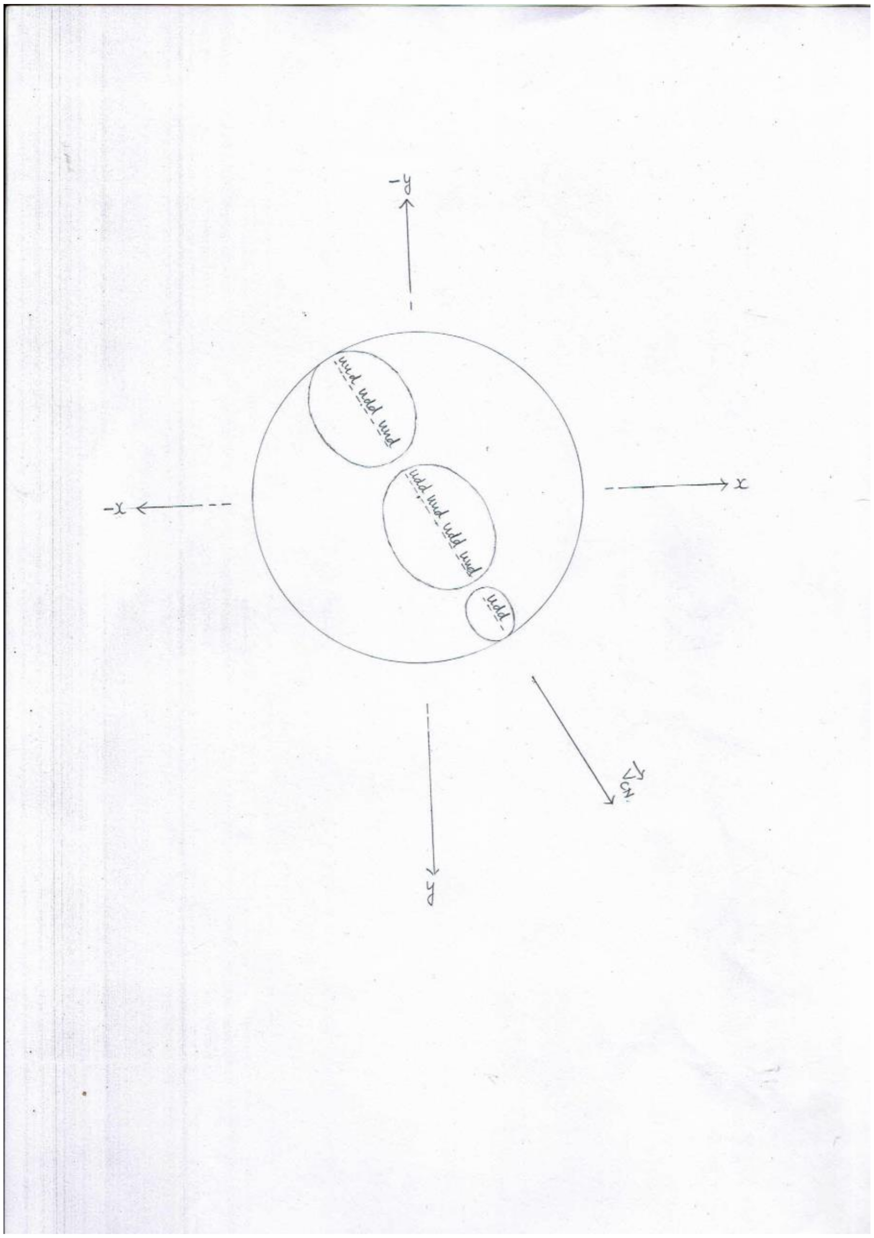
While , the remaining groups of quarks to become a stable nucleus (the neutron) includes its surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the beryllium – 7 nucleus and the smaller nucleus is the neutron.

The greater nucleus is the lobe ‘A ‘ and the smaller nucleus is the lobe ‘B’ while the remainigh space represent the remaining gluons .



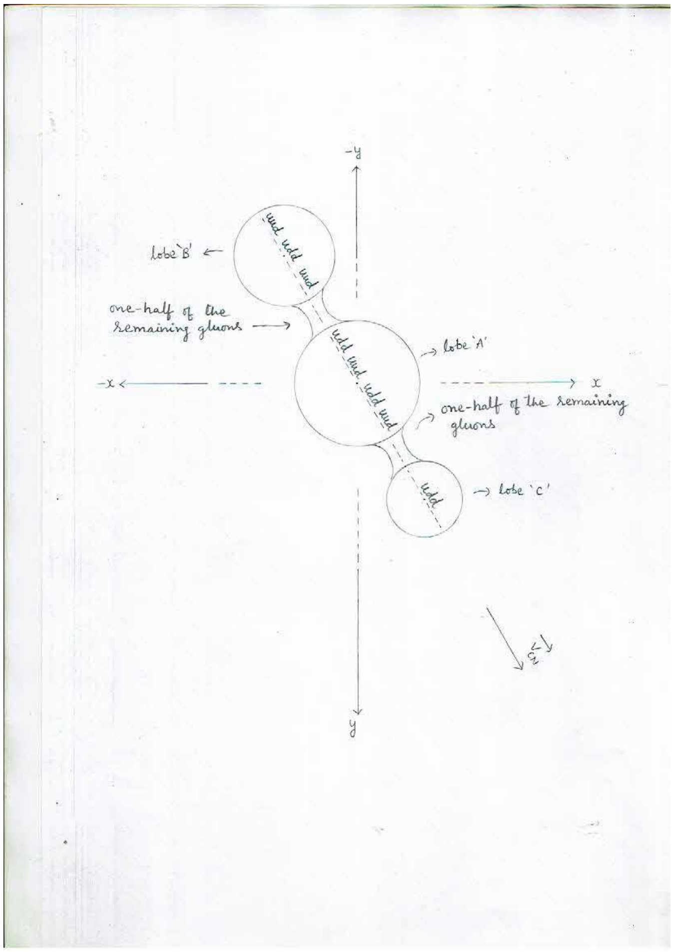
Formaton of lobes

4..Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

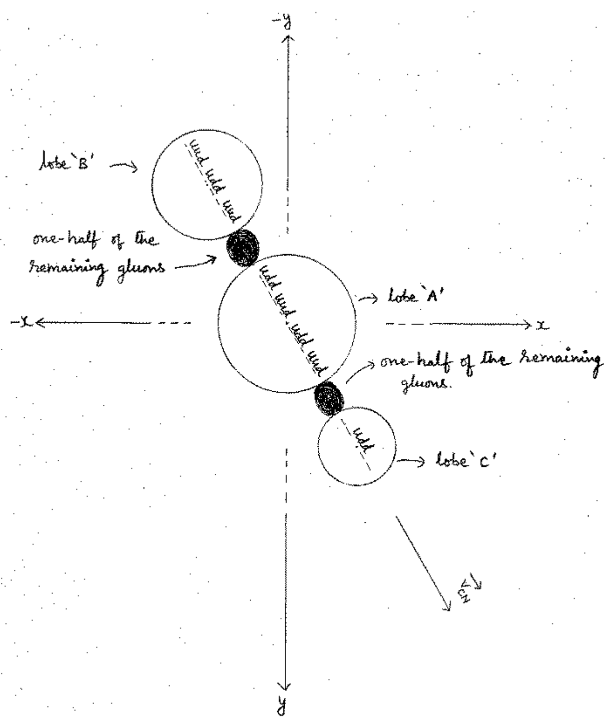
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degree

β = 30 degree



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

As the deuteron of n^{th} bunch reaches at point F , it fuses with the confined lithion-6 to form a compund nucleus .

1.Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

so, just before fusion,

the kinetic energy of n^{th} deuteon is –

E_b = 153.6 kev – 45.5598 kev

= 108.0402 kev

= 0.1080402 Mev

2.Just before fusion, to overcome the electrostatic repulsive force exerted by the deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves its energy equal to 136.0700kev.

so, just before fusion,

the kinetic energy of hellion-4 is –

E_b = 388.2043 kev – 136.0700 kev

= 252.1343 kev

= 0.2521343 Mev

Kinetic energy of the compound nucleus :-

K.E. =[E_b of deuteron] + [E_b of lithion-6]

= [108.0402Kev] +[252.1343 Kev]

= 360.1745 Kev.

= 0.3601745 Mev

Mass of the compound nucleus

M= m_d +m_{Li-6}

= [3.3434x10^{-27} Kg] +[9.9853 x 10^{-27} Kg]

= 13.3287 x 10^{-27} Kg

Velocity of compound nucleus

K.E. = ½ MV^2_{CN} = 0.3601745Mev

$$V_{CN} = \left(\frac{[\,2\times 0.3601745\times 1.6\times 10^{-13}]}{13.3287\times 10^{-27}\ \text{kg}} \right)^{1/2} \quad \text{m/s}$$

$$V_{CN} = \left(\frac{1.1525584 \times 10^{-13}}{13.3287 \times 10^{-27}} \right)^{1/2} m/s$$

V_{CN}= [0.08647192899 x 10^{14}] $^{1/2}$ m/s

V_{CN} = 0.2940 x 10^{7}m/s

Components of velocity of compound nucleus

$\vec{Vx}$ = V_{CN}cos α

=0.2940 X 10^{7}X0.5 m/s

= 0.1470 X 10^{7} m/s

$\vec{Vy}$ = V_{CN} cos β

= 0.2940X 10^{7}X0.866 m/s

= 0.2546 m/s

$\vec{Vz}$ = V_{CN} cosy

= 0.2940 X 10^{7}X0 m/s

= 0 m/s

The splitting of theheterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – helium –3 , the helium –4 and the neutron(Δm) .

Out of them , the two particles (the helium –3 , the helium –4 and the neutron) are stable while the reduced mass is unstable .

According to the law of inertia ,each particle that is produced due to splitting of the compound nucleus , has an inherited velocity($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

So, for conservation of momentum

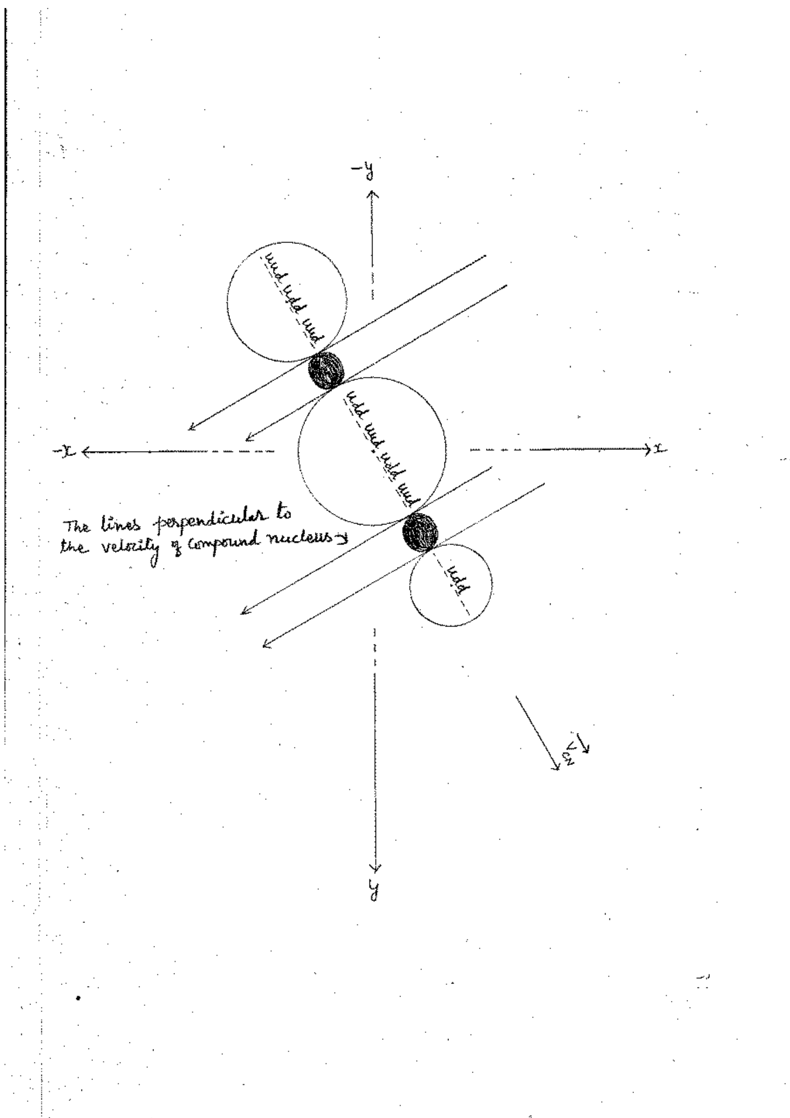
$M\overrightarrow{Vcn}$= (m_{He-3} + Δm/2 +m_{He-4} +Δm/2+m_n)$\overrightarrow{Vcn}$

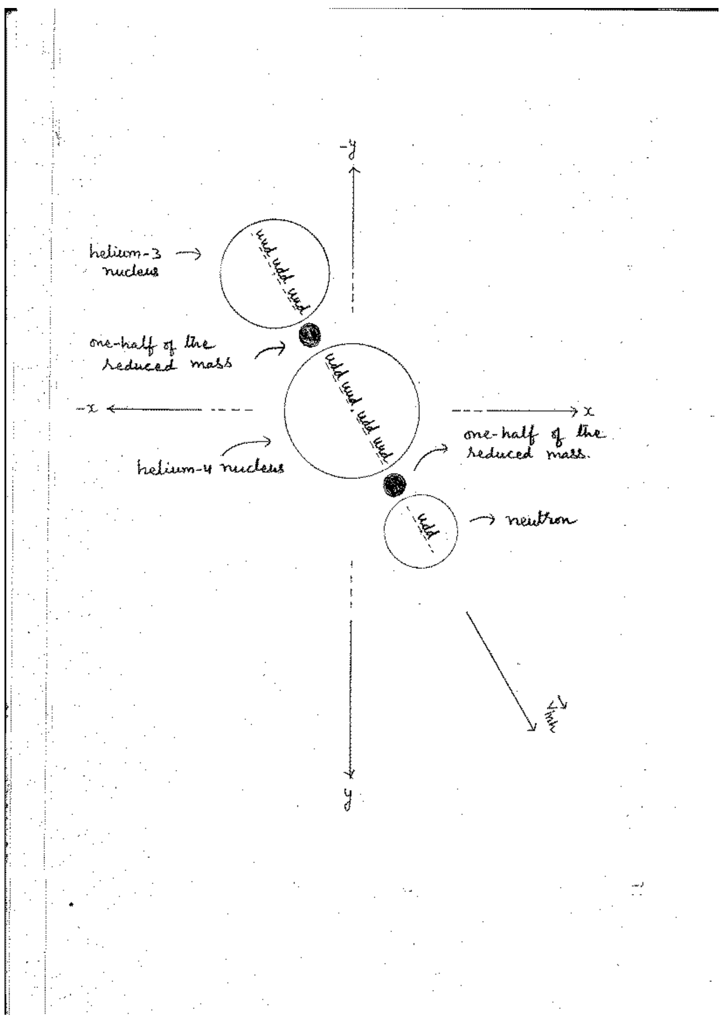
Where,

M = mass of the compound nucleus
$\overrightarrow{Vcn}$ = velocity of the compound nucleus
m_{He-3} = mass of the helium-3nucleus
m_{He-4} = mass of the helium-4 nucleus
Δm/2 = one half of thereduced mass
m_n = mass of the neutron

The splitting of the heterogenous compound nucleus

The heterogenous compound nucleus to show the lines perpendicular to the$\overrightarrow{Vcn}$


-y
uud udd uud
udd uud udd uud
udd
-x
x
y
The lines perpendicular to
the velocity of compound nucleus



Inherited velocity of the particles (s) : -

Each particles has inherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\underrightarrow{Vcn}$) .

(I). Inherited velocity of theparticle $_2{}^3He$

$V_{inh} = V_{CN} = 0.2940x10^7 m/s$

Components of the inherited velocityof the particle $_2{}^3He$

1.$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cos α = 0.1470x 10^7 m/s

2.$\underset{Vy}{\rightarrow}$ = V_{inh}cosβ = V_{CN}cos β= 0.2546 x 10^7m/s

3. $\underset{Vz}{\rightarrow}$ = V_{inh}cos y = V_{CN} cos y = 0 m/s

(II) . Inherited velocity of theparticle $_2{}^4He$

$V_{inh} = V_{CN} = 0.2940 x 10^7 m/s$

Components of the inherited velocity of theparticle $_2{}^4He$

1$\underset{Vx}{\rightarrow}$ = V_{inh}cos α =V_{CN} cosα = 0.1470x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$= V_{inh}cos β = V_{CN}cos β= 0.2546x 10^7m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

(III) . Inheritedvelocity of the neutron

$V_{inh} = V_{CN}= 0.2940 x 10^7 m/s$

Components of the inherited velocityof the neutron

1$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cosα = 0.1470x 10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inh} cosβ= V_{CN}cos β= 0.2546x 10^7m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inh}cos y = V_{CN} cos y = 0 m/s

iii Inherited velocity of the reduced mass

$V_{inh} = V_{CN} = 0.2940 x 10^7 m/s$

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propelboth the particles with equal and opposite momentum.

Reduced mass

$\Delta m = [m_d + m_{Li\text{-}6}] - [m_{He\text{-}3} + m_{He\text{-}4} + m_n]$

$\Delta m = [2.01355 + 6.01347708] – [3.014932 + 4.0015 + 1.00866]$ amu

$\Delta m = [8.02702708] – [8.025092]$ amu

$\Delta m = 0.00193508$ amu

$\Delta m = 0.00193508 \times 1.6605 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass (Δm) .

$E_{inh} = \frac{1}{2} \Delta m\, V^2_{CN}$

$\Delta m \quad 0.00193508 \times 1.6605 \times 10^{-27}$ kg

$V^2_{CN} = 0.08647192899 \times 10^{14}$

$E_{inh} = \frac{1}{2} \times 0.00193508 \times 1.6605 \times 10^{-27} \times 0.08647192899 \times 10^{14}$ J

$E_{inh} = 0.00013892581 \times 10^{-13}$ J

$E_{inh} = 0.000086$ Mev

Released energy (E_R)

$E_R = \Delta mc^2$

$E_R = 0.00193508 \times 931$ Mev

$E_R = 1.801559$ Mev

Total energy (E_T)

$E_T = E_{inh} + E_R$

$E_T = [0.000086 + 1.801559]$ Mev

$E_T = 1.801645$ Mev

(I) Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverseproportion to their masses. so,the increased energy (E_{inc}) of the particles are :-

1.. For helium - 3

$$E_{inc} = \frac{m_{He-4}}{m_{He-3} + m_{He-4}} \times E_T/2$$

$$E_{inc} = \frac{4.0015 \text{ amu}}{[3.014932 + 4.0015] \text{ amu}} \times 1.801645/2 \text{ Mev}$$

$$E_{inc} = \frac{4.0015}{7.016432} \times 0.900822 \text{ Mev}$$

$E_{inc} = 0.57030410898 \times 0.900822$ Mev

$E_{inc} = 0.513742$ Mev

2.increased energy of the helium-4

$E_{inc} = [E_T/2] - [$ increased energy of the He-3 $]$

E_{inc} = [0.900822] - [0.513742] Mev

E_{inc} = 0.38708 Mev

(II) Increased in the energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses . so,the increased energy (E_{inc}) of the particles are :-

1.. For helium - 4

$$E_{inc} = \frac{m_n}{m_n + m_{He-4}} \times E_T/2$$

$$E_{inc} = \frac{1.00866 \text{ amu}}{[1.00866 + 4.0015] \text{ amu}} \times 1.801645/2 \text{ Mev}$$

$$E_{inc} = \frac{1.00866}{5.01016} \times 0.900822 \text{ Mev}$$

E_{inc} = 0.20132291184 x 0.900822 Mev

E_{inc} = 0.181356 Mev

2..increased energy of the neutron

E_{inc} = [E_T/2] - [increased energy of the He-4]

E_{inc} = [0.900822] - [0.181356] Mev

E_{inc} = 0.719466 Mev

6..Increased velocity of the particles .

(1) For neutron

$E_{inc} = {}^1/_2 m_n \ v_{inc}^2$

$V_{inc} = [\,2 \times E_{inc}/m_n\,]^{1/2}$

$$= \left(\frac{2\times 0.719466 \times 1.6\times10^{-13}\ \text{J}}{1.6749\times10^{-27}\ \text{kg}} \right)^{1/2} \text{m/s}$$

$$= \left(\frac{2.3022912\times10^{-13}}{1.6749\times10^{-27}} \right)^{1/2} \text{m/s}$$

$$= [\ 1.37458427368 \times 10^{14}\ ]^{1/2}\ \text{m/s}$$

$$= 1.1724 \times 10^{7}\ \text{m/s}$$

For helium-3

$V_{inc} = [\,2 \times E_{inc} / m_{Be\text{-}7}\,]^{1/2}$

$$= \left(\frac{2\times0.513742\times1.6\times10^{-13}\ \text{J}}{5.00629\times10^{-27}\ \text{kg}} \right)^{1/2}$$

$$= \left(\frac{1.6439744\times10^{-13}}{5.00629\times10^{-27}} \right)^{1/2} \text{m/s}$$

$$= [\ 0.32838177572 \times 10^{14}\ ]^{1/2}\ \text{m/s}$$

$$= 0.5730 \times 10^{7}\ \text{m/s}$$

7 Angle of propulsion

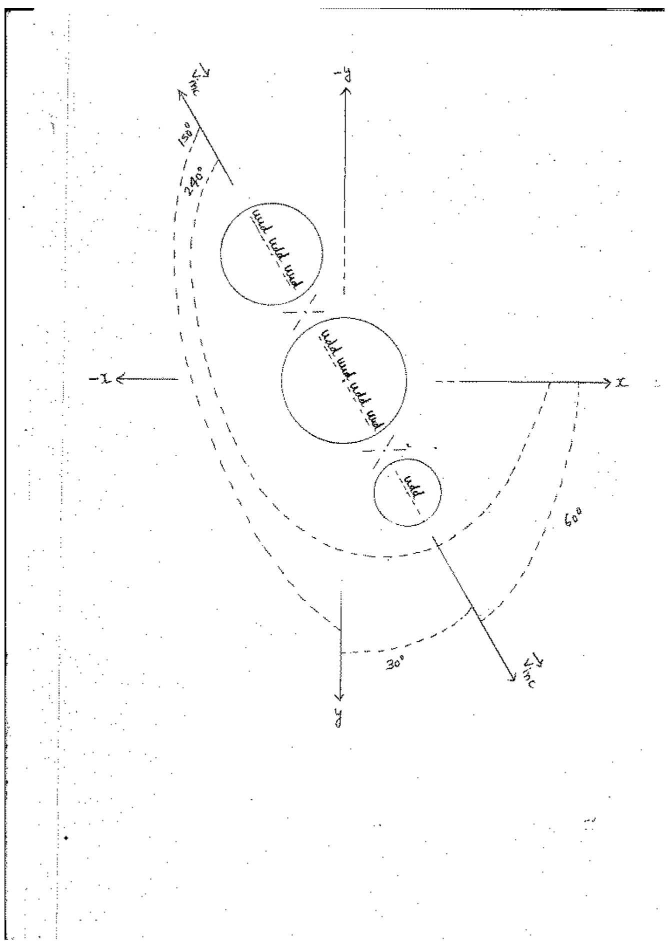
1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ‘ F ‘ , as V_{CN} makes 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

so, the neutron is propelled making 60° angle with x-axis , 30° angle with y-axis and 90°angle with z-axis . While the helium -3 nucleus is propelled making 240° angle with x-axis , 150°angle with y-axis and 90° angle with z-axis .

Propulsion of thte particles



Components of the increasedvelocity (V_{inc}) of the particles.

(i) For helium-3

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.5730×10^7 m/s

cosα = cos (240) = -0.5

$\underset{Vx}{\rightarrow}$= 0.5730×10^7x (-0.5) m/s

= -0.2865×10^7m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β= cos (150) = - 0.866

$\underset{Vy}{\rightarrow}$ = 0.5730×10^7x (- 0.866) m/s

= $- 0.4962 \times 10^7$ m/s

3 $\underset{Vz}{\rightarrow}$= V_{inc}cos y

Cosy = cos 90º= 0

$\underset{Vz}{\rightarrow}$ = 0.5730×10^7x0

= 0 m/s

For neutron

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 1.1724×10^7 m/s

cosα= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$ = 1.1724×10^7 x 0.5 m/s

= 0.5862×10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc}cos β

cos β= cos (30) = 0.866

$\underset{Vy}{\rightarrow}$= 1.1724×10^7 x 0.866m/s

= 1.0152×10^7m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc} cos y

cos y= cos (90)= 0

$\underset{Vz}{\rightarrow}$= 1.1724×10^7 x 0 m/s

= 0 m/s

Components ofthe increased momentumof helium-3

1 $\underset{Px}{\rightarrow}$ = $m_{He\text{-}3}$x $\underset{Vx}{\rightarrow}$

=5.00629×10^{-27} x(-0.2865×10^7) kgm/s

= -1.4343×10^{-20}kgm/s

2 $\underset{Py}{\rightarrow}$ =$m_{He\text{-}3}$ x $\underset{Vy}{\rightarrow}$

= 5.00629×10^{-27}x(-0.4962×10^7) kgm/s

$= - 2.4841 \times 10^{-20}$kgm/s

So theComponents of the increased momentum of helium-4

$\underset{Px}{\rightarrow} = - (-1.4343 \times 10^{-20})$

$= 1.4343 \times 10^{-20}$

$\underset{Py}{\rightarrow} = - (- 2.4841 \times 10^{-20})$

$= 2.4841 \times 10^{-20}$

Componentsof the increased momentum of neutron

1 $\underset{Px}{\rightarrow} = m_n \times \underset{Vx}{\rightarrow}$

$= 1.6749 \times 10^{-27} \times 0.5862 \times 10^{7}$ kgm/s

$= 0.9818 \times 10^{-20}$kgm/s

2 $\underset{Py}{\rightarrow} = m_{He-3} \times \underset{Vy}{\rightarrow}$

$= 1.6749 \times 10^{-27} \times 1.0152 \times 10^{7}$ kgm/s

$= 1.7003 \times 10^{-20}$ kgm/s

So the Components of the increased momentum of helium-4

$\underset{Px}{\rightarrow}$= -(0.9818x 10^{-20})

= - 0.9818 x 10^{-20}

$\underset{Py}{\rightarrow}$ = - (1.7003 x 10^{-20})

=- 1.7003 x 10^{-20}

9.. Components of the final velocity (Vf) of the particles

I For helium-3

According to -	Inherited Velocity($\overrightarrow{\text{Vinh}}$)	Increased Velocity($\overrightarrow{\text{Vinc}}$)	Final velocity ($\overrightarrow{Vf}$) =($\overrightarrow{\text{Vinh}}$+($\overrightarrow{\text{Vinc}}$)
X –axis	$\underset{Vx}{\rightarrow}$ = 0.1470x 10^7m/s	$\underset{Vx}{\rightarrow}$=-0.2865x 10^7m/s	$\underset{Vx}{\rightarrow}$= - 0.1395x$10^7$m/s
y – axis	$\underset{Vy}{\rightarrow}$ = 0.2546 x10^7m/s	$\underset{Vy}{\rightarrow}$= - 0.4962x 10^7m/s	$\underset{Vy}{\rightarrow}$ =- 0.2416x10^7m/s

z –axis	$\vec{V_z}$= 0m/s	$\vec{V_z}$= 0 m/s	$\vec{V_z}$=0 m/s

2..For neutron

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$) =($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X –axis	$\vec{V_x}$= 0.1470 x10^7m/s	$\vec{V_x}$ = 0.5862 x10^7m/s	$\vec{V_x}$ =0.7332x10^7m/s
y– axis	$\vec{V_y}$= 0.2546 x10^7m/s	$\vec{V_y}$= 1.0152 x10^7m/s	$\vec{V_y}$=1.2698x10^7m/s
z –axis	$\vec{V_z}$= 0 m/s	$\vec{V_z}$ = 0 m/s	$\vec{V_z}$ =0 m/s

10.. Final velocity (vf) of thehelium-3

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

V_x= 0.1395 X 10^7 m/s

V_y = 0.2416 X10^7m/s

V_z = 0 m/s

$V_f^2 = (0.1395 \text{ X } 10^7)^2 + (0.2416\text{X}10^7)^2 + (0)^2 \ m^2/s^2$

$V_f^2 = (0.01946025 \text{ X } 10^{14}) + (0.05837056 \text{ X } 10^{14}) + 0 \ m^2/s^2$

$V_f^2 = 0.07783081 \text{ X } 10^{14} \ m^2/s^2$

$V_f = 0.2789\text{x}10^7 m/s$

Final kineticenergy ofthe helium-3

E= ½ $m_{He\text{-}3} V_f^2$

E =½x5.00629x 10^{-27}x 0.07783081 X 10^{14}J

= $0.19482180289 \times 10^{-13}$ J

= 0.121763 Mev

$m_{He-3}V_f^2 = 5.00629 \times 10^{-27} \times 0.07783081 \times 10^{14}$ J

= 0.3896×10^{-13} J

10..Final velocity (vf) of the neutron

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.7332 \times 10^7$ m/s

$V_y = 1.2698 \times 10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.7332 \times 10^7)^2 + (1.2698 \times 10^7)^2 + (0)^2$ m^2/s^2
$V_f^2 = (0.53758224 \times 10^{14}) + (1.61239204 \times 10^{14}) + 0$ m^2/s^2
$V_f^2 = 2.14997428 \times 10^{14}$ m^2/s^2
$V_f = 1.4662 \times 10^7$ m/s

Final kinetic energy of the neutron

$E = ½ m_nV_f^2$

$E = ½ \times 1.6749 \times 10^{-27} \times 2.14997428 \times 10^{14}$ J

= $1.80049596078 \times 10^{-13}$ J

= 1.125309 Mev

Angles made by the final velocity of neutron

Cos α $= \overrightarrow{V_x} / V_f$

$\overrightarrow{V_x} = 0.7332 \times 10^7$ m/s

$V_f = 1.4662 \times 10^7$ m/s

Cos α $= 0.7332 \times 10^7 / 1.4662 \times 10^7$

Cosα = 0.5000

$\alpha = 60^o$

Cos β $= \overrightarrow{V_y} / V_f$

$\overrightarrow{V_y} = 1.2698 \times 10^7$ m/s

$V_f = 1.4662 \times 10^7$ m/s

Cos β$= 1.2698 \times 10^7 / 1.4662 \times 10^7$

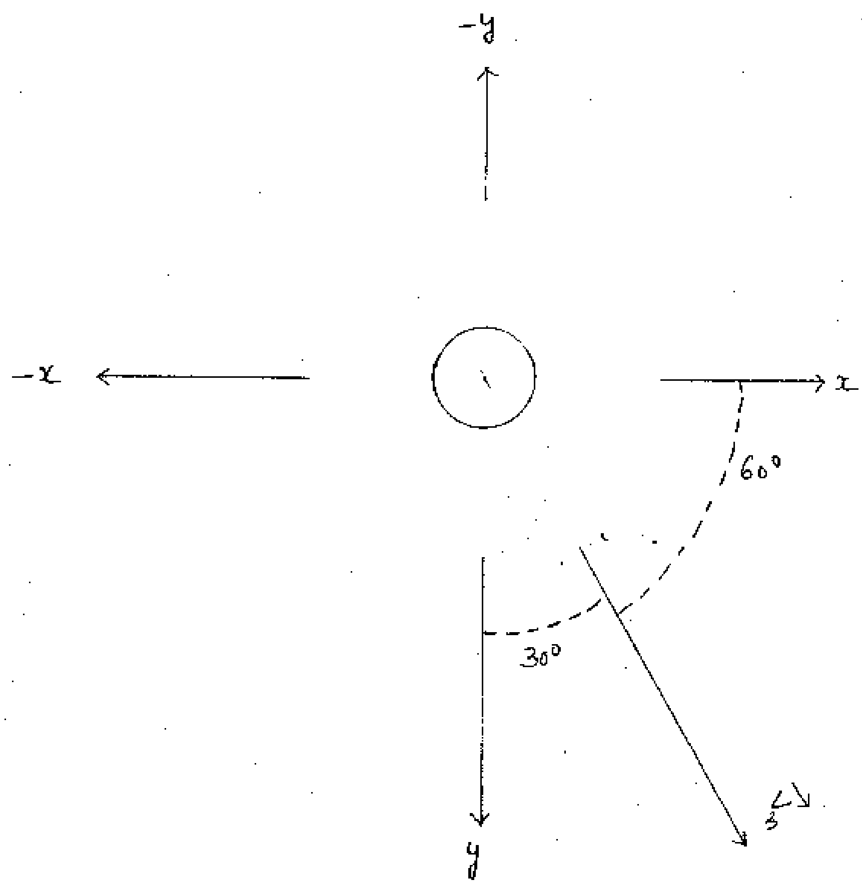
Cosβ = 0.8660

$\beta = 30^o$

Cos y $= \overrightarrow{V_z} / V_f = 0/1.4662 \times 10^7 = 0$

$y = 90^o$

The final velocity of neutron makes angels with positive x, y and z axes as follows :-



-y
-x
x
60°
30°
y

Forces acting on the helium-3 nucleus

1 F_y = q V_x B_z sinθ

$\overrightarrow{Vx}$ = -0.1395 x 10^7 m/s

$\overrightarrow{Bz}$= -1.001 x10^{-1} Tesla

q= 2 x 1.6 x 10^{-19} c

sin θ = sin 90° = 1

Fy = 2x1.6 x 10^{-19} x 0.1395x 10^7x 1.001x10^{-1}x 1 N
= 0.4468x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fy}$ is according to (+) y-axis ,

so ,
$\overrightarrow{Fy}$ = 0.4468 x10^{-13}N

2 F_z = q V_x B_y sin θ

$\overrightarrow{By}$=1.0013 x10^{-1}Tesla

sin θ = sin 90° = 1

Fz = 2 x 1.6 x10^{-19} x 0.1395 x 10^7 x 1.0013 x10^{-1} x 1 N
= 0.4469 x 10^{-13} N

Form the right hand palm rule , thedirection ofthe force $\overrightarrow{Fz}$ is according to(+) Z- axis ,

so ,
$\overrightarrow{Fz}$ = 0.4469 x 10^{-13}N

3 F_x = q V_y B_z sin θ

$\overrightarrow{Vy}$ =-0.2416 x 10^7 m/s

$\overrightarrow{Bz}$= 1.001x10^{-1} Tesla

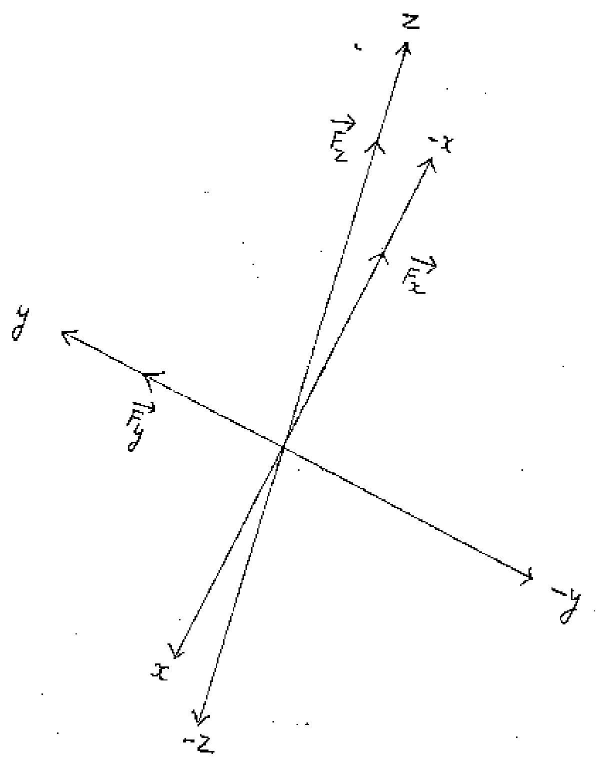
sinθ = sin 90° = 1

Fx = 2x1.6 x 10^{-19}x 0.2416x 10^7x 1.001x10^{-1} x 1N
= 0.7738 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (-) x axis ,

so , $\overrightarrow{Fx}$ = - 0.7738 x 10^{-13}N

Forces acting on the helion-3



Resultant force (F_R):

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 0.7738 \times 10^{-13}$ N

$F_y = 0.4468 \times 10^{-13}$ N

$F_z = 0.4469 \times 10^{-13}$

$F_R^2 = F_x^2 + F_y^2 + F_z^2$

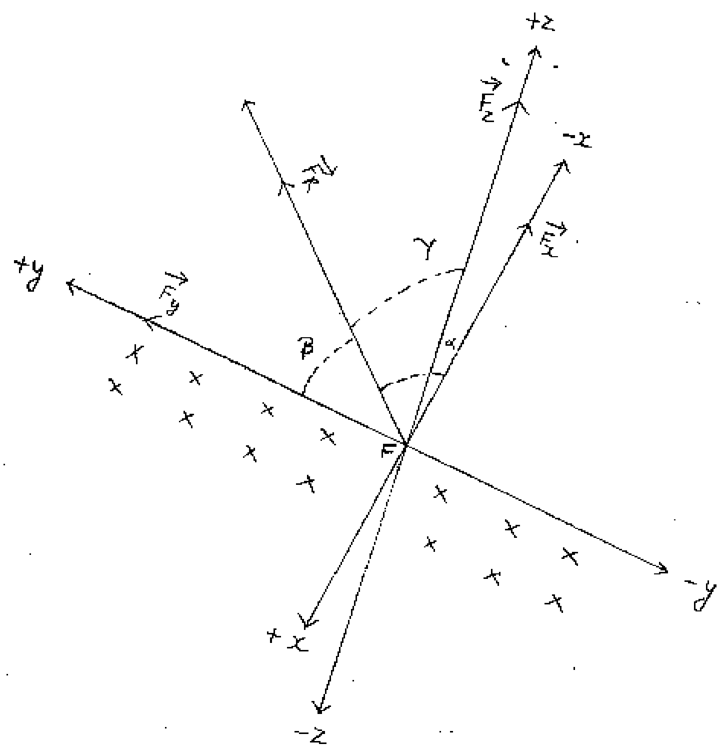
$F_R^2 = (0.7738 \times 10^{-13})^2 + (0.4468 \times 10^{-13})^2 + (0.4469 \times 10^{-13})^2 N^2$

$F_R^2 = (0.59876644 \times 10^{-26}) + (0.19963024 \times 10^{-26}) + (0.19971961 \times 10^{-26})$ N^2

$F_R^2 = 0.99811629 \times 10^{-26}$ N^2

$F_R = 0.9990 \times 10^{-13}$ N

Resultant force acting on the helium-3



Radius of the circular orbit to be followed by the helium - 3 :

$r = mv^2 / F_R$

$mv^2 = 0.3896 \times 10^{-13} J$

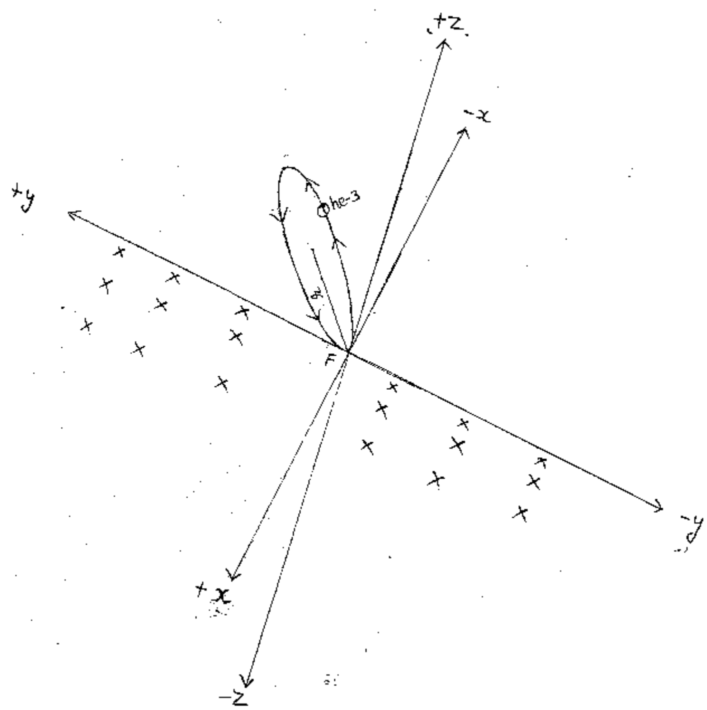
$F_r = 0.9990 \times 10^{-13}\ N$

$r = 0.3896 \times 10^{-13}\ J \ / \ 0.9990 \times 10^{-13}\ N$

$r = 0.3899\ m$

The circular orbit to be followed by the helium-3 lies in the plane made up of negative x-axis, positive y-axis and the positive z-axis.

C = center of thecircular orbit to be followed   by the helium-3.



The plane of the circular orbit to be followed by helium -3 makes angleswith positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr $= \underset{Fx}{\rightarrow} / F_r$

$\underset{Fx}{\rightarrow}$ = -0.7738 x 10^{-13} N

F_r= 0.9990 x 10^{-13} N

Puttingvalues

Cos α = - 0.7745

α= 219.24 degree [∴ cos (219.24) = - 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / F_r=$\underset{Fy}{\rightarrow}$ /F_r

$\underset{Fy}{\rightarrow}$= 0.4468 x 10^{-13} N

F_r = 0.9990 x 10^{-13} N

Putting values

Cos β = 0.4472

β = 63.43 degree [∴ cos (63.43) = 0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ F_r=$\underset{Fz}{\rightarrow}$ / F_r

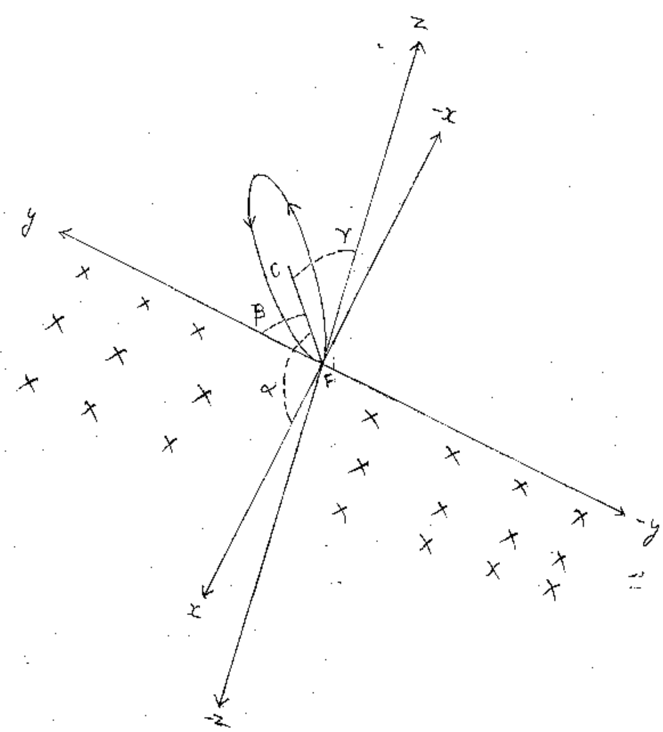
$\underset{Fz}{\rightarrow}$ = $\underline{0.4469 \text{x } 10^{-13} N}$

F_r = = 0.9990x 10^{-13}N

Putting values

Cos y = 0.4473
y = 63.425 degree

The plane of the circular orbit to be followed by the helium -3 nucleus makes angles with positive x , y , andz axes as follows :-



Where,

α= 219.24 degree

β = 63.43 degree

Y = 63.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the helium - 3.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

$= 2 \times 0.3899$ m

$= 0.7798$ m

Cos $\alpha = - 0.7745$

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 0.7798 \times (- 0.7745)$ m

$x_2 - x_1 = -0.6039$ m

$x_2 = - 0.6039$m [$\therefore x_1 = 0$]

$\cos \beta = \frac{y_2 - y_1}{d}$

$\cos\beta = 0.4472$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 0.7798 \times 0.4472$m

$y_2 - y_1 = 0.3487$ m

$y_2 = 0.3487$ m[$\therefore y_1 = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = 0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 0.7798 \times 0.4473$ m

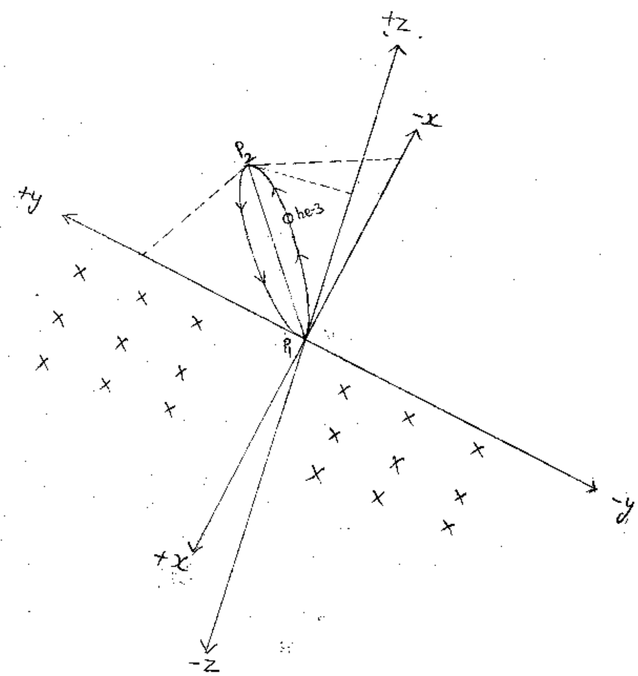
$z_2 - z_1 = 0.3488$ m

$z_2 = 0.3488$ m [$\therefore z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumfrence of the circle obtained by the helium - 3 are as shown below.

The line___ is the diameter of the circle .

P_1P_2


+z
-x
P2
+y
Φhe-3
P1
-y
+x
-z

Conclusion :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the helium-3 nucleus are along **-x , +y and +z** axes respectively .

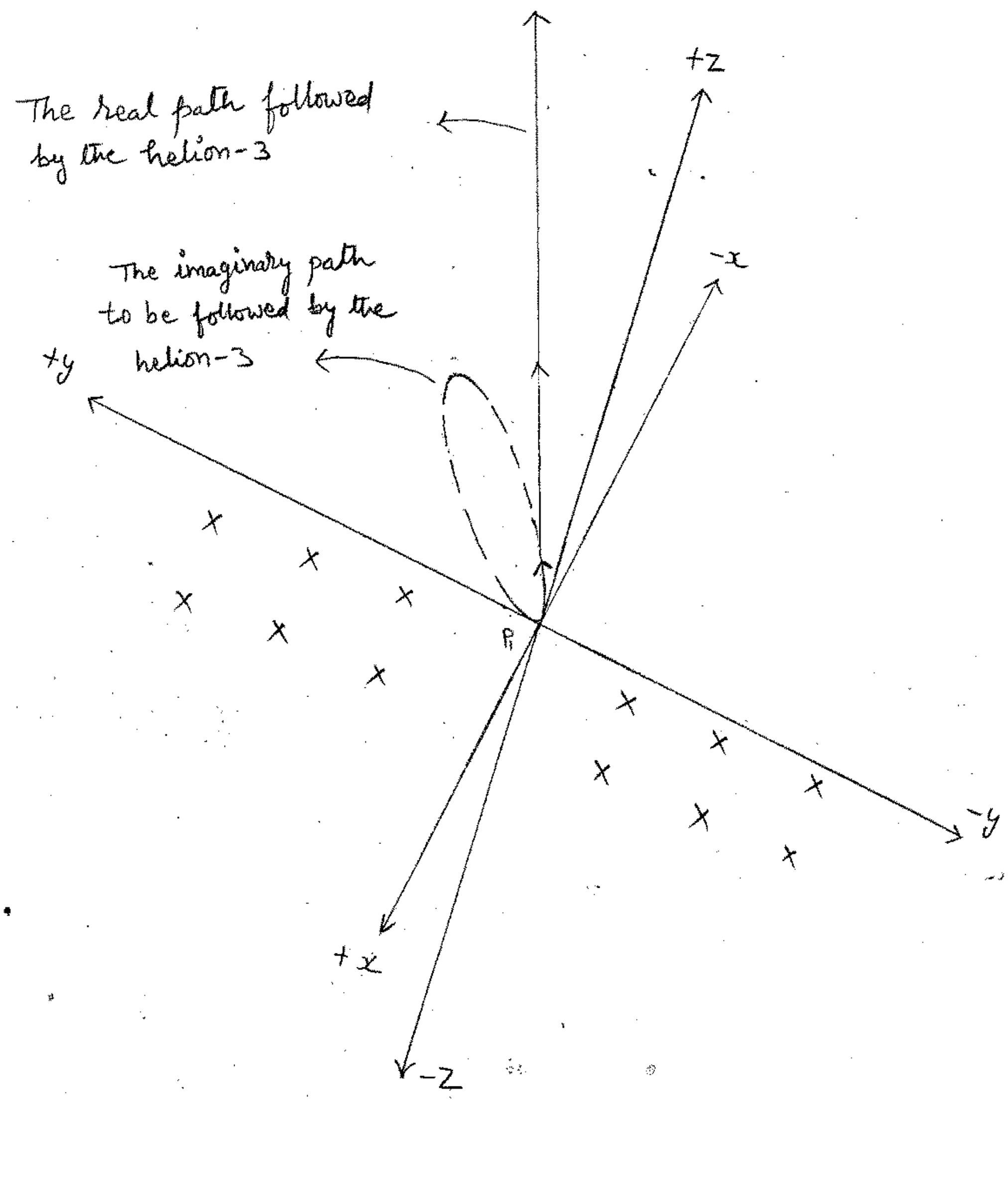
So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the helium-3 nucleus to undergo to a circular orbit of radius 0.3899 m.

It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.6039 m, 0.3487 m,0.3488m) where the magnetic fields are not applied

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circularpath (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite ofcompleting its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is notconfined.



The real path followed by the helion-3
The imaginary path to be followed by the helion-3
+z
-x
+y
-y
+x
-z
P1

9.. Components of the final momentum (P_f)of the particles

I For helium-4

According to -	Inherited momentum($\overrightarrow{Pinh}$) of the helium-4 nucleus	Increased momentum($\overrightarrow{Pinc}$) of the helium-4 nucleus whenthe one- half of the reduced mass freely located between hellion –4 and thehellion -3 converts into energy	Increased momentum($\overrightarrow{Pinc}$) of the helium-4 nucleuswhen the one- half of the reduced mass freely located between hellion – 4 and theneutron converts into energy	Finalmomentu helium-4 nucleus ($\overrightarrow{Pf}$) =($\overrightarrow{Pinh}$+(Pi
X–axis	$\overrightarrow{Px}$ =0.9767x10^{-20}kg m/s	$\overrightarrow{Px}$ = 1.4343 x 10^{-20}kg m/s	$\overrightarrow{Px}$= -0.9818x 10^{-20} kg m/s	$\overrightarrow{Px}$= 1.4292 x 10^{-20}kg
y –axis	$\overrightarrow{Py}$= 1.6916x 10^{-20}kgm/s	$\overrightarrow{Py}$ = 2.4841 x 10^{-20}kg m/s	$\overrightarrow{Py}$ = - 1.7003 x10^{-20} kg m/s	$\overrightarrow{Py}$ = 2.4754 x 10
z –axis	$\overrightarrow{Pz}$= 0 kg m/s	$\overrightarrow{Pz}$ = 0 kg m/s	$\overrightarrow{Pz}$=0kg m/s	$\overrightarrow{Pz}$= 0kg m/s

9..Components of the final velocity (V_f)of the particles

I For helium-4

1 $\overrightarrow{Vx}=\frac{\overrightarrow{Px}}{m}$

= 1.4292 $x10^{-20}$ kg m/s

6.64449 x 10^{-27} kg m/s

= 0.2150x 10^{7}m/s

$2 \underset{Vy}{\rightarrow} = \frac{\overrightarrow{Py}}{m}$

= $\underline{2.4754 \times 10^{-20} \text{ kg m/s}}$

6.64449 x 10^{-27} kg m/s

=0.3725x10^{7}m/s

$2 \underset{Vz}{\rightarrow} = \frac{\overrightarrow{Pz}}{m}$

= $\underline{0 \text{ kg m/s}}$ = 0

6.64449 x 10^{-27}/kg m/s

10. Final velocity (vf) of the helion - 4

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.2150 \text{ X } 10^7$ m/s

$V_y = 0.3725 \text{ X} 10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.2150 \text{ X } 10^7)^2 + (0.3725\text{X}10^7)^2 + (0)^2 \text{ m}^2/\text{s}^2$

$V_f^2 = (0.046225 \text{ X } 10^{14}) + (0.13875625\text{X } 10^{14}) + 0 \text{ m}^2/\text{s}^2$

$V_f^2 = 0.18498125 \text{ X } 10^{14} \text{ m}^2/\text{s}^2$

V_f = 0.4300 x 10^7 m/s

Final kinetic energy of the helion - 4

E= ½ $m_{He-4}V_f^2$

E = ½x6.64449x 10^{-27} x 0.18498125 X 10^{14} J

= 0.6145530329 X 10^{-13} J

= 0.384095Mev

$m_{He-4}V_f^2$ = 6.64449x 10^{-27}x 0.18498125 X 10^{14} J

= 1.2291 x 10^{-13} J

Forces acting on the helium - 4 nucleus

1 F_y= q V_x B_z sin θ

$\vec{V_x}$ = 0.2150 x 10^7 m/s

$\vec{B_z}$ = -1.001 x10^{-1} Tesla

q= 2 x 1.6 x 10^{-19} c

sin θ = sin 90° = 1

Fy = 2x1.6 x 10^{-19}x0.2150x 10^7x 1.001x10^{-1}x 1 N
= 0.6886 x10^{-13} N

Form the right hand palm rule , thedirection of the force $\vec{F_y}$ is according to(-) y-axis ,

so ,
$\vec{F_y}$ = - 0.6886 x10^{-13} N

2 F_z = q V_x B_y sin θ

$\vec{B_y}$ = 1.0013 x10^{-1}Tesla

sin θ = sin 90° = 1

Fz = 2 x 1.6 x 10^{-19} x 0.2150 x 10^7 x 1.0013 x10^{-1} x 1 N
= 0.6888 x 10^{-13} N

Formthe right hand palm rule , the direction ofthe force $\vec{F_z}$ is according to (-) Z- axis ,

so ,

$\overrightarrow{F_z}$ = - 0.6888 x 10^{-13}N

3 F_x = q V_y B_z sinθ

$\overrightarrow{V_y}$= 0.3725 x 10^7 m/s

$\overrightarrow{B_z}$= 1.001x10^{-1} Tesla

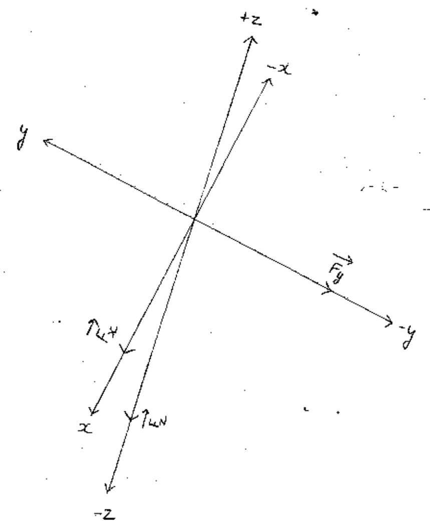
sin θ = sin 90° = 1

Fx = 2x1.6 x 10^{-19} x 0.3725x 10^7x1.001x10^{-1} x 1 N
= 1.1931x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{F_x}$ is according to (+) x axis ,

so, $\overrightarrow{F_x}$ = 1.1931x 10^{-13} N

Forces acting on helium -4 nucleus :-



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 1.1931 \times 10^{-13}$ N

$F_y = 0.6886 \times 10^{-13}$ N

$F_z = 0.6888 \times 10^{-13}$

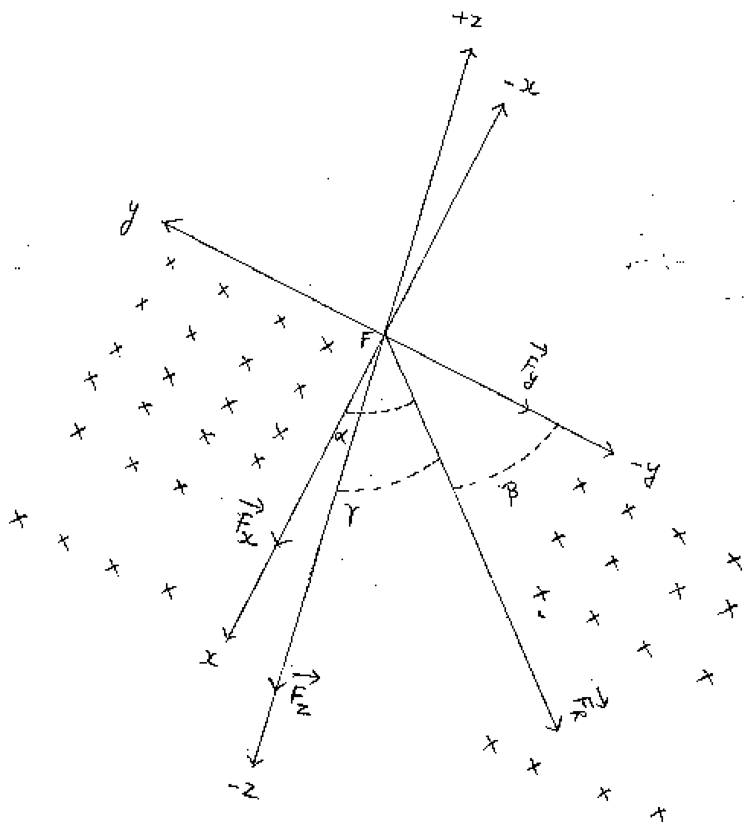
$F_R^2 = F_x^2 + F_y^2 + F_z^2$

$$F_R^2 = (1.1931 \times 10^{-13})^2 + (0.6886 \times 10^{-13})^2 + (0.6888 \times 10^{-13})^2 \ N^2$$

$$F_R^2 = (1.42348761 \times 10^{-26}) + (0.47416996 \times 10^{-26}) + (0.47444544 \times 10^{-26}) \ N^2$$

$$F_R^2 = 2.37210301 \times 10^{-26} \ N^2$$

$$F_R = 1.5401 \times 10^{-13} \ N$$


+z
-x
y
F
-y
x
-z
α
β
γ
$\vec{F_x}$
$\vec{F_y}$
$\vec{F_z}$
$\vec{F_R}$

Radius of the circular orbit followed by the helium - 4 :

$r = mv^2 / F_R$

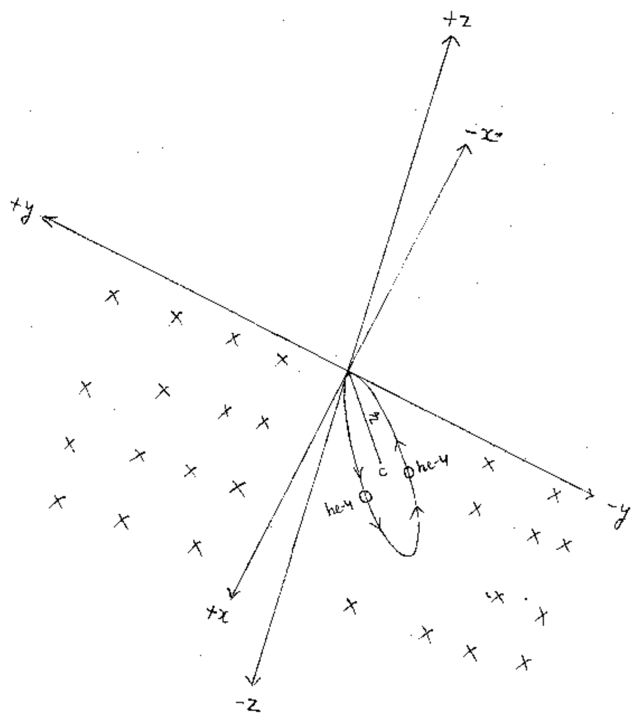
$mv^2 = 1.2291 \times 10^{-13}$ J

$F_r = 1.5401 \times 10^{-13}$ N

$$r = \frac{1.2291 \times 10^{-13}\ \text{J}}{1.5401 \times 10^{-13}\ \text{N}}$$

$r = 0.7980$ m

The circular orbit followed by helion -4 the lies in the plane made up of positivex-axis, negative y-axis and the negative z-axis.
C= center of the circular orbit followed by thehelion -4


+z
-x
+y
-y
+x
-z
c
he-4
he-4

The plane of the circular orbit followed by the helium -4 nucleus makes angles with positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr $= \vec{F_x} / F_r$

$\vec{F_x}$ = 1.1931 x 10^{-13} N

F_r =1.5401x 10^{-13} N

Puttingvalues

Cos α = 0.7746

α= 39.23degree [∴ cos (39.23) = 0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / $F_r = \vec{F_y} / F_r$

$\vec{F_y}$ = - 0.6886 x 10^{-13} N

F_r= 1.5401 x 10^{-13} N

Putting values

Cosβ= - 0.4471

β = 243.44 degree [∴ cos (243.44) = - 0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \vec{F_z} / F_r$

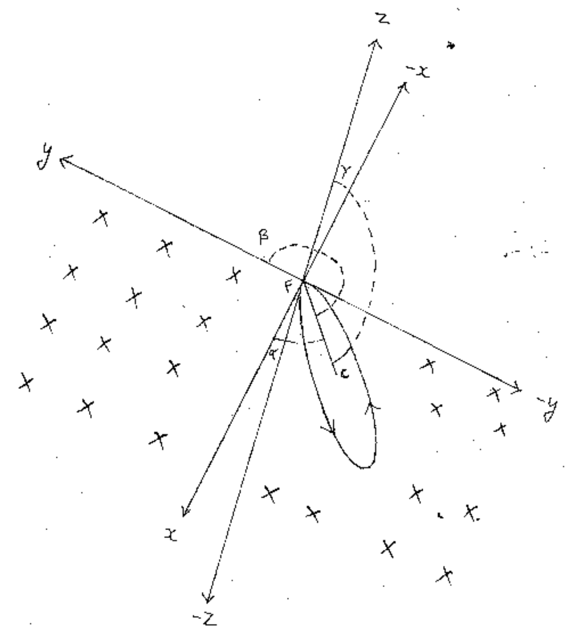
$\vec{F_z}$ = $\underline{-0.6888 \times 10^{-13} N}$

F_r= = 1.5401 x 10^{-13} N

Puttingvalues

Cos y = - 0.4472
y = 243.43 degree

The plane of the circular orbitfollowed by the helium -4 nucleus makes angles with positive x , y , andz axes as follows :-



Where,

α = 39.23 degree

β= 243.44 degree

Y = 243.43 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle obtained by the helium - 4.

$\cos \alpha = \frac{x_2 - x_1}{d}$

$d = 2 \times r$

$= 2 \times 0.7980$ m

$= 1.596$ m

$\cos \alpha = -0.7746$

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 1.596 \times 0.7746$ m

$x_2 - x_1 = 1.2362$ m

$x_2 = 1.2362$ m $[\therefore x_1 = 0]$

$\cos \beta = \frac{y_2 - y_1}{d}$

$\cos\beta = -0.4471$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 1.596 \times (-0.4471)$ m

$y_2 - y_1 = -0.7135$m

$y_2 = -0.7135$ m$[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = -0.4472$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 1.596 \times (-0.4472)$ m

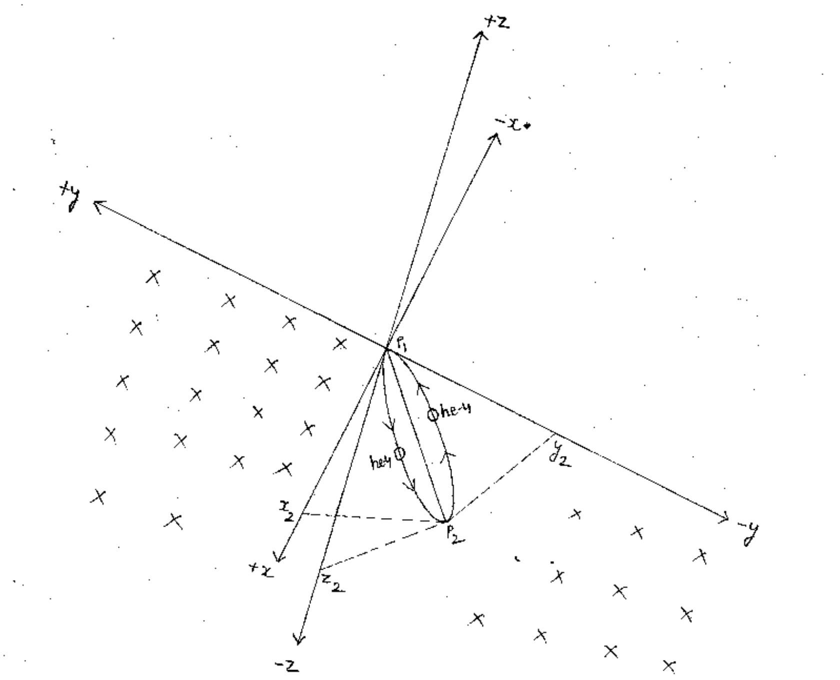
$z_2 - z_1 = 0.7137$ m

$z_2 = 0.7137$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point $p_1 (x_1, y_1, z_1)$ and $p_2 (x_2, y_2, z_2)$ located on the circumfrence of the circle obtained by the helium - 4 are as shown below.

The line ___is the diameter of the circle .

P_1P_2


+z
-x
+y
P1
he-y
he-y
y2
-y
x2
P2
+x
z2
-z

Conclusion:-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the helium-4 nucleusare along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields areapplied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the helium-4 nucleus to undergo to a circular orbit of radius of 0.7980 m.

It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.2362 m ,-0.7135 m,-0.7137 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circle until it fuses with the confined deuteron or deuteron of later injected bunch (that reaches at point "F") at point "F"

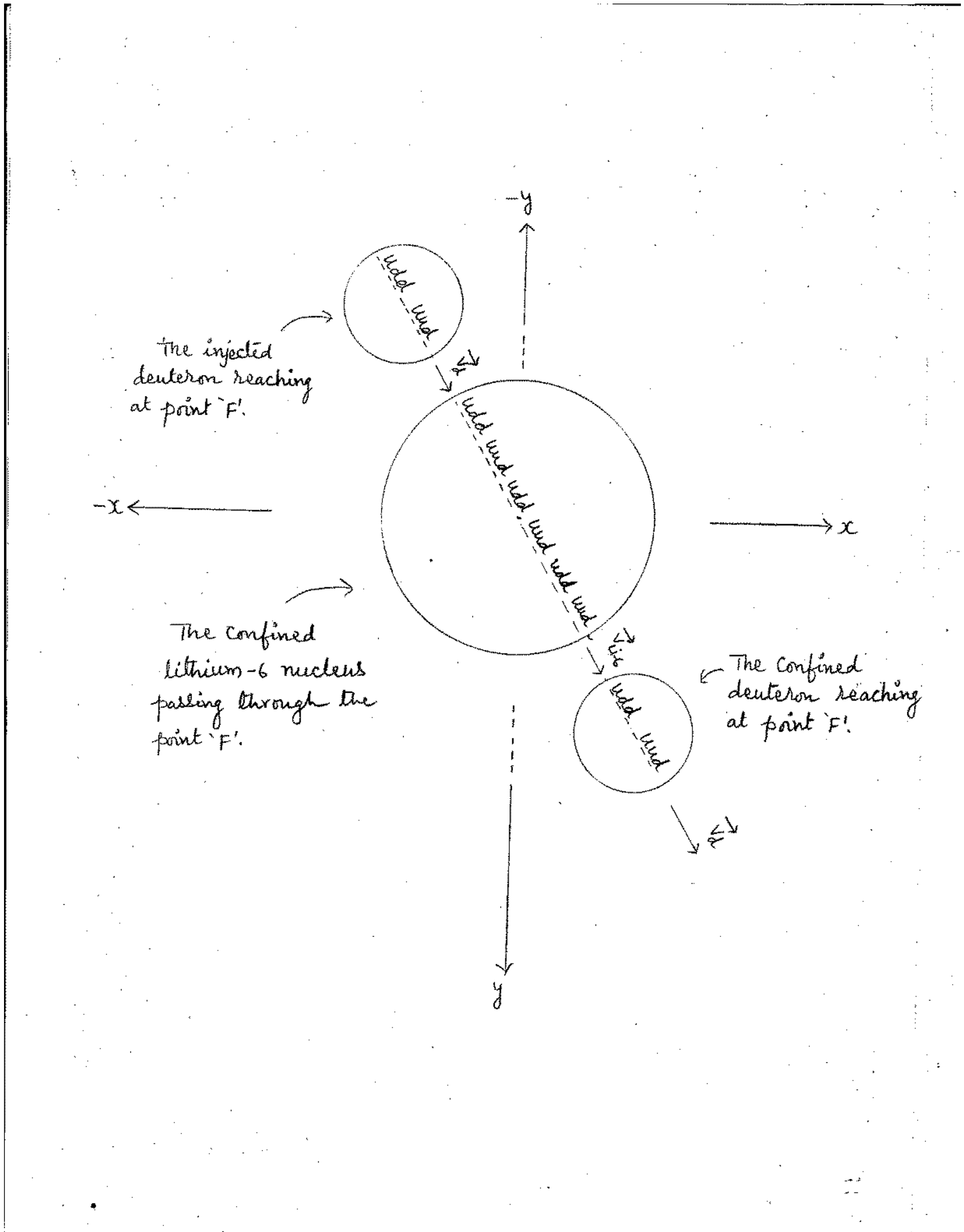
For fusion reaction

$^{2}{}_{1}H + {}^{6}{}_{3}Li + {}^{2}{}_{1}H \rightarrow [{}_{5}{}^{10}B] \rightarrow {}_{3}{}^{7}Li + {}^{3}{}_{2}He$

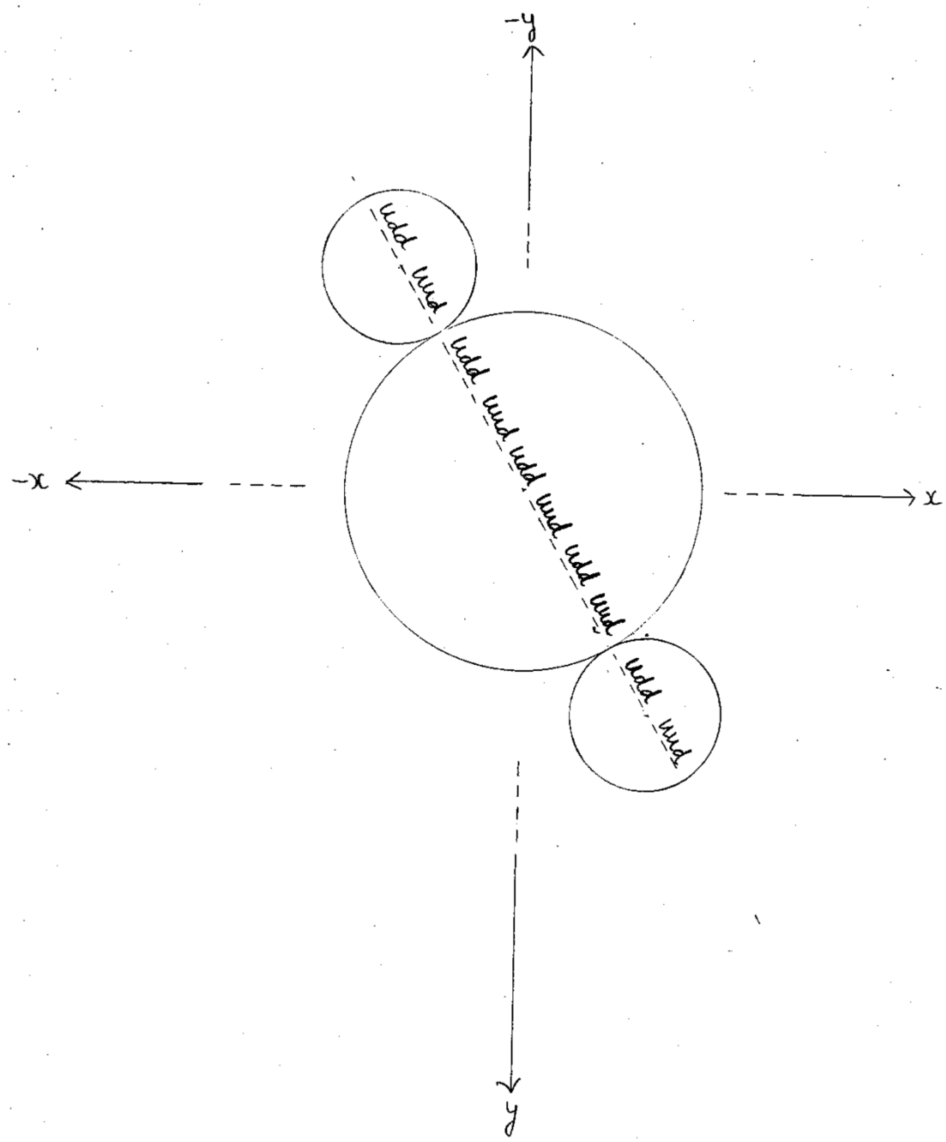
The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6 and confined deuteron] with the confined lithion-6 and confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6 and confined deuteron.

Interaction of nuclei (1)



Interaction of nuclei (2)

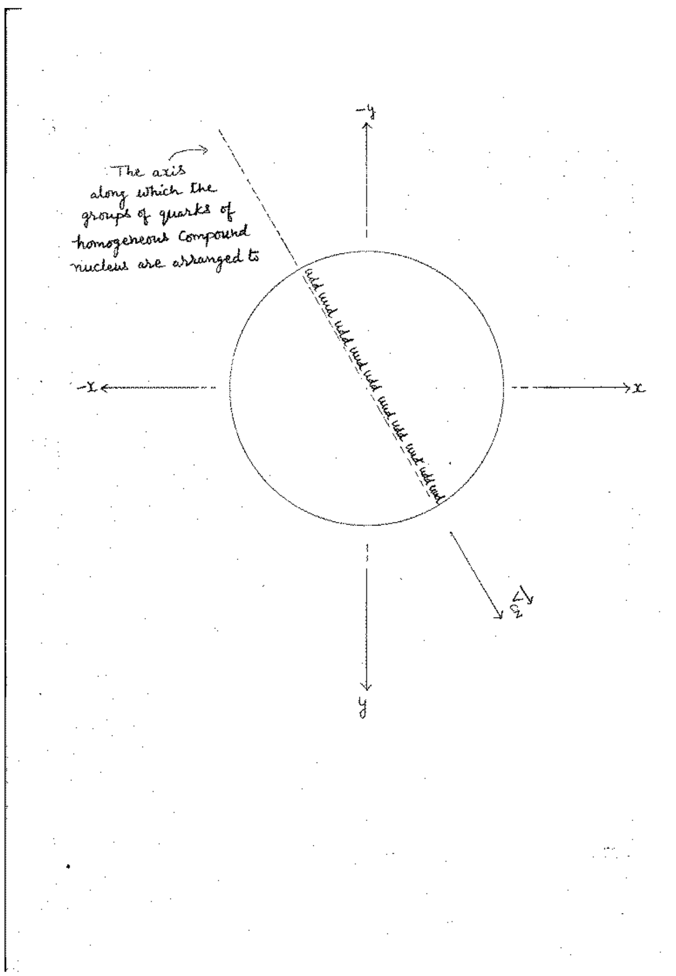

-y
udd uud
udd uud udd uud udd uud
udd uud
-x
x
y

2.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (the injected deuteron and the lithion-6 nucleus and confined deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 10 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3. Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the lithium - 7) than the reactant one (the lithion-6) includes the other six

(nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

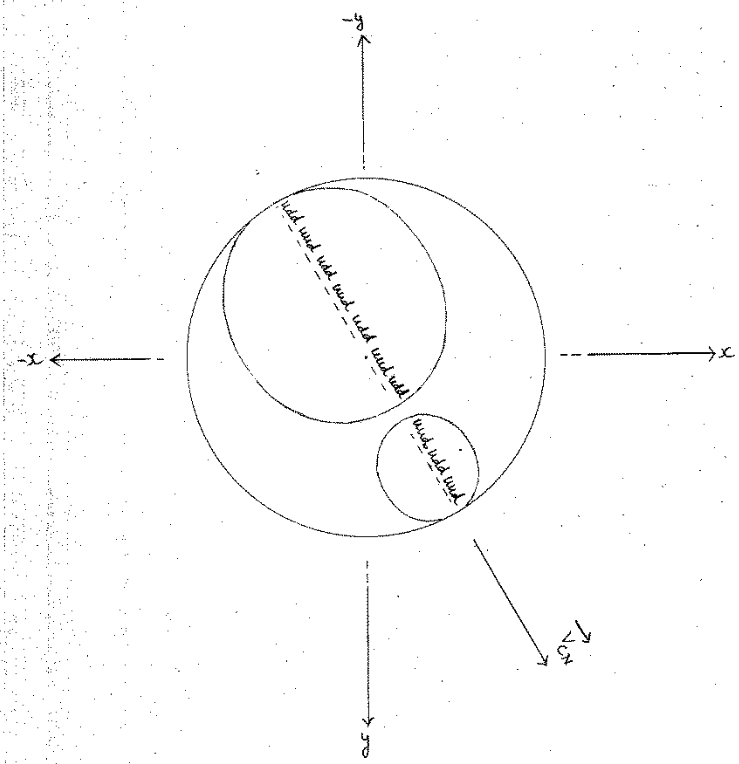
While , the remaing groups of quarks to become a stable nucleus (the helium - 3) includes the other two (nearby located) groups of quarks with their surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the lithium – 7 nucleus and the smaller nucleus is the helium-3.

The greater nucleus is the lobe ‘A ‘ and the smaller nucleus is the lobe ‘B’ while the remainigh space represent the remaining gluons .



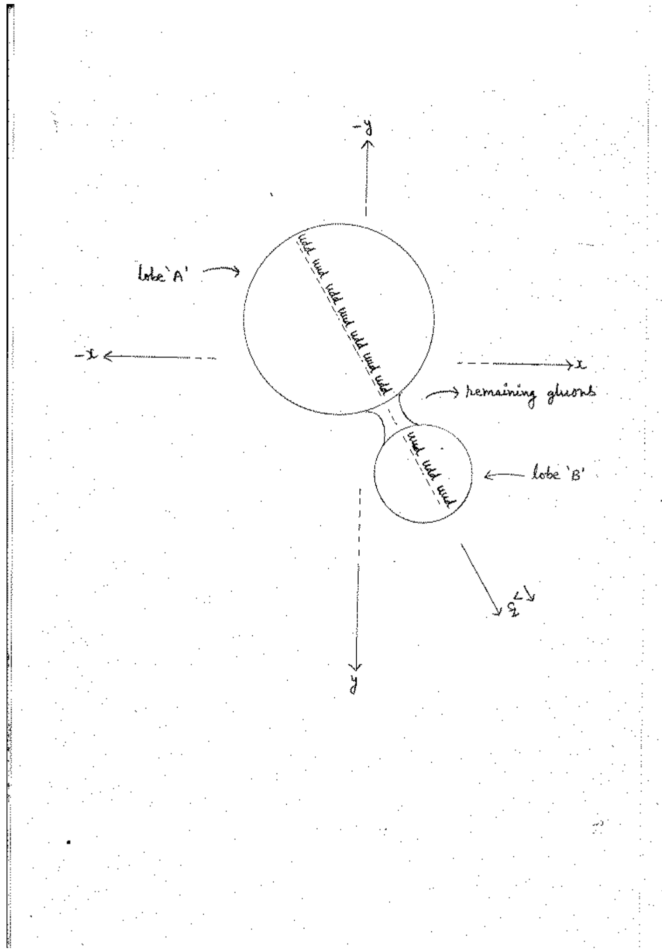
Formaton of lobes

4..Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

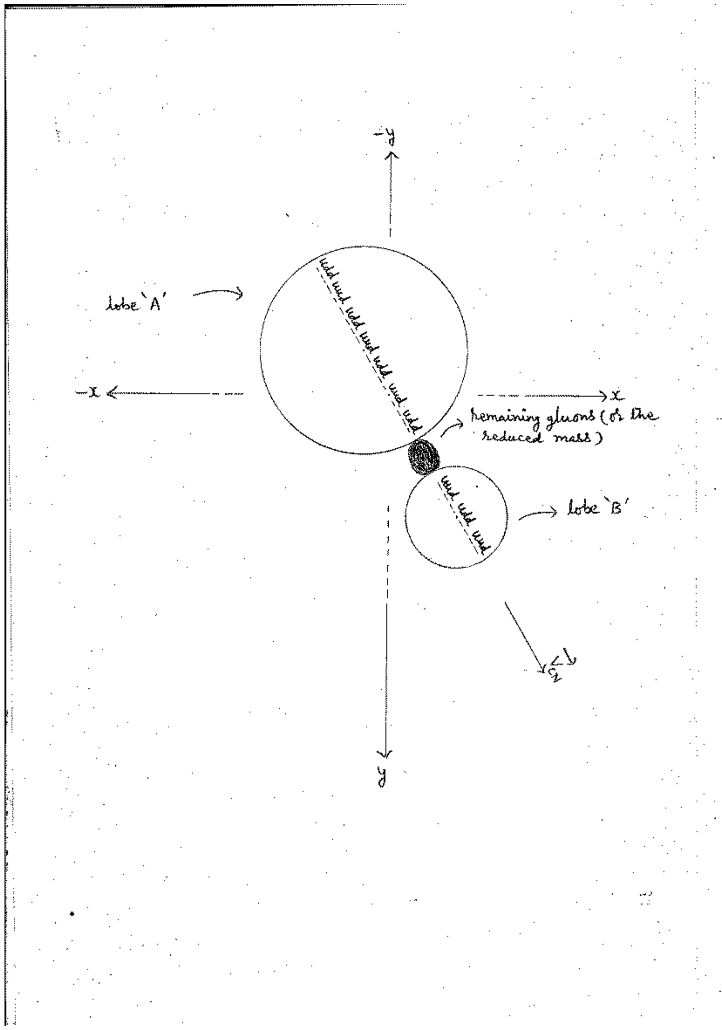
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degrees

β = 30 degrees



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

Each deuteron has to overcome the the electrostatic repulsive force exerted by the lithion-6 as well as by other deuteron to form a compund nucleus .

(1)Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

Just before fusion, to overcome the electrostatic repulsive force exerted by the confined deuteron , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 5.0622 kev.

so, just before fusion, the total loss in kinetic energy of the deuteron is --

E_{loss} = (5.0622+ 45.5598) kev
= 50.622 Kev

so, just before fusion the kinetic energy of deuteron is –

$E_b = E_{injected} – E_{loss}$

E_b = 153.6 kev – 50.622 kev
= 102.978 kev
= 0.102978 Mev

(2)just before fusion lithion – 6 opposes each deuteron with 136.0700 kev

as there are two deuterons so Just before fusion, to overcome the electrostatic repulsive force exerted by the each deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves) its energy equal to 272.14 kev.

so, just before fusion,

the kinetic energy of lithion -6 is –

$E_b = E_{confined} – E_{loss}$

E_b = 388.2043 kev – 272.14 kev
= 116.0643 kev
= 0.1160643 Mev

Kinetic energy of the compound nucleus

K.E. =[E_b of injected deuteron] + [E_b of lithion-6] + [E_b of confined deuteron]

= [102.978 Kev] +[116.0643 Kev]+ [102.978 Kev]

= 322.0203 Kev.

= 0. 3220203 Mev

M = $m_d + m_{Li-6} + m_d$

= [3.3434 x10^{-27} Kg] +[9.9853 x 10^{-27} Kg] + [3.3434x10^{-27} Kg]

= 16.6721 x 10^{-27} Kg

Velocity of compound nucleus

K.E. = ½ MV^2_{CN} = 0.3220203 mev

$V_{CN} = \left(\frac{2 \times 0.3220203 \times 1.6 \times 10^{-13}}{16.6721 \times 10^{-27} \text{ kg}} \right)^{1/2}$ m/s

$V_{CN} = \left(\frac{1.03046496 \times 10^{-13}}{16.6721 \times 10^{-27}} \right)^{1/2}$ m/s

V_{CN}= [0.06180774827 x 10^{14}] $^{1/2}$ m/s

V_{CN} = 0.2486 x 10^7 m/s

Components of velocity of compound nucleus

(1). $\overrightarrow{Vx}$ = V_{CN} cos α

=0.2486 X 10^7X0.5 m/s

= 0.1243 X 10^7 m/s

(2). $\overrightarrow{Vy}$ = V_{CN} cos β

= 0.2486 X 10^7X0.866 m/s

= 0.2152 m/s

(3).$\overrightarrow{Vz}$= V_{CN} cos y

= 0.2486 X 10^7 X 0 m/s

= 0 m/s

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – lithium-7, the helium - 3 andthe reduced mass (Δm) .

Out of them , the two particles (the lithium-7, the helium - 3) are stable while the third one (reduced mass) is unstable .

According to thelaw of inertia , each particle that is produced due to splitting of the compound nucleus, hasan inherited velocity ($\overrightarrow{Vinh}$)equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$).

So, for conservation of momentum

$M\overrightarrow{Vcn} = (m_{Li-7} + \Delta m + m_{He-3})\overrightarrow{Vcn}$

Where ,

M = mass of the compound nucleus

$\overrightarrow{Vcn}$ = velocity of the compound nucleus

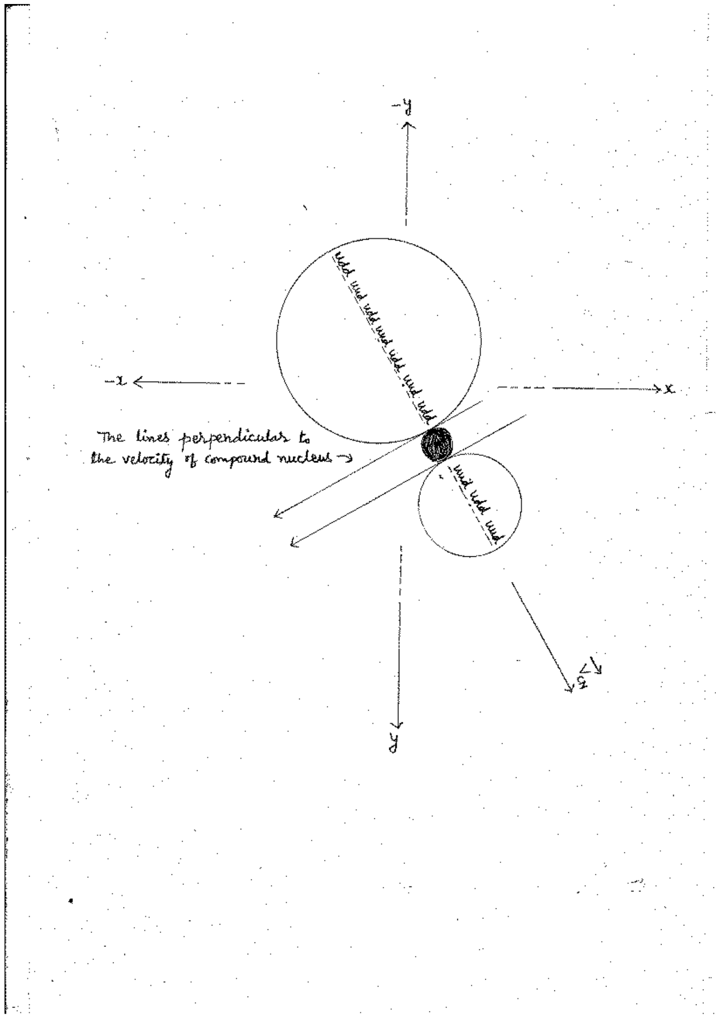
m_{Li-7} = mass of the lithium-7

m_{He-3} = mass of the helium - 3 nucleus

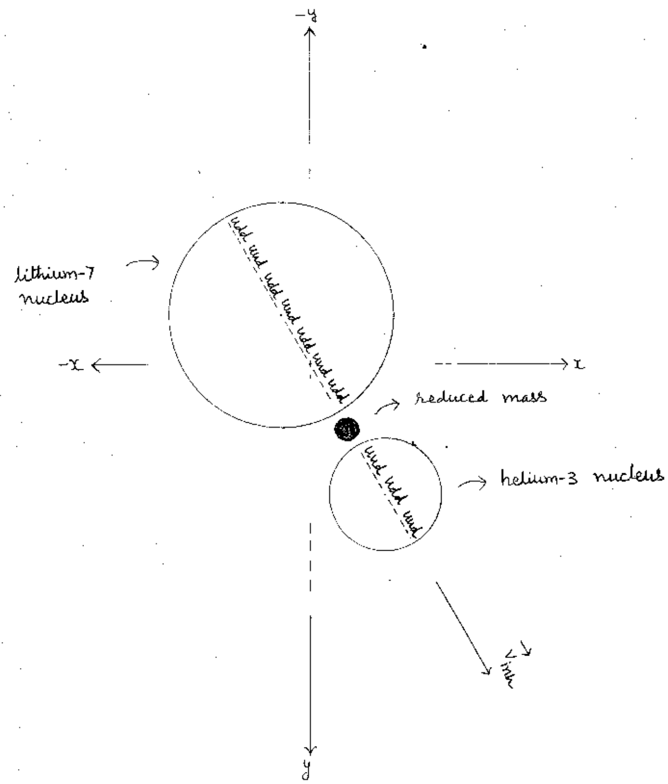
Δm = reduced mass

The splitting of the heterogenous compoundnucleus

The hetererogenous compound nucleus to show the lines perpendicularto the$\overrightarrow{Vcn}$



The splitting of the heterogenous compound nucleus


-y
lithium-7 nucleus
-x
x
reduced mass
helium-3 nucleus
y

Inherited velocity of the particles (s) : -

Eachparticles has inherited velocity ($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

(I). Inherited velocity of the particle lithion -7

V_{inh} = V_{CN} = 0.2486 x 10^7 m/s

Components of the inherited velocity ofthe particle Li-7

1.$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN}cosα = 0.1243 x 10^7 m/s

2 .$\underset{Vy}{\rightarrow}$ = V_{inh} cos β = V_{CN}cosβ= 0.2152 x 10^7m/s

3 .$\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

(II). Inherited velocity of the He-3

V_{inh} = V_{CN} = 0.2486x 10^7 m/s

Components of the inherited velocity of the He-3

1.$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN}cosα= 0.1243 x 10^7 m/s

2 .$\underset{Vy}{\rightarrow}$ = V_{inh} cos β =V_{CN}cos β= 0.2152 x 10^7m/s

3.$\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

(iii)Inherited velocity of the reduced mass

V_{inh} = V_{CN} = 0.2486 x 10^7 m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propelboth the particles with equal and opposite momentum.

Reduced mass

Δm = [m_d+m_{Li-6}+ m_d] - [m_{Li-7} + m_{He-3}]

Δm = [2.01355 + 6.01347708 + 2.01355]– [7.01435884 + 3.014932] amu

Δm = [10.04057708] – [10.02929084] amu

Δm = 0.01128624 amu

Δm = 0.01128624 x 1.6605 x 10^{-27} kg

The Inherited kinetic energy of reduced mass (Δm) .

E_{inh} = $\frac{1}{2}\Delta m\, V^2_{CN}$

Δm = 0.01128624 x 1.6605 x 10^{-27} kg

V^2_{CN} = 0.06180774827x 10^{14}

E_{inh} = ½ x 0.01128624 x 1.6605 x 10^{-27} x 0.06180774827 x 10^{14}J

E_{inh} = 0.00057916337 x 10^{-13} J

E_{inh} = 0.000361Mev

Released energy (E_R)

E_R = Δmc^2

E_R = 0.01128624 x 931 Mev

E_R = 10.507489 Mev

Total energy (E_T)

E_T = E_{inh} + E_R

E_T = [0.000361+ 10.507489] Mev

E_T = 10.50785 Mev

Increased energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses .so,the increased energy (E_{inc}) of the particles are :-

1.. For lithion – 7

$$E_{inc} = \frac{m_{He-3}}{m_{He-3} + m_{Li-7}} \times E_T$$

$$E_{inc} = \frac{3.014932 \text{ amu}}{[3.014932 + 7.01435884] \text{ amu}} \times 10.50785 \text{ Mev}$$

$$E_{inc} = \frac{3.014932}{10.02929084} \times 10.50785 \text{ Mev}$$

$$E_{inc} = 0.3006126802 \times 10.50785 \text{ Mev}$$

$$E_{inc} = 3.158792 \text{ Mev}$$

2..increased energy of the helium- 3

$$E_{inc} = [E_T] - [\text{increased energy of the Li-7}]$$

$$E_{inc} = [10.50785] - [3.158792] \text{ Mev}$$

E_{inc} = 7.349058 Mev

6..Increased velocity of the particles .

(1) For helium- 3

$E_{inc} = {}^{1}/_{2} m_{He-3} \; v_{inc}^{2}$

$V_{inc} = [\, 2 \times E_{inc}/m_{He-3} \,]^{1/2}$

$$= \left(\frac{2 \times 7.349058 \times 1.6 \times 10^{-13}\ J}{5.00629 \times 10^{-27}\ kg} \right)^{1/2} m/s$$

$$= \left(\frac{23.5169856 \times 10^{-13}}{5.00629 \times 10^{-27}} \right)^{1/2} m/s$$

$$= [\; 4.69748768049 \times 10^{14} \;]^{1/2} \; m/s$$

$$= 2.1673 \times 10^{7} \; m/s$$

(2) For lithium-7

$V_{inc} = [\, 2 \times E_{inc} / m_{Li-7} \,]^{1/2}$

$$= \left(\frac{2 \times 3.158792 \times 1.6 \times 10^{-13}\ J}{11.6473 \times 10^{-27}\ kg} \right)^{1/2}$$

$$= \left(\frac{10.1081344 \times 10^{-13}}{11.6473 \times 10^{-27}} \right)^{1/2} m/s$$

$$= [\, 0.86785215457 \times 10^{14} \,]^{1/2} \; m/s$$

$$= 0.9315 \times 10^{7} \; m/s$$

7 Angle of propulsion

1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum .

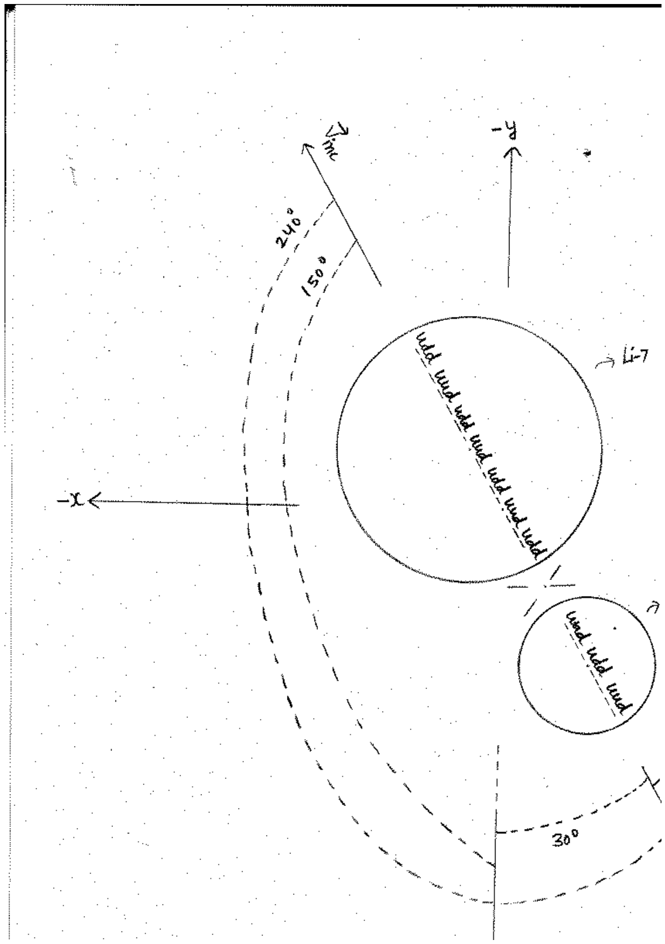
2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in thedirection of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ' F ' , as V_{CN}makes 60^o angle with x-axis , 30^o angle with y-axis and 90^o angle with z-axis .

so, the helium-3 is propelled making 60^o angle with x-axis , 30^o angle with y-axis and 90^oangle with z-axis .

While the lithium - 7 is propelled making 240^oangle with x-axis , 150^o angle with y-axis and 90^o angle with z-axis .

Propulsion of the particles



Components of the increasedvelocity (V_{inc}) of the particles.

(i) Forlithium- 7

1 $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.9315×10^7 m/s

cosα = cos (240) = -0.5

$\underset{Vx}{\rightarrow}$= $0.9315 \times 10^7 \times (-0.5)$ m/s

= -0.4657×10^7 m/s

2 $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β= cos (150) = - 0.866

$\underset{Vy}{\rightarrow}$ = $0.9315 \times 10^7 \times (-0.866)$ m/s

= -0.8066×10^7 m/s

3 $\underset{Vz}{\rightarrow}$= V_{inc}cos y

Cosy = cos 90° =0

$\underset{Vz}{\rightarrow}$ = $0.9315 \times 10^7 \times 0$

= 0 m/s

For helium - 3

1 $\underset{Vx}{\rightarrow}$ = V_{inc}cosα

V_{inc} = 2.1673×10^7 m/s

cosα= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$= $2.1673 \times 10^7 \times 0.5$ m/s

= 1.0836×10^7 m/s

2 $\underset{Vy}{\rightarrow}$= V_{inc}cos β

cos β =cos (30) = 0.866

$\underset{Vy}{\rightarrow}$=$2.1673 \times 10^7 \times 0.866$m/s

= 1.8768×10^7 m/s

3 $\underset{Vz}{\rightarrow}$ = V_{inc} cos y

cos y = cos(90) = 0

$\underset{Vz}{\rightarrow}$Vz = $2.1673 \times 10^7 \times 0$m/s

= 0 m/s

9.. Components of thefinalvelocity (Vf)of the particles

I Forlithium-7

According to-	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity $(\overrightarrow{Vf})$=($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X –axis	$\overrightarrow{Vx}$= 0.1243 x10^7m/s	$\overrightarrow{Vx}$ =-0.4657 x10^7m/s	$\overrightarrow{Vx}$= -0.3414x10^7m/s
y – axis	$\overrightarrow{Vy}$=0.2152x10^7m/s	$\overrightarrow{Vy}$ = -0.8066x 10^7m/s	$\overrightarrow{Vy}$ =-0.5914x10^7m/s
z –axis	$\overrightarrow{Vz}$ =0 m/s	$\overrightarrow{Vz}$ =0 m/s	$\overrightarrow{Vz}$ = 0 m/s

2..For helium -3

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity $(\overrightarrow{Vf})$ =($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X –axis	$\overrightarrow{Vx}$= 0.1243 x10^7m/s	$\overrightarrow{Vx}$= 1.0836 x10^7m/s	$\overrightarrow{Vx}$ =1.2079 x10^7m/s
y – axis	$\overrightarrow{Vy}$=0.2152x 10^7m/s	$\overrightarrow{Vy}$ = 1.8768 x10^7m/s	$\overrightarrow{Vy}$= 2.092x10^7m/s
z –axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$ =0 m/s

10.. Final velocity (vf) of the lithion- 7

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.3414 \text{ X } 10^7$ m/s

V_Y= 0.5914 X10^7m/s

V_Z= 0 m/s

V_f^2= (0.3414 X10^7)^2 + (0.5914 X10^7)^2 +(0)^{2}m^2/s^2

V_f^2 = (0.11655396 X10^{14})+(0.34975396X10^{14})+0 m^2/s^2

$V_f^2 = 0.46630792 \text{ X } 10^{14}\ m^2/s^2$
$V_f = 0.6828 \text{ x}10^7 m/s$

Final kinetic energy of the lithion - 7

$E= ½\ m_{Li-7}V_f^2$

$E = ½ \text{ x } 11.6473 \text{x } 10^{-27} \text{x } 0.46630792 \text{ X } 10^{14} J$

$= 2.7156141183 \text{ X } 10^{-13} J$

= 1.697258 Mev

$mLi_{-7}V_f^2 = 11.6473 \text{x } 10^{-27} \text{ x } 0.46630792 \text{ X } 10^{14}\ J$

$= 5.4312 \text{ x } 10^{-13} J$

10.. Final velocity (vf) of the helion -3

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 1.2079 \text{ X } 10^7\ m/s$

$V_y = 2.092 \text{ X}10^7\ m/s$

$V_z = 0\ m/s$

$V_f^2 = (1.2079\text{X}10^7\ )^2 + (2.092 \text{ X}10^7\ )^2 + (0)^2\ m^2/s^2$
$V_f^2 = (1.45902241\text{X}10^{14}) + (4.376464 \text{ X}10^{14}) + 0\ m^2/s^2$
$V_f^2 = 5.83548641 \text{ X } 10^{14} m^2/s^2$
$V_f = 2.4156 \text{ x}10^7 m/s$

Final kinetic energy of the helium -3

$E= ½\ m_{He-3}V_f^2$

$E = ½ x 5.00629 x 10^{-27} x 5.83548641 X 10^{14}$ J

$= 14.6070686297 X 10^{-13}$J

= 9.129417 Mev

$m_{He-3}V_f^2 = 5.00629 x 10^{-27} x 5.83548641 X 10^{14}$J

$= 29.2141 x 10^{-13}$ J

Forces acting on the lithion – 7 nucleus

1 $F_y = q V_x B_z \sin\theta$

$\overrightarrow{V_x} = -0.3414 x 10^7$ m/s

$\overrightarrow{B_z} = -1.001 x 10^{-1}$ Tesla

$q = 3 x 1.6 x 10^{-19}$ c

$\sin\theta = \sin 90^o = 1$

$Fy = 3x1.6 x 10^{-19} x 0.3414 x 10^7 x 1.001x10^{-1} x 1$ N

$= 1.6403x 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fy}$ is according to (+) y-axis ,

so ,

$\overrightarrow{Fy} = 1.6403 x10^{-13}$N

2 $F_z = q V_x B_y \sin\theta$

$\overrightarrow{B_y} = 1.0013 x10^{-1}$Tesla

$\sin\theta = \sin 90^o = 1$

$Fz = 3 x 1.6 x10^{-19} x 0.3414 x 10^7 x 1.0013 x10^{-1} x 1$ N

$= 1.6408 x 10^{-13}$ N

Form the right hand palm rule , thedirection ofthe force $\overrightarrow{Fz}$ is according to(+) Z- axis ,

so ,

$\overrightarrow{Fz} = 1.6408 x 10^{-13}$N

3 $F_x = q\, V_y\, B_z \sin\theta$

$\overrightarrow{V_y} = -0.5914 \times 10^{7}$ m/s

$\overrightarrow{B_z} = 1.001 \times 10^{-1}$ Tesla

$\sin\theta = \sin 90^{o} = 1$

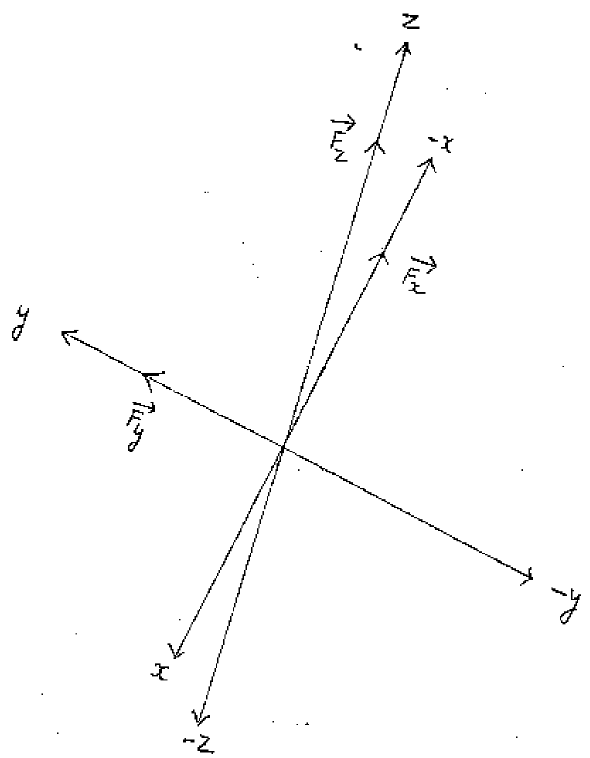
$F_x = 3 \times 1.6 \times 10^{-19} \times 0.5914 \times 10^{7} \times 1.001 \times 10^{-1} \times 1$ N

$= 2.8415 \times 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (-) x axis ,

so, $\overrightarrow{Fx} = -2.8415 \times 10^{-13}$ N

Forces acting on the lithion-7



Resultant force (F_R) :

$$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$$

$$F_x = 2.8415 \times 10^{-13} \text{ N}$$

$$F_y = 1.6403 \times 10^{-13} \text{ N}$$

$$F_z = 1.6408 \times 10^{-13} \text{ N}$$

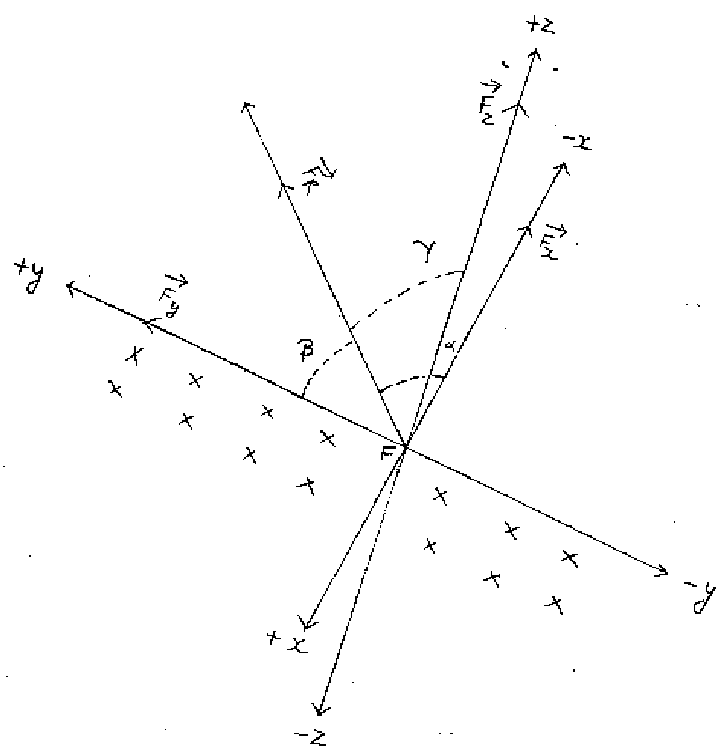
$$F_R^2 = (2.8415 \times 10^{-13})^2 + (1.6403 \times 10^{-13})^2 + (1.6408 \times 10^{-13})^2 \text{ N}^2$$

$$F_R^2 = (8.07412225 \times 10^{-26}) + (2.69058409 \times 10^{-26}) + (2.69222464 \times 10^{-26}) \text{ N}^2$$

$$F_R^2 = 13.45693098 \times 10^{-26} \text{ N}^2$$

$$F_R = 3.6683 \times 10^{-13} \text{ N}$$

Resultant force acting on the lithion-7



Radius of the circular orbit to be followed by the lithion - 7

$r = mv^2 / F_R$

$mv^2 = 5.4312 \times 10^{-13}$ J

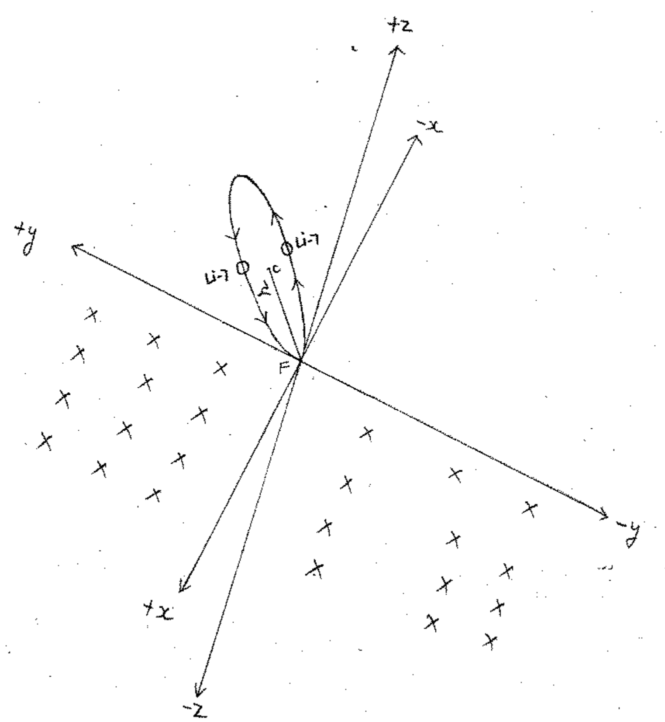
$F_r = 3.6683 \times 10^{-13}$ N

$$r = \frac{5.4312 \times 10^{-13} \text{ J}}{3.6683 \times 10^{-13} \text{ N}}$$

$r = 1.4805$ m

The circular orbit to be followed by the lithion -7 lies in theplane made up of negative x-axis, positive y-axis and the positive z-axis.

C= center of the circular orbitto be followed by the lithion -7.



The plane of the circular orbit to be followed by the lithion -7 makes angleswith positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow}$ / F_r

$\underset{Fx}{\rightarrow}$ = -2.8415 x 10^{-13} N

F_r= 3.6683 x 10^{-13} N

Puttingvalues

Cos α = - 0.7746

α= 219.23 degree [∴ cos (219.23) = -0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ = 1.6403 x 10^{-13} N

F_r = 3.6683x 10^{-13}N

Putting values

Cosβ= 0.4471

β= 63.44 degree [∴ cos (63.44)= 0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/$F_r = \underset{Fz}{\rightarrow}$ / F_r

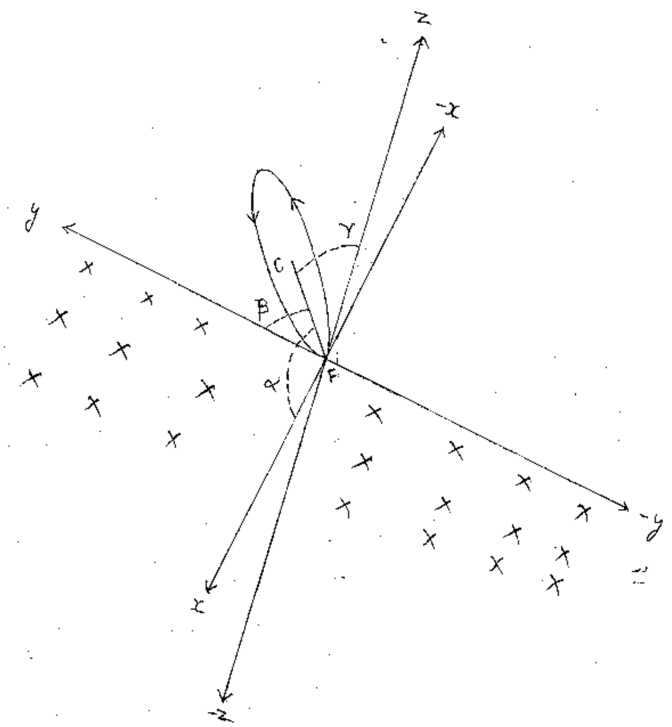
$\underset{Fz}{\rightarrow}$ = $\underline{1.6408 \times 10^{-13} N}$

F_r= 3.6683 x 10^{-13}N

Putting values

Cos y = 0.4472
y = 63.43 degree

The plane of the circular orbit to be followed by the lithion -7makesangles with positivex ,y , and z axes as follows :-



Where,

α =219.23 degree

β = 63.44 degree

Y = 63.43 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2(x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the lithion- 7.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

d = 2 x r

= 2x 1.4805m

= 2.961 m

Cos α = - 0.7746

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 2.961 \times (-0.7746)$ m

$x_2 - x_1 = -2.2935$m

$x_2 = -2.2935$ m [∴ $x_1 = 0$]

$\cos\beta = \frac{y_2 - y_1}{d}$

cosβ = 0.4471

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 2.961 \times 0.4471$ m

$y_2 - y_1 = 1.3238$ m

$y_2 = 1.3238$ m [∴ $y_1 = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

cos y = 0.4472

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 2.961 \times 0.4472$m

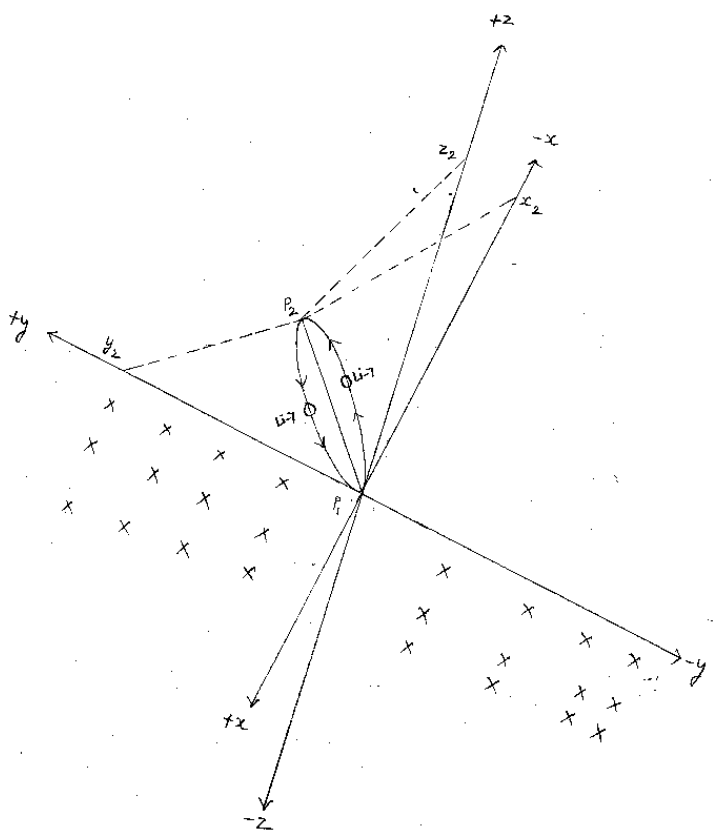
$z_2 - z_1 = 1.3241$ m

$z_2 = 1.3241$ m [∴ $z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2, z_2) located on the circumfrence of the circle to beobtained by the beryllium-7 are as shown below.

The line ___ is the diameter of the circle .

P_1P_2



Conclusion :-

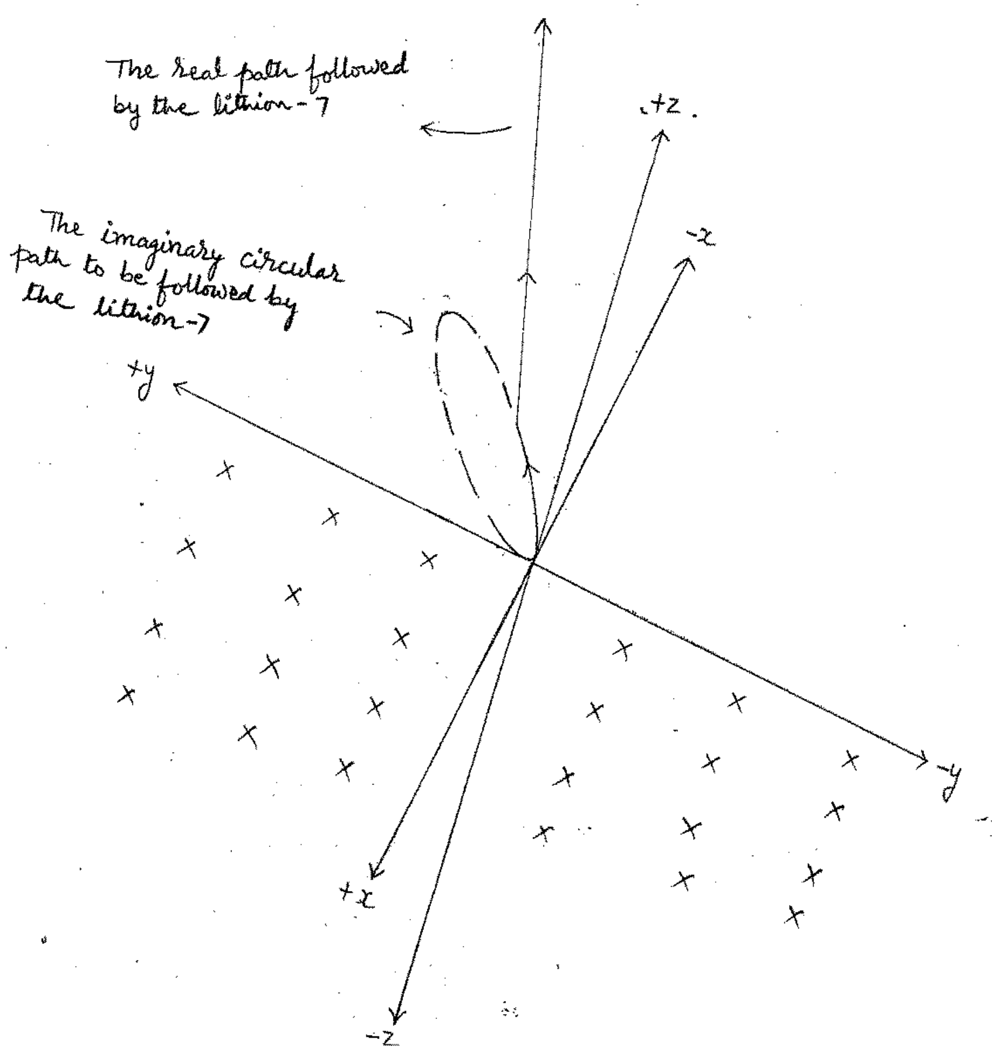
Thedirections components[$\vec{F_x}$,$\vec{F_y}$,and$\vec{F_z}$] ofthe resultant force($\vec{F_r}$)that are acting on the lithium-7 nucleus are along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axisand positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow}$) tends the lithium-7 nucleus to undergo to a circular orbit ofradius 1.4805 m. It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-2.2935 m,1.3238 m,1.3241 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. soas the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

The lithium-7 nucleus is not confined within into the tokamak.


The real path followed
by the lithion-7
+z
The imaginary circular
path to be followed by
the lithion-7
-x
+y
-y
+x
-z

Forces acting on thehelion- 3nucleus

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow}$ = 1.2079 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= -1.001 x$10^{-1}$ Tesla

q= 2 x 1.6 x 10^{-19} c

sin θ = sin 90^o = 1

Fy = 2x1.6 x 10^{-19}x 1.2079 x 10^7x 1.001x10^{-1}x 1 N

= 3.8691x 10^{-13} N

Form the right hand palm rule , the direction of the force$\underset{Fy}{\rightarrow}$ is according to (-) y-axis ,

so ,

$\underset{Fy}{\rightarrow}$ = - 3.8691x10^{-13}N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow}$= 1.0013 x$10^{-1}$Tesla

sin θ = sin 90^o = 1

Fz = 2 x 1.6 x 10^{-19} x 1.2079 x 10^7 x 1.0013 x10^{-1} x 1 N

= 3.8703 x 10^{-13} N

Form the right hand palm rule , the direction of the force$\underset{Fz}{\rightarrow}$ is accordingto (-) Z- axis ,

so ,

$\underset{Fz}{\rightarrow}$ = - 3.8703x 10^{-13}N

3 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow}$= 2.092 x 10^7 m/s

$\underset{Bz}{\rightarrow}$= - 1.001x$10^{-1}$ Tesla

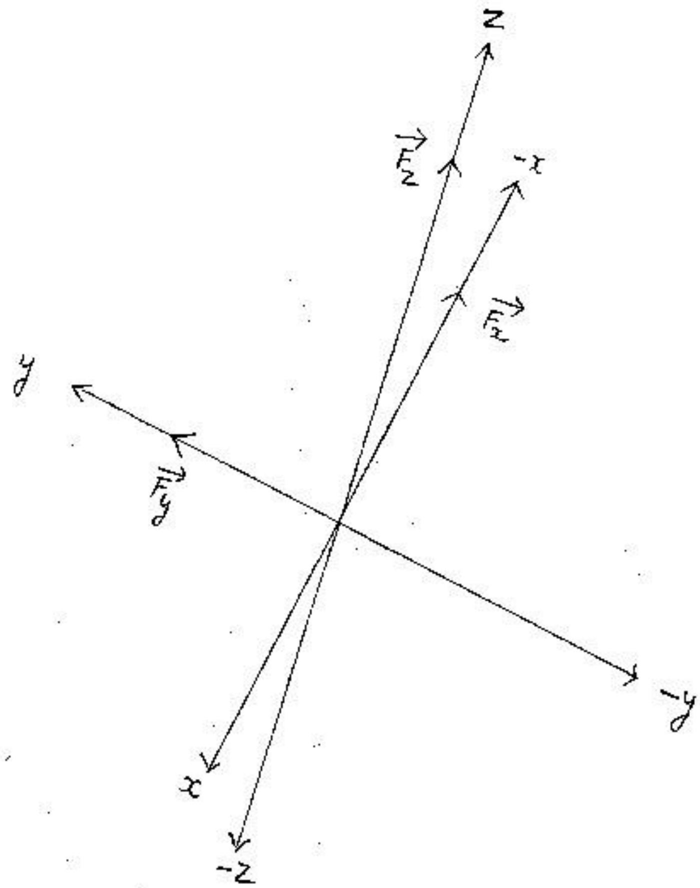
sin θ = sin 90^o = 1

Fx = 2x1.6 x 10^{-19} x 2.092 x 10^7x 1.001x10^{-1} x 1N

= 6.7010 x 10^{-13} N

Form the right hand palm rule , the direction of the force$\underset{Fx}{\rightarrow}$ is according to (+) x axis ,

so ,$\underset{Fx}{\rightarrow}$ = 6.7010x 10^{-13}N


z
-x
y
-y
x
-z

Resultant force (F_R) :

$$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$$

$$F_x = 6.7010 \times 10^{-13} \quad N$$

$$F_y = 3.8691 \times 10^{-13} \quad N$$

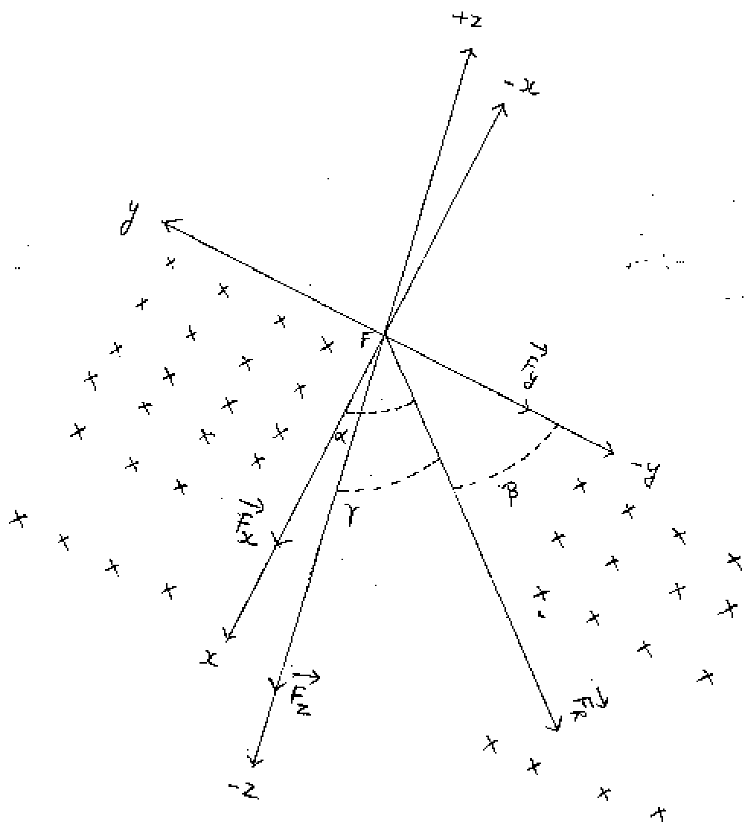
$$F_z = 3.8703 \times 10^{-13} \quad N$$

$$F_R^2 = (6.7010 \times 10^{-13})^2 + (3.8691 \times 10^{-13})^2 + (3.8703 \times 10^{-13})^2 \; N^2$$

$$F_R^2 = (44.903401 \times 10^{-26}) + (14.96993481 \times 10^{-26}) + (14.97922209 \times 10^{-26}) \quad N^2$$

$$F_R^2 = 74.8525579 \times 10^{-26} \quad N^2$$

$$F_R = 8.6517 \times 10^{-13} \quad N$$


+z
-x
y
F
α
γ
β
-y
x
-z

Radius of the circular orbit to be followed by the helium-3

$r = mv^2/F_R$

$mv^2 = 29.2141\text{x } 10^{-13}$ J

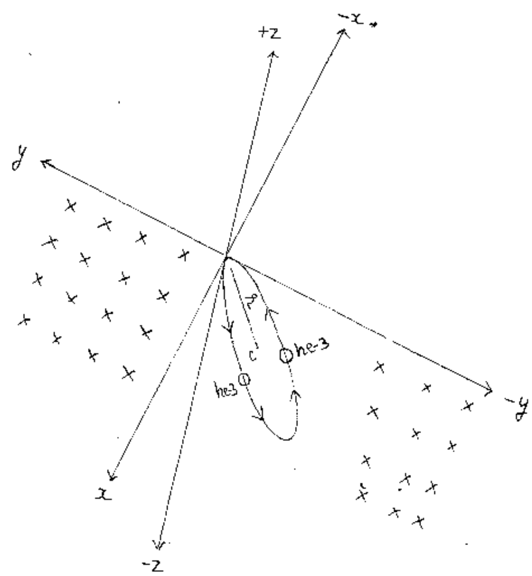
$F_r = 8.6517\text{x } 10^{-13}$ N

$$r = \frac{29.2141 \times 10^{-13}\ \text{J}}{8.6517 \times 10^{-13}\ \text{N}}$$

$r = 3.3766$ m

The circular orbit to be followed by the helium-3 lies in the plane made up of positive x-axis, positive y-axis and the positive z-axis.

C = center of the circular orbit to be followed by the helium-3.



The plane of the circular orbit to be followed by the helium -3 nucleus makes angleswith positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \overrightarrow{Fx} / F_r$

$\overrightarrow{Fx}$ = 6.7010 x 10^{-13} N

F_r =8.6517 x 10^{-13} N

Puttingvalues

Cos α = 0.7745

α=39.24degree [∴ cos (39.24) = 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / F_r=$\overrightarrow{Fy}$ / F_r

$\overrightarrow{Fy}$ = - 3.8691 x 10^{-13} N

F_r= 8.6517 x 10^{-13} N

Putting values

Cosβ = - 0.4472

β = 243.43 degree [∴ cos (243.43)= -0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/F_r=$\overrightarrow{Fz}$ / F_r

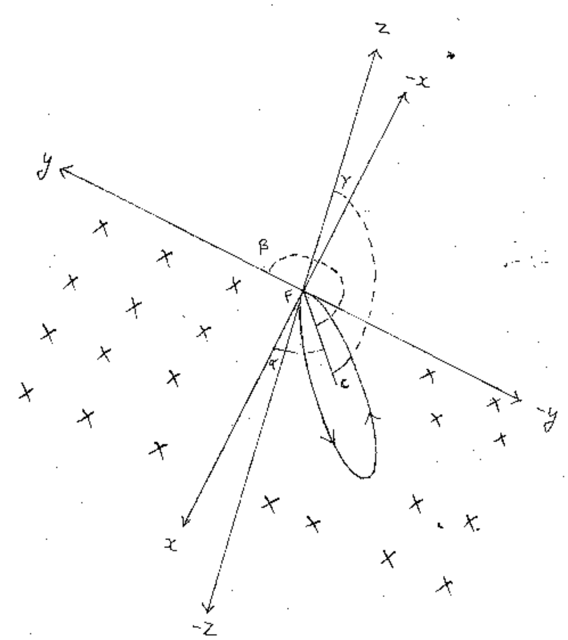
$\overrightarrow{Fz}$ = $\underline{-3.8703 \times 10^{-13} N}$

F_r = = 8.6517x 10^{-13} N

Putting values

Cos y = - 0.4473
y = 243.425 degree

The plane of the circular orbit to be followed by the helium -3 nucleus makes angles with positive x , y ,and z axes as follows :-



Where,

α = 39.24 degree

β = 243.43 degree

Y = 243.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the helium-3.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

$= 2x\ 3.3766\ m$

$= 6.7532\ m$

$Cos\ \alpha = 0.7745$

$x_2 - x_1 = d\ x\ \cos\alpha$

$x_2 - x_1 = 6.7532x\ 0.7745\ m$

$x_2 - x_1 = 5.2303m$

$x_2 = 5.2303\ m \quad [\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = - 0.4472$

$y_2 - y_1 = d\ x\ \cos\beta$

$y_2 - y_1 = 6.7532\ x\ (-0.4472)m$

$y_2 - y_1 = -3.0200\ m$

$y_2 = -3.0200\ m \quad [\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = - 0.4473$

$z_2 - z_1 = d\ x\ \cos y$

$z_2 - z_1 = 6.7532\ x\ (-0.4473)\ m$

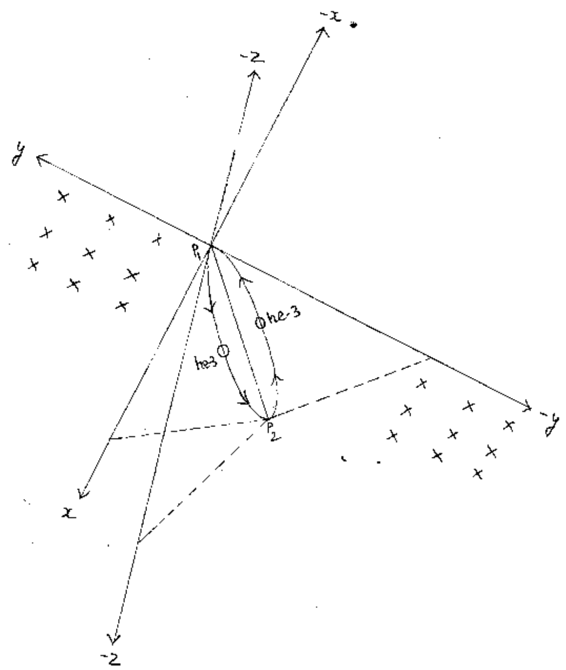
$z_2 - z_1 = -3.0207\ m$

$z_2 = -3.0207\ m \quad [\therefore z_1 = 0]$

The cartesian coordinates of the point p_1 (x_1 , y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumfrence of thecircle obtained by the helium - 3 are as shown below.

The line___ is the diameter of the circle .

P_1P_2



Conclusion :-

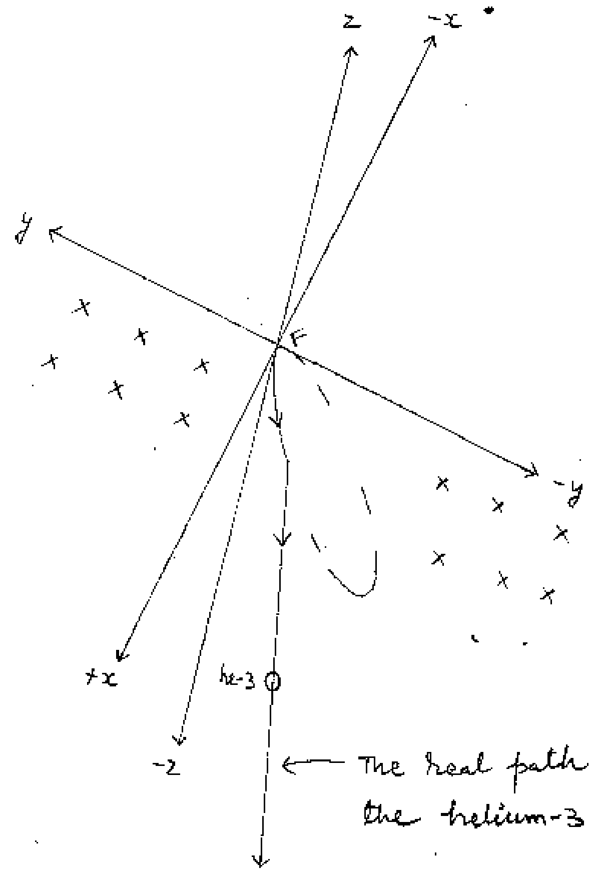
The directions components[$\vec{F_x}$,$\vec{F_y}$,and$\vec{F_z}$] of the resultant force($\vec{F_r}$)that are acting on the helium-3 nucleusare along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force($\vec{F_r}$) we come to know that the circular orbit to be followed by the helium-3 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axiswhere the magnetic fields are applied.

The resultant force($\vec{F_r}$) tends the helium-3 nucleus to undergo to a circular orbit of radius 3.3766 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (5.2303m,- 3.0200 m ,-3.0207 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the helium-3nucleus is not confined.



← The real path followed by the helium-3 nucleus.

(In trying to follow the circular orbit, the produced helium-3 nucleus strike to the base wall of the tokamak. So, it can not complete the circle.)

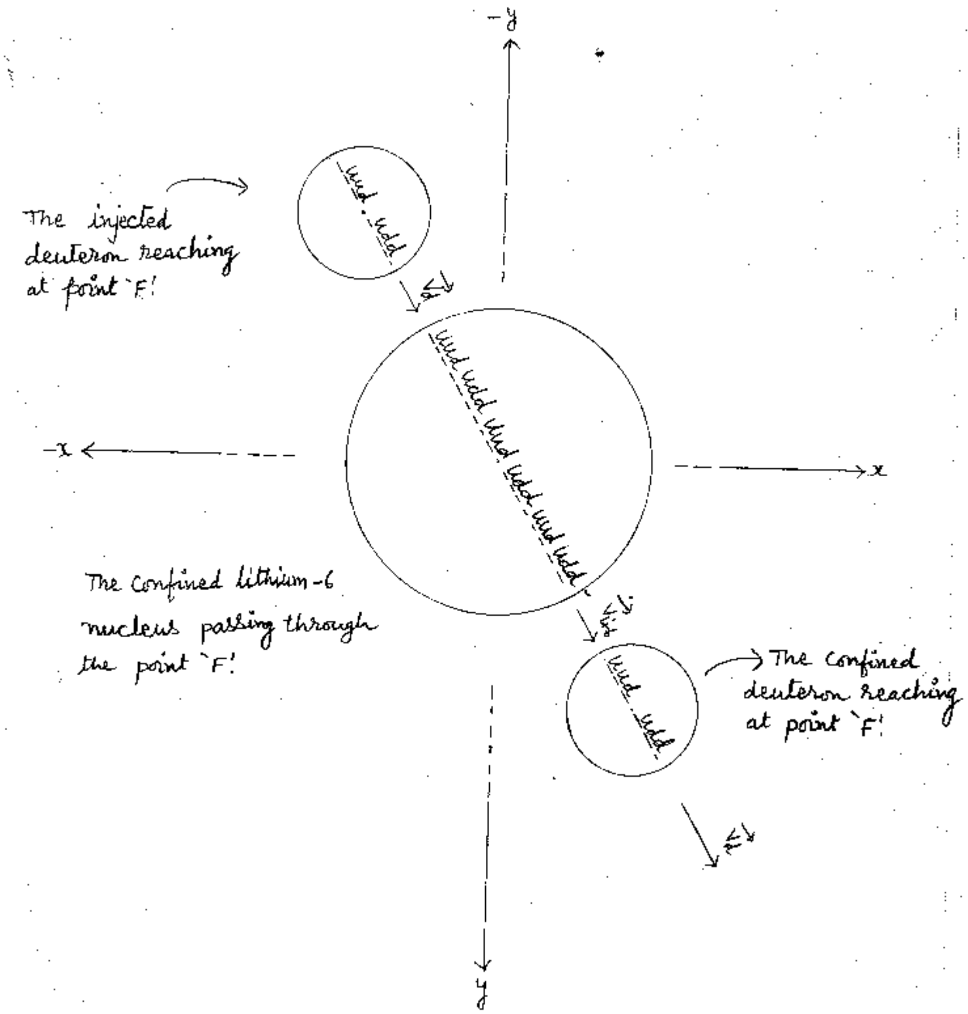
For fusion reaction

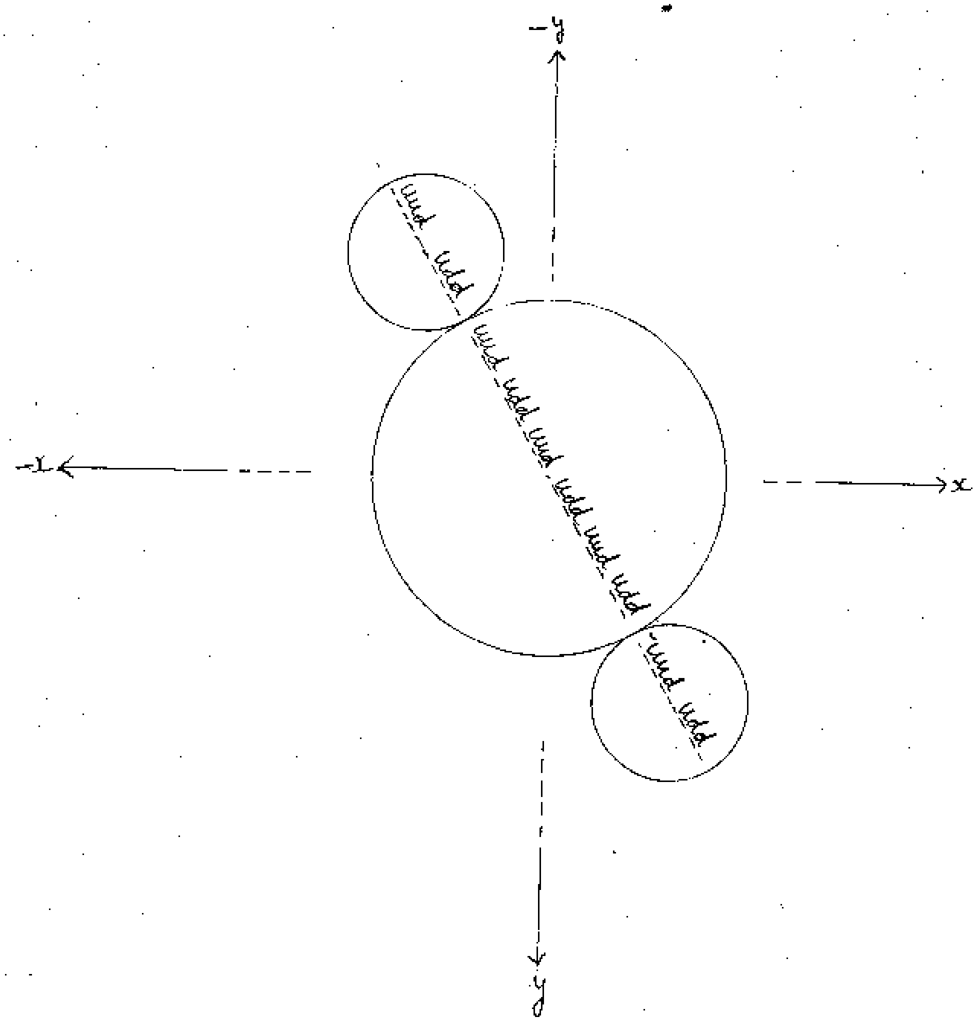
$^{2}_{1}H$ + $^{6}_{3}$ Li+ $^{2}_{1}H$→ [$_{5}^{10}B$] →$_{4}^{7}Be$ + $^{3}_{1}$ T

1.The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6 and confined deuteron] with the confined lithion-6 and confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6 and confined deuteron.

Interaction of nuclei :-


-y
The injected deuteron reaching at point `F'
uud udd
uud udd uud udd uud udd
-x
x
The confined lithium-6 nucleus passing through the point `F'
The confined deuteron reaching at point `F'
uud udd
y

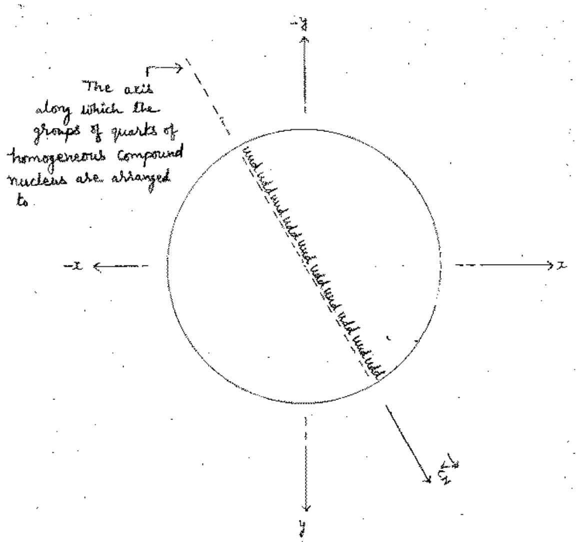

-y
-x
x
y
uud udd
uud udd uud udd uud udd
uud udd

2.Formation of the homogeneous compound nucleus : -

The constituents (quarks and gluons) of the dissimilarly joined nuclei (the injected deuteron and the lithion-6 nucleus and confined deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 10 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,

α = 60 degrees

β = 30 degrees

3 . Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the beryllium-7) than the reactant one (the lithion-6) includes the other six(nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

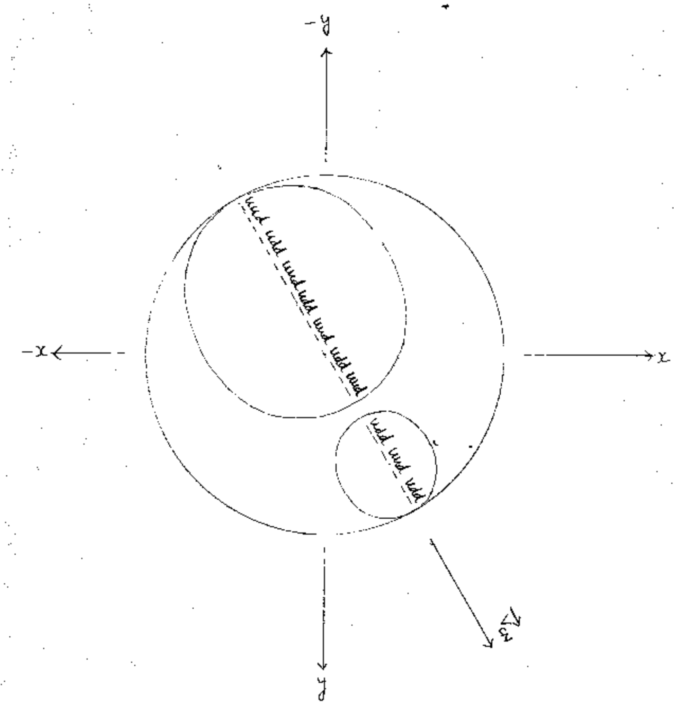
While , the remaining groups of quarks to become a stable nucleus (the triton) includes the other two (nearby located) groups of quarks with their surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the beryllium-7 nucleus and the smaller nucleus is the triton.

The greater nucleus is the lobe ‘A ‘ and the smaller nucleus is the lobe ‘B’ while the remainigh space represent the remaining gluons .



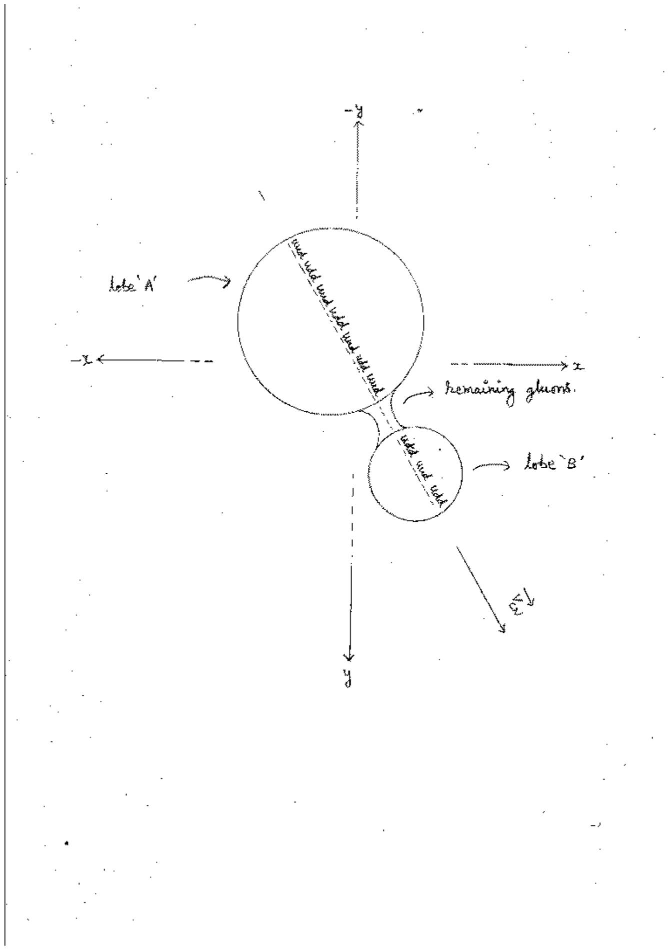
Formaton of lobes

4.Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

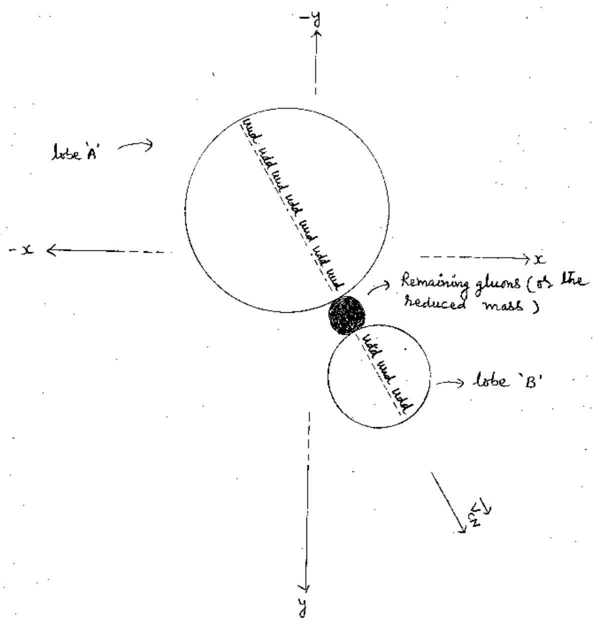
So, finally , the heterogeneous compound nucleus becomes like an abnormal digity eight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degree

β = 30 degree



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

Each deuteron has to overcome the the electrostatic repulsive force exerted by the lithion-6 and deuteron to form a compund nucleus .

Jut before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energy in the form of eletromagnetic waves its energy equal to 136.070070 kev.

Jut before fusion, to overcome the electrostatic repulsive force exerted by the confined deuteron , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 5.0622 kev.

so, just before fusion, the total loss in kinetic energy of the deuteron is --

E_{loss} = (5.0622+136.07007) kev
= 141.13227 Kev

so, just before fusion the kinetic energy of deuteron is –

E_b = $E_{injected} – E_{loss}$

E_b = 204.8 kev – 141.13227 kev
= 63.66773 kev
= 0.06366773 Mev

Formation of compound nucleus :

Each deuteron has to overcome the the electrostatic repulsive force exerted by the lithion-6 as well as by other deuteron to form a compund nucleus .

(1)Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

Just before fusion, to overcome the electrostatic repulsive force exerted by the confined deuteron , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 5.0622 kev.

so, just before fusion, the total loss in kinetic energy of the deuteron is --

E_{loss} = (5.0622+ 45.5598) kev
= 50.622 Kev

so, just before fusion the kinetic energy of deuteron is –

$E_b = E_{injected} – E_{loss}$

E_b = 153.6 kev – 50.622 kev
= 102.978 kev
= 0.102978 Mev

(2)just before fusion lithion – 6 opposes each deuteron with 136.0700 kev

as there are two deuterons so Just before fusion, to overcome the electrostatic repulsive force exerted by the each deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves) its energy equal to 272.14 kev.

so, just before fusion,

the kinetic energy of lithion -6 is –

$E_b = E_{confined} – E_{loss}$

E_b = 388.2043 kev – 272.14 kev
= 116.0643 kev
= 0.1160643 Mev

Kinetic energy of the compound nucleus

K.E. =[E_b of injected deuteron] + [E_b of lithion-6] + [E_b of confined deuteron]

= [102.978 Kev] +[116.0643 Kev]+ [102.978 Kev]

= 322.0203 Kev.

= 0. 3220203 Mev

M = $m_d + m_{Li-6} + m_d$

= [3.3434 x10^{-27} Kg] +[9.9853 x 10^{-27} Kg] + [3.3434x10^{-27} Kg]

= 16.6721 x 10^{-27} Kg

Velocity of compound nucleus

K.E. = ½ MV^2_{CN} = 0.3220203 mev

$$V_{CN} = \left(\frac{2 \times 0.3220203 \times 1.6 \times 10^{-13}}{16.6721 \times 10^{-27}\ \text{kg}} \right)^{1/2} \text{m/s}$$

$$V_{CN} = \left(\frac{1.03046496 \times 10^{-13}}{16.6721 \times 10^{-27}} \right)^{1/2} \text{m/s}$$

V_{CN}= [0.06180774827 x 10^{14}] ^{½} m/s

V_{CN} = 0.2486 x 10^7 m/s

Components of velocity of compound nucleus

(1). $\overrightarrow{Vx} = V_{CN}$ cos α

=0.2486 X 10^7X0.5 m/s

= 0.1243 X 10^7 m/s

(2). $\underset{Vy}{\rightarrow}$ = V_{CN} cos β

= 0.2486 X 10^7X0.866 m/s

= 0.2152 m/s

(3). $\underset{Vz}{\rightarrow}$= V_{CN} cos y

= 0.2486 X 10^7 X 0 m/s

= 0 m/s

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the directionof the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles – beryllium-7, the triton and the reduced mass (Δm) .

Out of them , the two particles (theberyllium-7and the triton) are stable while the thirdone (reduced mass) isunstable .

According to the law of inertia , each particle that is produced due to splitting of the compound nucleus , has an inherited velocity ($\underset{Vinh}{\longrightarrow}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$) .

So, for conservation of momentum

$M\overrightarrow{Vcn}$= (m_{Be-7} + Δm +m_t)$\overrightarrow{Vcn}$

Where ,

M = mass of the compound nucleus

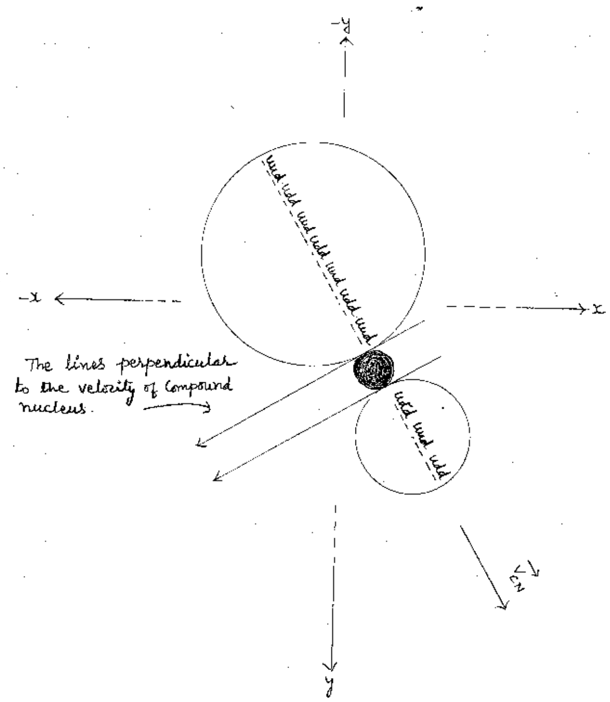
$\overrightarrow{Vcn}$ = velocity of the compound nucleus

m_{Be-7} = mass of the beryllium-7

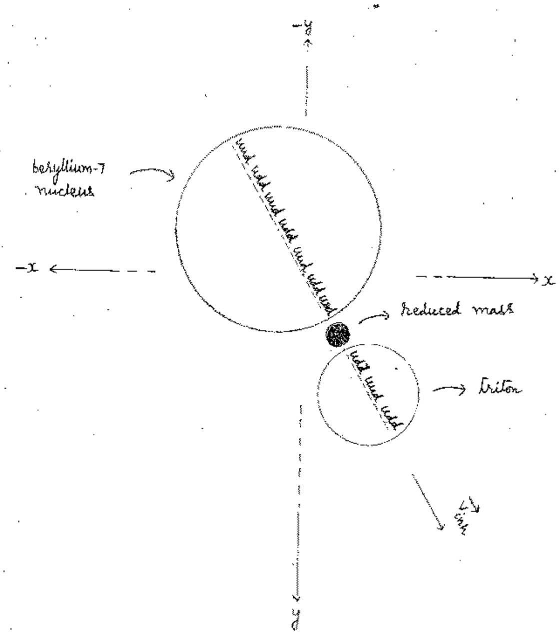
m_t = mass of the triton

Δm = reduced mass

The splitting ofthe heterogenous compound nucleus



The heterogenous compound nucleus to show the linesperpendicular to the$\overrightarrow{Vcn}$



Inherited velocity of the particles (s) : -

Each particles has inherited velocity ($\underset{Vinh}{\longrightarrow}$) equal to the velocity of the compound nucleus($\underset{Vcn}{\longrightarrow}$) .

(I). Inherited velocity of the particle Beryllium-7

V_{inh} = V_{CN} = 0.2486×10^7 m/s

Components of the inherited velocity of the particle Beryllium-7

1.$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cosα = 0.1243×10^7 m/s

2. $\underset{Vy}{\rightarrow}$ = V_{inh} cos β= V_{CN}cos β= 0.2152×10^7m/s

3.$\underset{Vz}{\rightarrow}$ = V_{inh}cos y = V_{CN} cos y = 0 m/s

(II) . Inherited velocity of the triton

V_{inh} = V_{CN} = 0.2486×10^7 m/s

Components of theinherited velocity of the triton

1.$\underset{Vx}{\rightarrow}$ = V_{inh} cos α =V_{CN} cosα = 0.1243×10^7 m/s

2 .$\underset{Vy}{\rightarrow}$ = V_{inh}cosβ =V_{CN}cos β= 0.2152×10^7m/s

3.$\underset{Vz}{\rightarrow}$ = V_{inh} cos y = V_{CN} cos y = 0 m/s

(iii) Inherited velocity of the reduced mass

V_{inh} = V_{CN} = 0.2486×10^7 m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propelboth the particles with equal and opposite momentum.

Reduced mass

Δm = [m_d + $m_{Li\text{-}6}$ + m_d] - [$m_{Be\text{-}7}$ + m_t]
Δm = [2.01355 + 6.01347708 + 2.01355]– [7.01473555 + 3.0155] amu
Δm = [10.04057708] – [10.03023555] amu
Δm = 0.01034153 amu
Δm = 0.01034153 x 1.6605 x 10^{-27} kg

The Inherited kinetic energy of reduced mass (Δm) .

E_{inh} = ½Δm V^2_{CN}

Δm = 0.01034153 x 1.6605 x 10^{-27} kg

V^2_{CN} = 0.06180774827x 10^{14}

E_{inh} = ½ x 0.01034153 x 1.6605 x 10^{-27} x 0.06180774827 x 10^{14} J

E_{inh} = 0.00053068474 x 10^{-13} J

E_{inh} = 0.000331 Mev

Released energy (E_R)

E_R = Δmc^2

E_R = 0.01034153 x 931 Mev

E_R = 9.627964 Mev

Total energy (E_T)

E_T = E_{inh} + E_R

E_T = [0.000331 + 9.627964] Mev

E_T = 9.628295 Mev

Increased energy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses .So, ,the increased energy (E_{inc}) of the particles are :-

1.. For beryllium -7

$$E_{inc} = \frac{m_t}{m_t + m_{Be-7}} \times E_T$$

$$E_{inc} = \frac{3.0155 \text{ amu}}{[3.0155 + 7.01473555] \text{ amu}} \times 9.628295 \text{ Mev}$$

$$E_{inc} = \frac{3.0155}{10.03023555} \times 9.628295 \text{ Mev}$$

$$E_{inc} = 0.30064099541 \times 9.628295 \text{ Mev}$$

$$E_{inc} = 2.894660 \text{ Mev}$$

2..increased energy of the triton

$$E_{inc} = [E_T] - [\text{increased energy of the Be-7}]$$

$$E_{inc} = [9.628295] - [2.894660] \text{ Mev}$$

E_{inc} = 6.733635 Mev

6.Increased velocity of the particles .

(1) For triton

$E_{inc} = {}^{1}/_{2} m_t \; v_{inc}^2$

$V_{inc} = [\, 2 \times E_{inc}/m_t]^{½}$ $\frac{2 \times 6.733635 \times 1.6\times10^{-13}\,J}{5.0072\times10^{-27}\ kg}^{½}$ m/s

$$= \left(\frac{21.547632 \times 10^{-13}}{5.0072 \times 10^{-27}} \right)^{½} \text{ m/s}$$

$= [\; 4.30332960536 \times 10^{14} \;]^{½}$ m/s

$= 2.0744 \times 10^{7}$ m/s

(2).For beryllium-7

$V_{inc} = [\, 2 \times E_{inc} \,/\, m_{Be\text{-}7}]^{½}$

$$= \left(\frac{2\times 2.894660 \times 1.6\times10^{-13}\ J}{11.6479 \times 10^{-27} kg} \right)^{½}$$

$$= \left(\frac{9.262912 \times 10^{-13}}{11.6479 \times 10^{-27}} \right)^{½} \text{ m/s}$$

$= [\; 0.79524309102 \times 10^{14} \;]^{½}$ m/s

$= 0.8917 \times 10^{7}$ m/s

7. Angle of propulsion

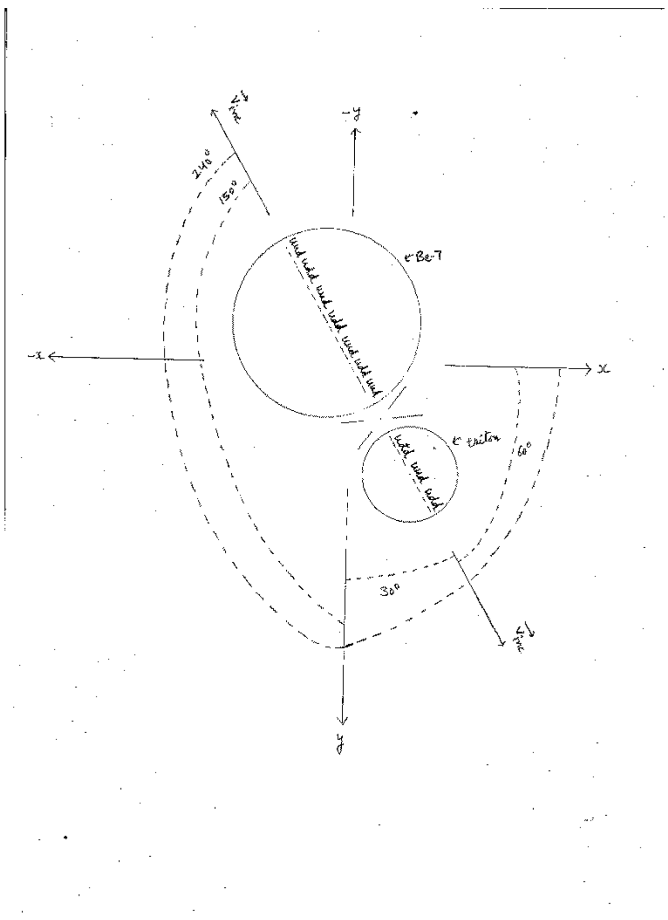
1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forwarddirection [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ' F ' , as V_{CN} makes 60^o angle with x-axis , 30^o angle with y-axis and 90^o angle with z-axis .

so, the triton is propelled making 60^o angle with x-axis , 30^o angle with y-axis and 90^o angle with z-axis . While the beryllium - 7 is propelled making 240^o angle with x-axis, 150^o angle with y-axis and 90^{o}angle with z-axis .

Propulsion of thte particles



Components of the increased velocity (V_{inc}) of the particles.

(i) For beryllium - 7

1. $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.8917 x 10^7 m/s

cos α= cos (240) = -0.5

$\underset{Vx}{\rightarrow}$= 0.8917 x 10^7 x(-0.5) m/s

= -0.4458 x 10^7 m/s

2 . $\underset{Vy}{\rightarrow}$ =V_{inc} cos β

cos β= cos (150) = - 0.866

$\underset{Vy}{\rightarrow}$ = 0.8917 x 10^7x (- 0.866) m/s

= - 0.7722x 10^7 m/s

3 . $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

Cos y= cos 90º = 0

$\underset{Vz}{\rightarrow}$= 0.8917 x 10^7x 0

= 0 m/s

(II) For triton

1. $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 2.0744 x 10^7m/s

cosα= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$= 2.0744 x 10^7 x 0.5m/s

= 1.0372 x 10^7 m/s

2. $\underset{Vy}{\rightarrow}$ = V_{inc} cosβ

cos β = cos (30) = 0.866

$\underset{Vy}{\rightarrow}$=2.0744 x 10^7x 0.866m/s

= 1.7964 x 10^7 m/s

3. $\underset{Vz}{\rightarrow}$ = V_{inc} cos y

cos y = cos(90) = 0

$\underset{Vz}{\rightarrow}$Vz = 2.0744 x$10^7$x0 m/s

= 0 m/s

9..Components of the final velocity(Vf)ofthe particles

IForberyllium- 7

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$) =($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X – axis	$\overrightarrow{Vx}$= 0.1243 x10^7m/s	$\overrightarrow{Vx}$=-0.4458x 10^7m/s	$\overrightarrow{Vx}$ = - 0.3215x10^7m/s
y –axis	$\overrightarrow{Vy}$= 0.2152 x10^7m/s	$\overrightarrow{Vy}$ = - 0.7722x 10^7m/s	$\overrightarrow{Vy}$=-0.557 x10^7m/s
z – axis	$\overrightarrow{Vz}$ =0 m/s	$\overrightarrow{Vz}$ = 0m/s	$\overrightarrow{Vz}$=0 m/s

2..Fortriton

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$)=($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X –axis	$\overrightarrow{Vx}$=0.1243 x10^7m/s	$\overrightarrow{Vx}$= 1.0372x10^7m/s	$\overrightarrow{Vx}$ =1.1615x10^7m/s
y– axis	$\overrightarrow{Vy}$= 0.2152 x10^7m/s	$\overrightarrow{Vy}$ = 1.7964 x10^7m/s	$\overrightarrow{Vy}$=2.0116x10^7m/s
z –axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$=0 m/s

10.. Final velocity (vf) of theberyllium - 7

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.3215 \times 10^7$ m/s

$V_y = 0.557 \times 10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.3215 \times 10^7)^2 + (0.557 \times 10^7)^2 + (0)^2 \; m^2/s^2$

$V_f^2 = (0.10336225 \times 10^{14}) + (0.310249 \times 10^{14}) + 0 \; m^2/s^2$

$V_f^2 = 0.41361125 \text{ X } 10^{14} m^2/s^2$
$V_f = 0.6431x10^7$ m/s

Final kinetic energy of the beryllium - 7

$E= ½\ m_{Be-7}V_f^2$

E = ½X11.6479x 10^{-27} x 0.41361125 X 10^{14} J

= 2.40885123943X 10^{-13} J

= 1.505532 Mev

$m_{Be-7}V_f^2$ =11.6479x 10^{-27} x 0.41361125 X 10^{14} J

= 4.8177 x 10^{-13}J

10.. Final velocity (vf) of the triton

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

V_x = 1.1615 X 10^7 m/s

V_y = 2.0116X10^7 m/s

V_z = 0 m/s

$V_f^2 = (1.1615X10^7\ )^2 + (2.0116\ X10^7)^2 + (0)^2\ m^2/s^2$
$V_f^2 = (1.34908225X10^{14}) + (4.04653456\ X10^{14}) + 0\ m^2/s^2$
$V_f^2 = 5.39561681\ X\ 10^{14}\ m^2/s^2$
$V_f = 2.3228\ x10^7$ m/s

Final kinetic energy of the triton

$E= ½\ m_t\ V_f^2$

E = ½X5.0072 x 10^{-27} x 5.39561681 X 10^{14} J

= 13.5084662455 X 10^{-13} J

= 8.442791 Mev

$m_tV_f^2$ = 5.0072x 10^{-27} x 5.39561681 X 10^{14} J

= 27.0169 x 10^{-13} J

Forces acting on the beryllium - 7 nucleus

1 $F_y = qV_x B_z \sin\theta$

$\overrightarrow{V_x}$ = -0.3215 x 10^7 m/s

$\overrightarrow{B_z}$ = -1.001 x10^{-1} Tesla

q= 4 x 1.6 x 10^{-19} c

$\sin\theta = \sin 90^o = 1$

Fy = 4x1.6 x 10^{-19} x 0.3215 x 10^7x 1.001x10^{-1}x 1 N
=2.0596x 10^{-13} N

Form the right hand palm rule , thedirection of the force $\overrightarrow{Fy}$ is according to (+) y-axis ,

so ,
$\overrightarrow{Fy}$ =2.0596 *10^{-13} N

2 $F_z = q V_x B_y \sin\theta$

$\overrightarrow{B_y}$ = 1.0013 x10^{-1}Tesla

$\sin\theta = \sin 90^o = 1$

Fz = 4 x 1.6 x 10^{-19} x 0.3215 x 10^7x 1.0013 x10^{-1} x 1 N
= 2.0602 x 10^{-13} N
Formthe right hand palm rule , thedirection of the force $\overrightarrow{Fz}$ is according to(+) Z- axis ,

so ,
$\overrightarrow{Fz}$ =2.0602x 10^{-13}N

3 $F_x = q V_y B_z \sin\theta$

$\overrightarrow{Vy}$ = - 0.557 x 10^{7} m/s

$\overrightarrow{Bz}$= - 1.001x10^{-1}Tesla

sin θ = sin 90° = 1

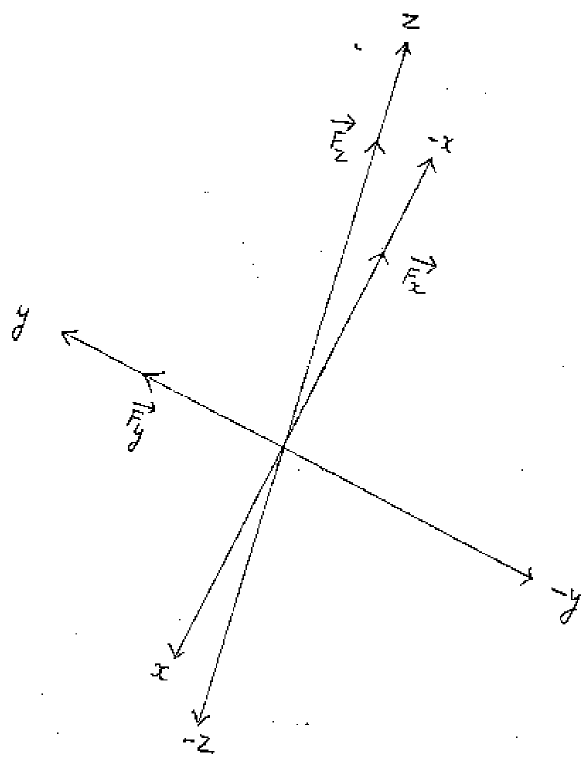
Fx = 4x1.6 x 10^{-19} x 0.557 x 10^{7}x 1.001x10^{-1} x 1N

= 3.5683 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to(-) x axis ,

so ,$\overrightarrow{Fx}$ = - 3.5683 x 10^{-13}N

Forces acting on the beryllium-7



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 3.5683 \times 10^{-13}$ N

$F_y = 2.0596 \times 10^{-13}$N

$F_z = 2.0602 \times 10^{-13}$ N

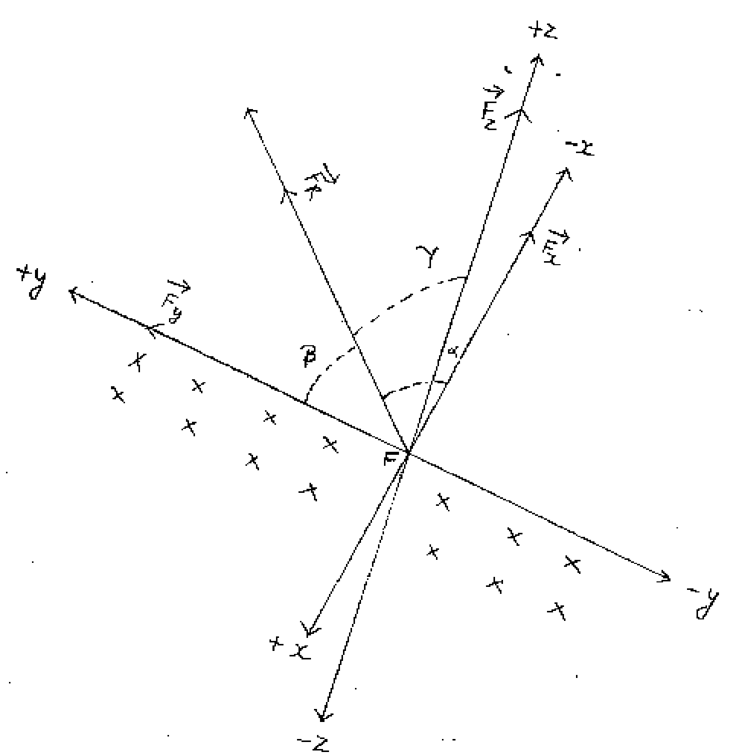
$F_R^2 = (3.5683 \times 10^{-13})^2 + (2.0596 \times 10^{-13})^2 + (2.0602 \times 10^{-13})^2$ N^2

$F_R^2 = (12.73276489 \times 10^{-26}) + (4.24195216 \times 10^{-26}) + (4.24442404 \times 10^{-26})$ N^2

$F_R^2 = 21.21914109 \times 10^{-26}$ N^2

$F_R = 4.6064 \times 10^{-13}$ N

Resultant force acting on the beryllium-7


+z
-x
+y
-y
+x
-z
F
β
γ
α

Radius of the circular orbit to be followed by the beryllium - 7

$r = mv^2 / F_R$

$mv^2 = 4.8177 \times 10^{-13}$ J

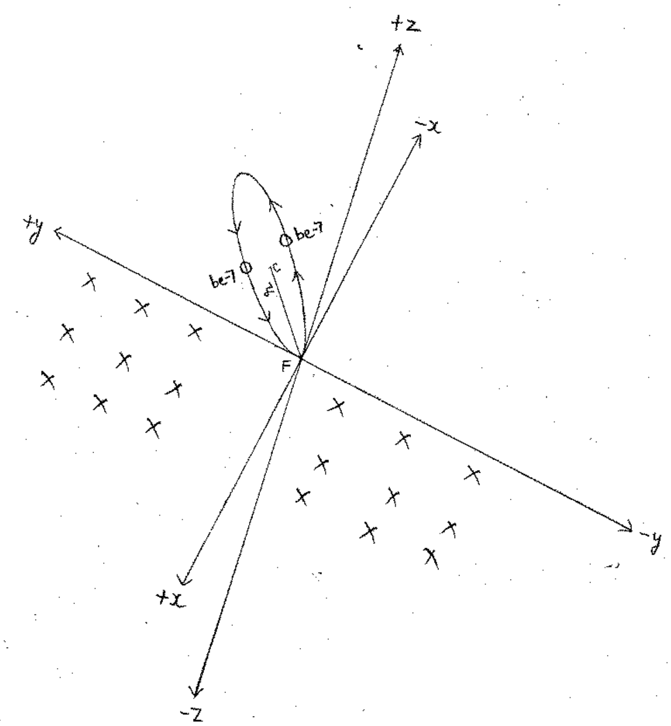
$F_r = 4.6064 \times 10^{-13}$ N

$$r = \frac{4.8177 \times 10^{-13} \text{ J}}{4.6064 \times 10^{-13} \text{ N}}$$

$r = 1.0458$ m

The circular orbit to be followed by the beryllium - 7 lies in the plane made up of negative x-axis, positive y-axis and the positive z-axis.

C= center of the circular orbit tobe followed by the beryllium - 7.



The plane of the circular orbit to be followed by the beryllium -7 makes angleswith positive x , y and z-axes as follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr $= \overrightarrow{Fx}$ / F_r

$\overrightarrow{Fx}$ = -3.5683 x 10^{-13} N

F_r= 4.6064 x 10^{-13} N

Putting values

Cos α = - 0.7746

α= 219.23degree [∴cos (219.23) = - 0.7746]

2 with y- axis

Cos β = $\underline{F_R \cos\beta}$ / $F_r = \overrightarrow{Fy}$ / F_r

$\overrightarrow{Fy}$ =2.0596x 10^{-13} N

F_r = 4.6064 x 10^{-13} N

Putting values

Cosβ= 0.4471

β = 63.44 degree [∴ cos(63.44) = 0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/$F_r = \overrightarrow{Fz}$ / F_r

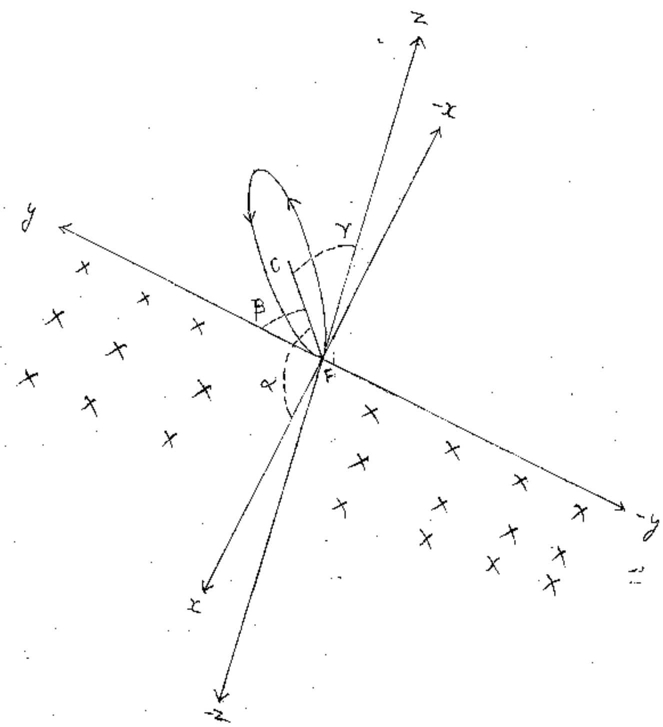
$\overrightarrow{Fz}$ = $\underline{2.0602\text{x } 10^{-13}\text{N}}$

F_r = = 4.6064 x 10^{-13}N

Putting values

Cos y = 0.4472
y = 63.43 degree

The plane of the circular orbit to be followed by the beryllium -7 makes angles with positive x , y , and z axes as follows :-



Where,

α= 219.23 degree

β= 63.44 degree

Y = 63.43 degree

The cartesian coordinates of the points P_1 (x_1, y_1, z_1) and P_2 (x_2, y_2, z_2) located on the circumference of the circle to be obtained by the beryllium – 7.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

$= 2x\ 1.0458$ m

$= 2.0916$ m

$\text{Cos}\ \alpha = -0.7746$

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 2.0916 \times (-0.7746)$ m

$x_2 - x_1 = -1.6201$m

$x_2 = -1.6201$m $[\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = 0.4471$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 2.0916 \times 0.4471$ m

$y_2 - y_1 = 0.9351$ m

$y_2 = 0.9351$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = 0.4472$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 2.0916 \times 0.4472$ m

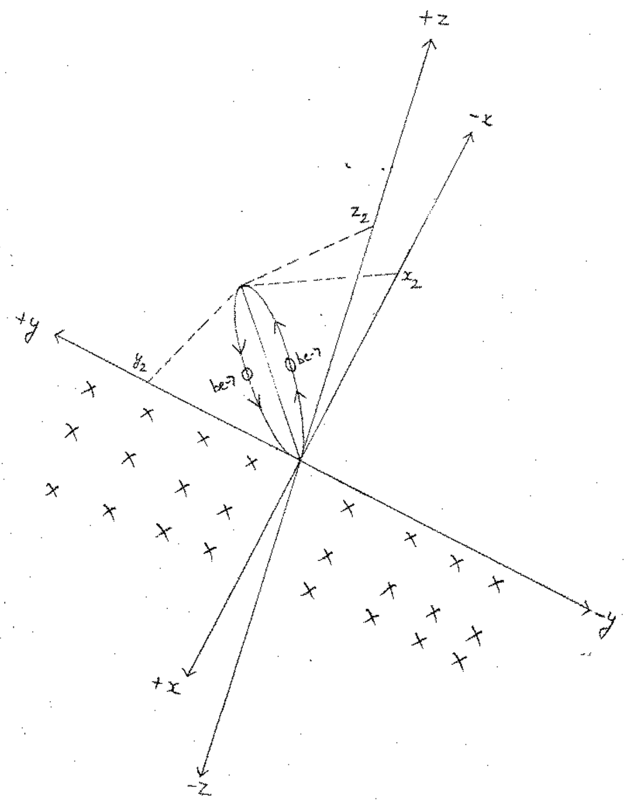
$z_2 - z_1 = 0.9353$ m

$z_2 = 0.9353$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point p_1 (x_1, y_1, z_1) and p_2 (x_2, y_2, z_2) located on the circumfrence of the circle to be obtained by the beryllium-7 are as shown below.

The line ___ is the diameter of thecircle .

P_1P_2



Conclusion :-

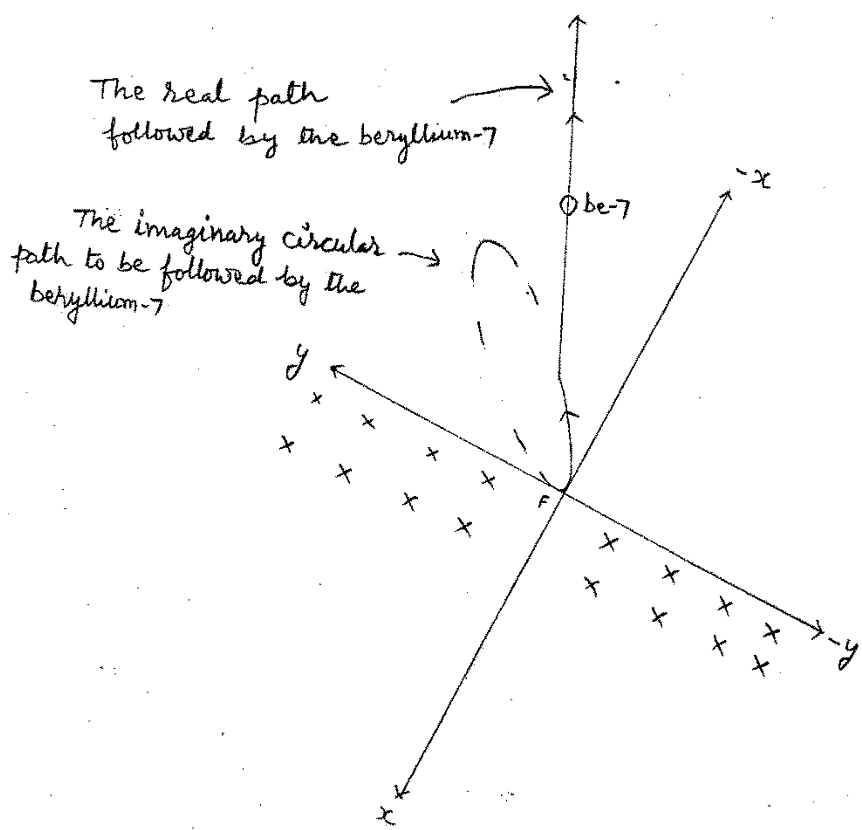
The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the beryllium-7 nucleus are along-**x , +y and +z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields arenot applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the beryllium-7 nucleus to undergo to a circular orbit of radius 1.0458 m . It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-1.6201 m,0.9351 m,0.9353 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligiblecircular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

The beryllium-7 nucleus is not confined within into the tokamak.


The real path followed by the beryllium-7
The imaginary circular path to be followed by the beryllium-7
be-7
-x
y
F
-y
x

Forces acting on the triton

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow}$ = 1.1615 x 10^{7} m/s $\underset{Bz}{\rightarrow}$= -1.001 x$10^{-1}$ Tesla

q = 1.6 x 10^{-19} c

sin θ = sin 90^{o} = 1

Fy = 1.6 x 10^{-19} x1.1615 x 10^{7}x 1.001x10^{-1}x 1 N
= 1.8602 x 10^{-13} N

Form the right hand palm rule , thedirection of the force $\underset{Fy}{\rightarrow}$ is according to (-) y-axis ,

so ,
$\underset{Fy}{\rightarrow}$= - 1.8602 x 10^{-13} N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow}$=1.0013 x$10^{-1}$Tesla

sin θ = sin 90^{o} = 1

Fz = 1.6x 10^{-19} x 1.1615 x 10^{7} x 1.0013 x10^{-1} x 1 N
= 1.8608 x 10^{-13} N
Form the right hand palm rule , the direction of the force $\underset{Fz}{\rightarrow}$ is accordingto (-) Z- axis ,
so ,
$\underset{Fz}{\rightarrow}$ = - 1.8608x 10^{-13}N

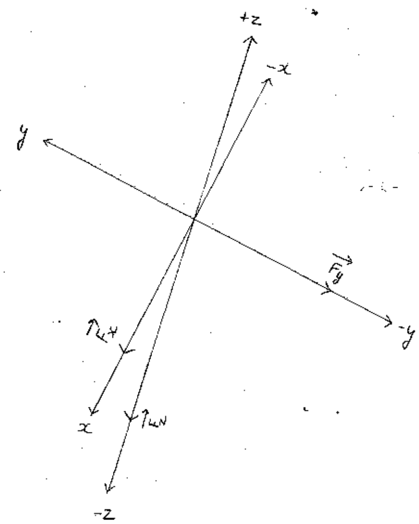
3 $F_x = q V_y B_z \sin\theta$

$\underset{Vy}{\rightarrow}$= 2.0116 x 10^{7} m/s

$\underset{Bz}{\rightarrow}$= - 1.001x$10^{-1}$ Tesla

sin θ = sin 90^{o} = 1

Fx = 1.6 x 10^{-19} x 2.0116x 10^{7}x 1.001x10^{-1} x 1 N
= 3.2217x 10^{-13}N
Form the right hand palm rule , the direction of the force $\underset{Fx}{\rightarrow}$ is accordingto (+) x axis ,
so ,$\underset{Fx}{\rightarrow}$ = 3.2217 x 10^{-13}N



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 3.2217 \times 10^{-13}$ N

$F_y = 1.8602x\ 10^{-13}$ N

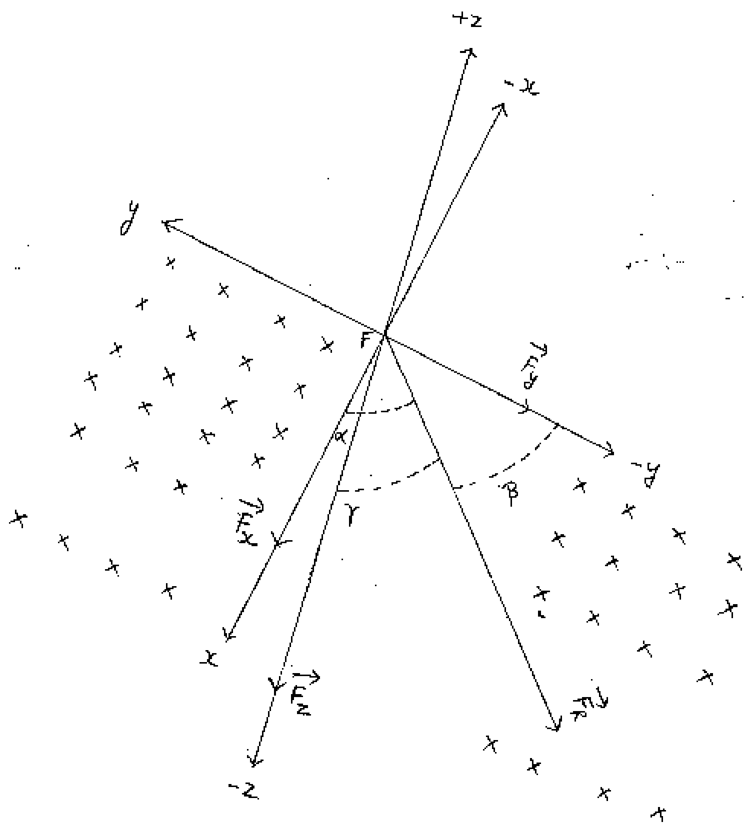
$F_z = 1.8608 * 10^{-13}$ N

$F_R^2 = (3.2217 \times 10^{-13})^2 + (1.8602x\ 10^{-13})^2 + (1.8608x\ 10^{-13})^2$ N^2

$F_R^2 = (10.37935089 \times 10^{-26}) + (3.46034404x\ 10^{-26}) + (3.46257664 \times 10^{-26})$ N^2

$F_R^2 = 17.30227157 \times 10^{-26}$ N^2

$F_R = 4.1595 \times 10^{-13}$ N


+z
-x
y
F
-y
α
β
γ
x
-z

Radius of the circular orbitto be followed by the triton

$r = mv^2 / F_R$

$mv^2 = 27.0169 \times 10^{-13}$ J

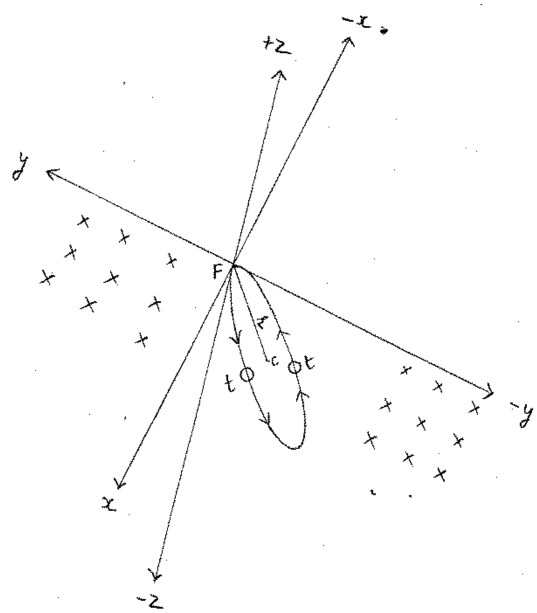
$F_r = 4.1595 \times 10^{-13}$ N

$$r = \frac{27.0169 \times 10^{-13} J}{4.1595 \times 10^{-13} N}$$

$r = 6.4952$ m

The circular orbit followed by thetriton lies in the plane made up of positive x-axis, negative y-axis and thenegative z-axis.

C= center of the circular orbit to be followed by the triton.



The plane of the circular orbit to be followed by the triton makes angles with positive x , y and z-axesas follows :-

1 withx- axis

Cos α = $\underline{F_R \cos\alpha}$ /Fr $= \overrightarrow{Fx}$ / F_r

$\overrightarrow{Fx}$ = 3.2217 x 10^{-13} N

F_r= 4.1595 x 10^{-13} N

Putting values

Cos α= 0.7745

α= 39.24 degree [∴cos ( ) =]

2 with y- axis

Cosβ = $\underline{F_R \cos\beta}$ / F_r=$\overrightarrow{Fy}$/ F_r

$\overrightarrow{Fy}$ = - 1.8602 x 10^{-13}N

F_r= 4.1595 x 10^{-13} N

Putting values

Cosβ = - 0.4472

β=243.43 degree [∴ cos (243.43) = - 0.4472]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ F_r=$\overrightarrow{Fz}$/ F_r

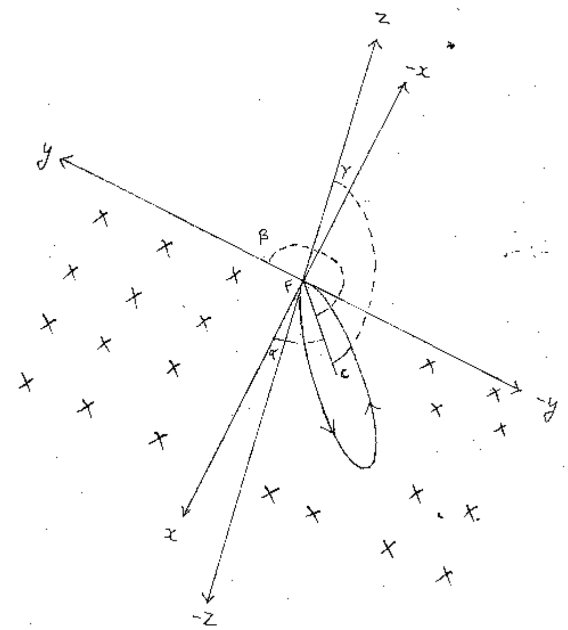
$\overrightarrow{Fz}$ = $\underline{-1.8608 \text{x } 10^{-13}\text{N}}$

F_r = 4.1595 x 10^{-13} N

Putting values

Cos y = - 0.4473
y =243.44 degree

The plane of the circular orbit to be followed by the triton makes angles withpositive x , y , and z axes as follows :-



Where,

α = 39.24 degree

β= 243.43 degree

Y =243.44 degree

The cartesian coordinates of the points $P_1(x_1, y_1, z_1)$ and P_2 (x_2, y_2, z_2) located on the circumference of the circle to be obtained by the triton.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$$d = 2 \times r$$

$= 2x\ 6.4952$ m

$= 12.9904$ m

$\cos\alpha = 0.7745$

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 12.9904 \times 0.7745$ m

$x_2 - x_1 = 10.0610$ m

$x_2 = 10.0610$ m $[\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = -0.4472$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 12.9904 \times (-0.4472)$ m

$y_2 - y_1 = -5.8093$ m

$y_2 = -5.8093$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 12.9904 \times (-0.4473)$ m

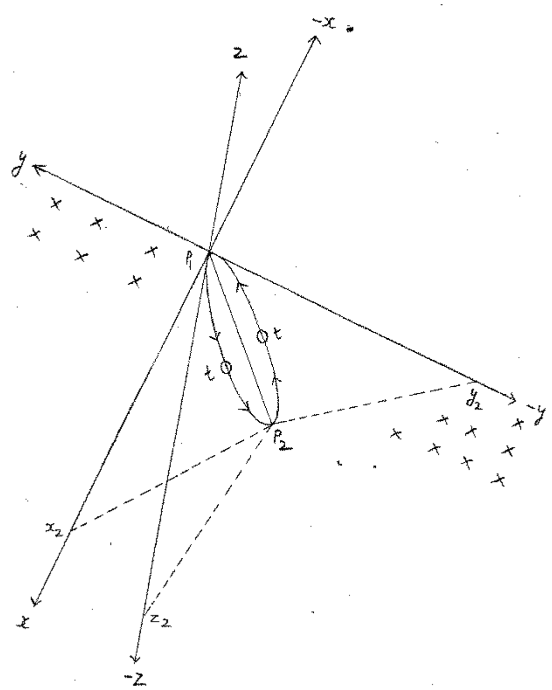
$z_2 - z_1 = -5.8106$ m

$z_2 = -5.8106$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point $p_1(x_1, y_1, z_1)$ and $p_2(x_2, y_2, z_2)$ located on the circumfrence of the circle to be obtained bythe triton are as shown below.

The line ___is the diameter of the circle .

P_1P_2


-x
z
y
P_1
t
t
y_2
-y
P_2
x_2
x
z_2
-z

Conclusion :-

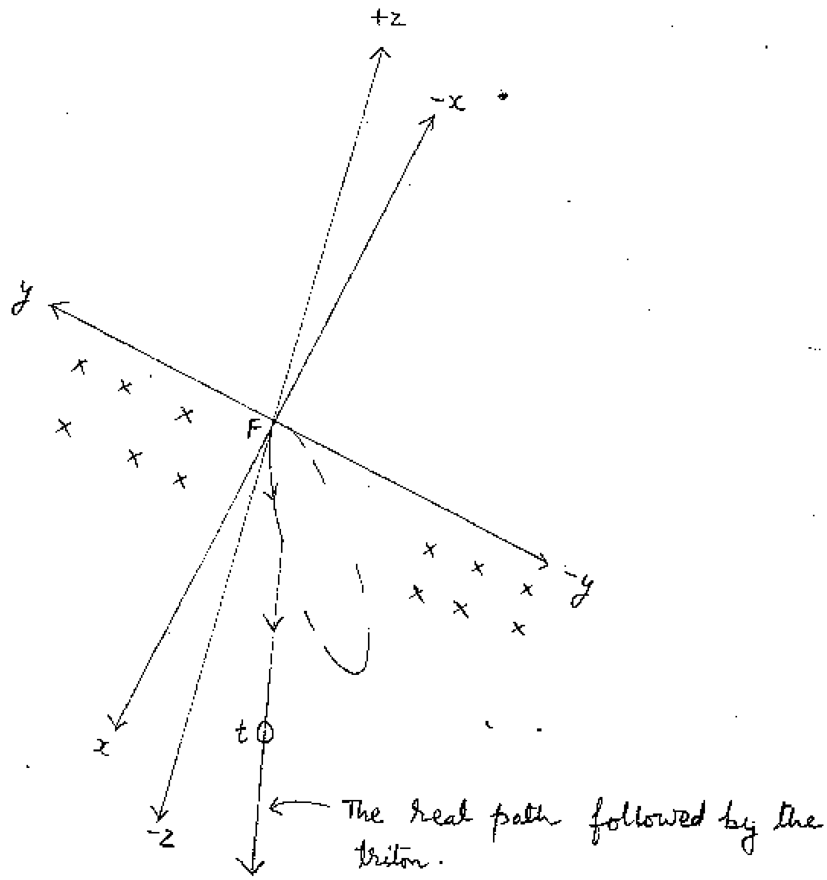
The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force$(\underset{Fr}{\rightarrow})$that are acting on the tritonare along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the triton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis where the magnetic fields are applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the triton to undergo to a circular orbit of radius 6.4952 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (10.0610 m,- 5.8093 m ,-5.8106 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the triton is not confined.



(In trying to complete the circular orbit, the produced triton strike to the base wall of the tokamak. So, it cannot complete the circle.)

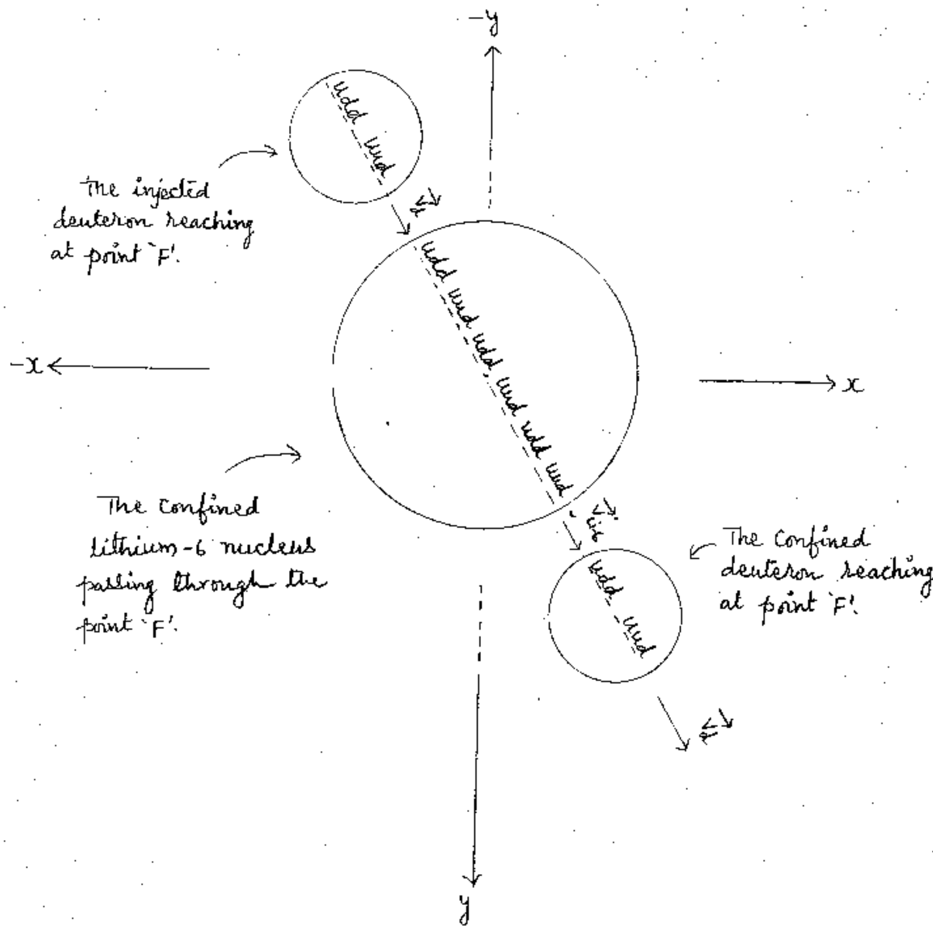
For fusion reaction

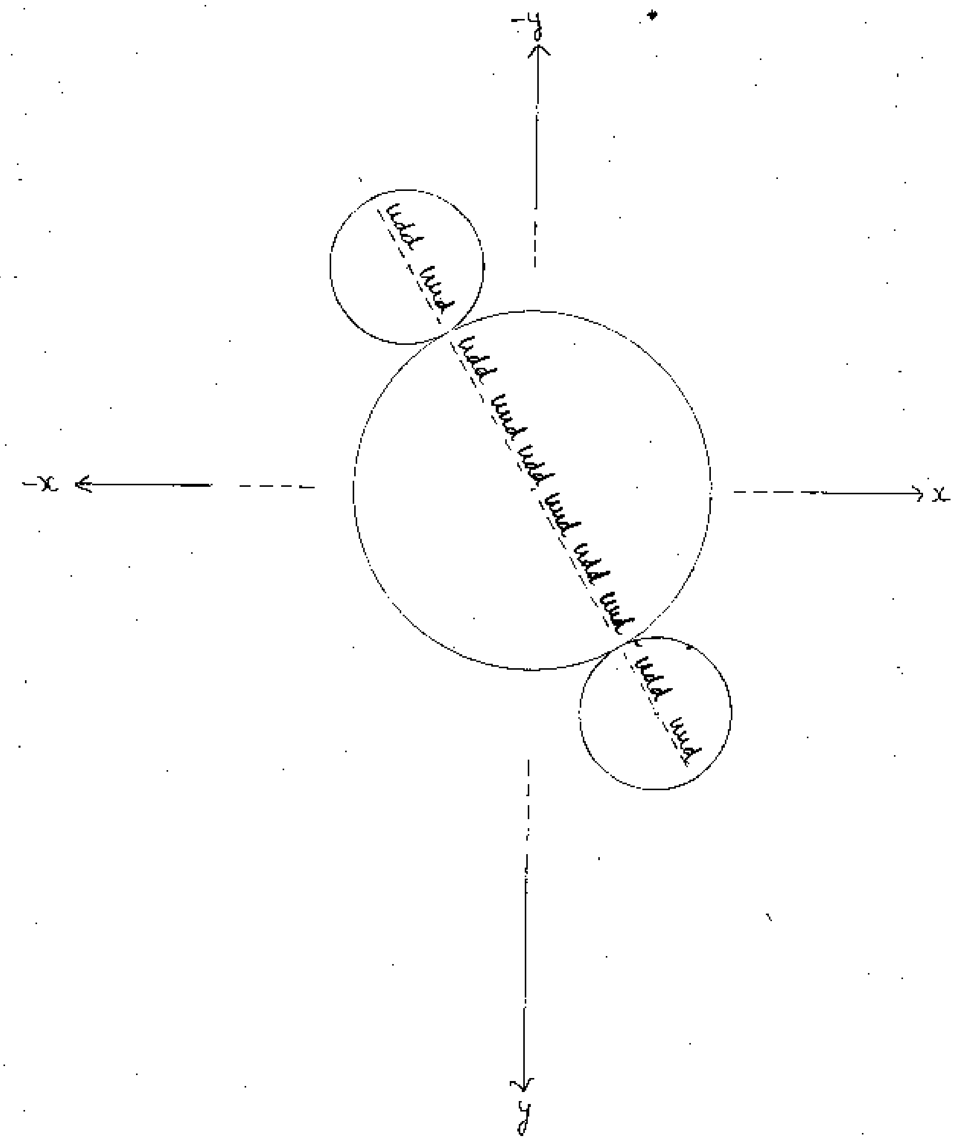
$^{2}_{1}H + ^{6}_{3}Li + ^{2}_{1}H \rightarrow [_{5}^{10}B] \rightarrow _{4}^{9}Be + ^{1}_{1}P$

The interaction of nuclei : -

The injected deuteron reaches at point F ,and interacts [experiences a repulsive force due to the confined lithion-6 and confined deuteron] with the confined lithion-6 and confined deuteron passing through the point F . the injected deuteron overcomes the electrostatic repulsive force and – a like two solid spheres join - the injected deuteron dissimilarly joins with the confined lithion-6 and confined deuteron.

Interaction of nuclei :-

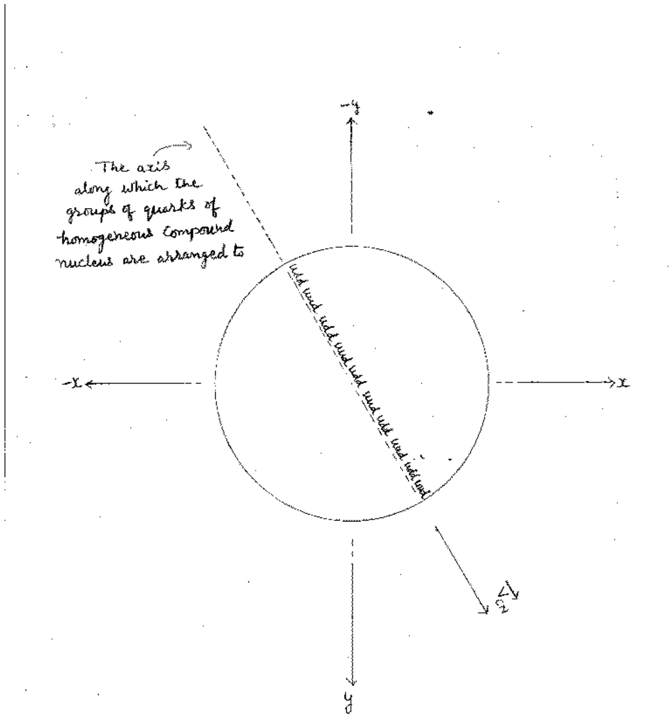

-y
udd uud
The injected deuteron reaching at point 'F'.
-x
udd uud udd uud udd uud
x
The confined lithium-6 nucleus passing through the point 'F'.
The confined deuteron reaching at point 'F'.
udd uud
y


-y
-x
x
y
udd uud udd uud udd uud udd uud udd uud

2.Formation of the homogeneous compound nucleus : -
The constituents (quarks and gluons) of the dissimilarly joined nuclei (the injected deuteron and the lithion-6 nucleus and confined deuteron) behave like a liquid and form a homogeneous compound nucleus having similarly distributed groups of quarks with similarly distributed surrounding gluons .

Thus within the homogeneous compound nucleus – each group of quarks is surrounded by the gluons in equal proportion . so, within the homogeneous compound nucleus there are 10 groups of quarks surrounded by the gluons.

The homogenous compound nucleus



where,velocity of compound nucleus makes angles with positive x, y and z axes as follows :-

α = 60 degrees

β = 30 degrees

y =90 degrees

3 . Formation of lobes within into the homogeneous compound nucleus or the transformation of the homogenous compound nucleus into the heterogeneous compound nucleus : -

The central group of quarks with its surrounding gluons to become a stable and the next higher nucleus (the beryllium-9) than the reactant one (the lithion-6) includes the other six(nearby located) groups of quarks with their surrounding gluons and rearrange to form the ‘ A ‘ lobe of the heterogeneous compound nucleus.

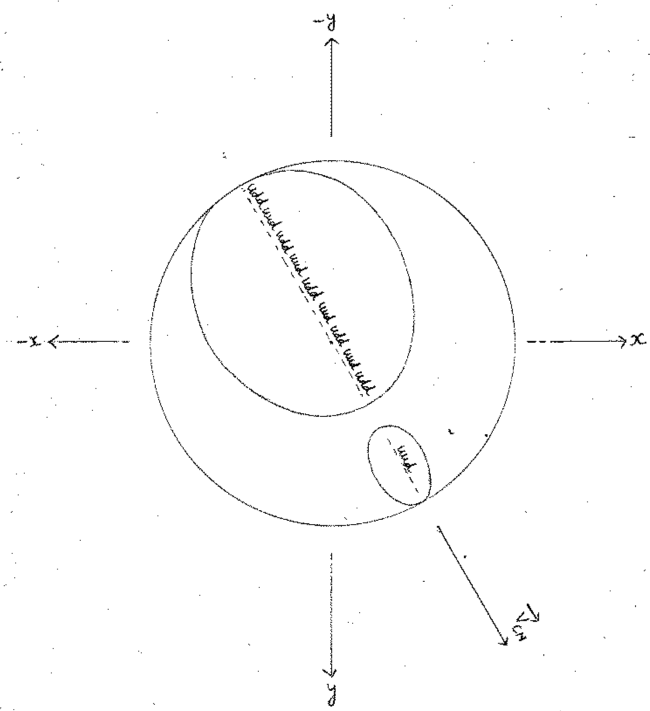
While , the remaing groups of quarks to become a stable nucleus (the proton) includes the other two (nearby located) groups of quarks with their surrounding gluons or mass [out of the available mass (or gluons) that is not included in the formation of the lobe ‘ A ‘] and rearrange to form the ‘B‘ lobe of the heterogeneous compound nucleus .

Thus , due to formation of two dissimilar lobes within into the homogeneous compound nucleus , the homogeneous compound nucleus transforms into the heterogeneous compound nucleus.

Formation of lobes

Within into the homogeneous compound nucleus the greater nucleus is the beryllium-9 nucleus and the smaller nucleus is the proton.

The greater nucleus is the lobe ‘A ‘ and the smaller nucleus is the lobe ‘B’ while the remainigh space represent the remaining gluons .



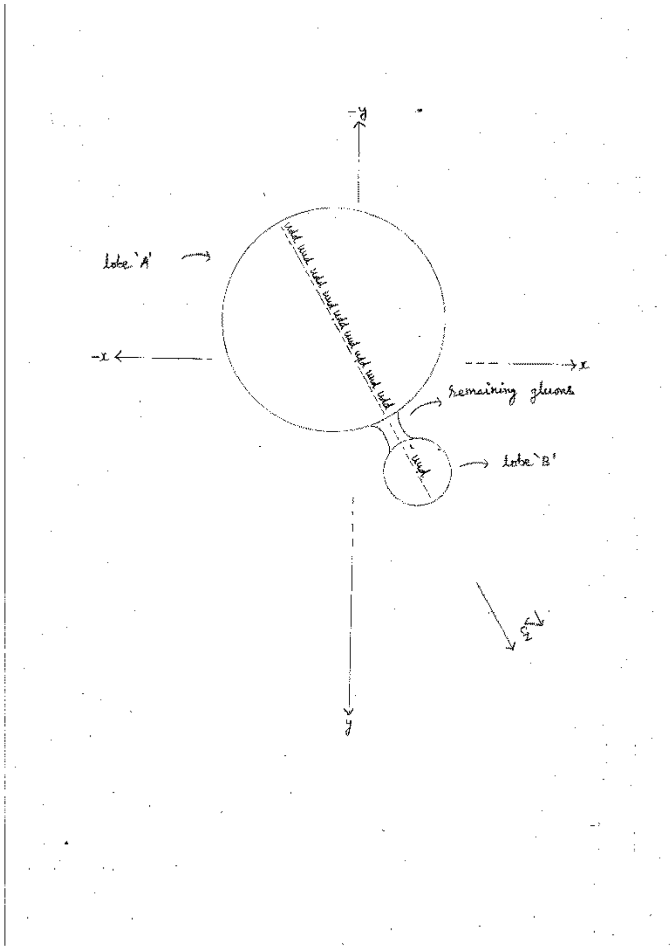
Formaton of lobes

4.Final stage of the heterogeneous compound nucleus : -

The process of formation of lobes creates void between the lobes . so, the remaining gluons (or the mass that is not involved in the formation of any lobe) rearrange to fill the voids between the lobes and thus the remaining gluons form a node between the two dissimilar lobes of the heterogeneous compound nucleus .

Thus , the reduced mass (or the remaining gluons) keeps both the dissimilar lobes of the heterogeneous compound nucleus joined them together .

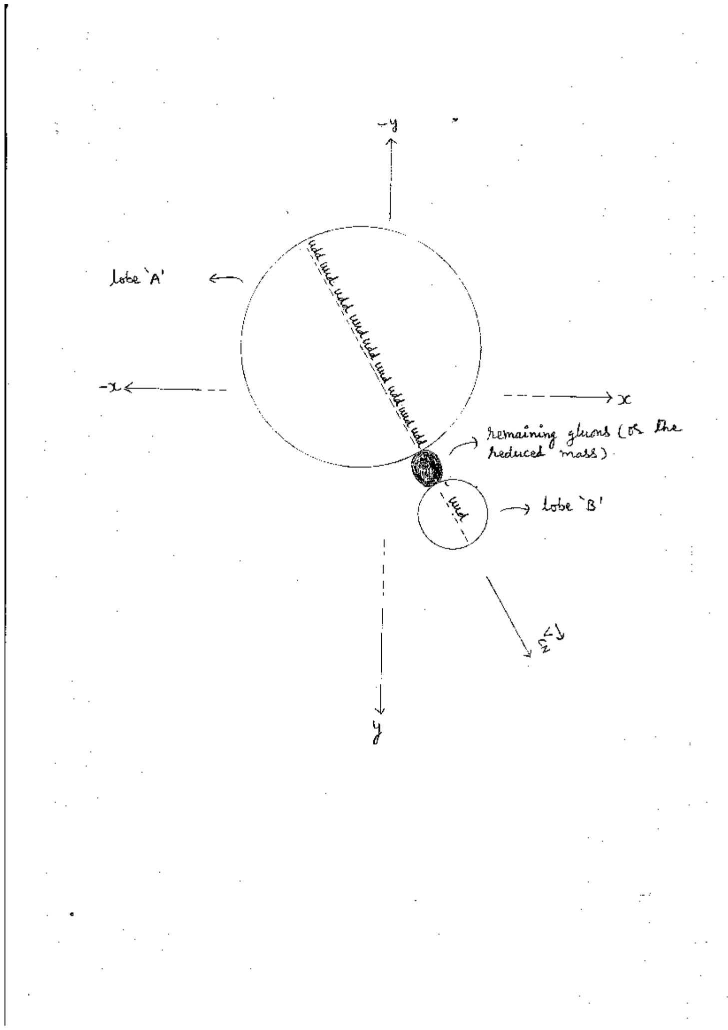
So, finally , the heterogeneous compound nucleus becomes like an abnormal digiteight or becomes as a dumbbell.



The heterogenous compound nucleus

For α = 60 degree

β = 30 degree



Final stage of the heterogenous compound nucleus

where, α = 60 degree

β = 30 degree

Formation of compound nucleus :

Each deuteron has to overcome the the electrostatic repulsive force exerted by the lithion-6 as well as by other deuteron to form a compund nucleus .

(1)Just before fusion, to overcome the electrostatic repulsive force exerted by the lithion-6 , the deuteron of n^{th} bunch loses (radiates its energy in the form of eletromagnetic waves its energy equal to 45.5598 kev.

Just before fusion, to overcome the electrostatic repulsive force exerted by the confined deuteron , the deuteron of n^{th} bunch loses (radiates its energhy in the form of eletromagnetic waves its energy equal to 5.0622 kev.

so, just before fusion, the total loss in kinetic energy of the deuteron is --

E_{loss} = (5.0622+ 45.5598) kev

= 50.622 Kev

so, just before fusion the kinetic energy of deuteron is –

$E_b = E_{injected} – E_{loss}$

E_b = 153.6 kev – 50.622 kev

= 102.978 kev

= 0.102978 Mev

(2)just before fusion lithion – 6 opposes each deuteron with 136.0700 kev

as there are two deuterons so Just before fusion, to overcome the electrostatic repulsive force exerted by the each deuteron, the lithion-6 loses (radiates its energy in the form of eletromagnetic waves) its energy equal to 272.14 kev.

so, just before fusion,

the kinetic energy of lithion -6 is –

$E_b = E_{confined} – E_{loss}$

E_b = 388.2043 kev – 272.14 kev

= 116.0643 kev

= 0.1160643 Mev

Kinetic energy of the compound nucleus

K.E. =[E_b of injected deuteron] + [E_b of lithion-6] + [E_b of confined deuteron]

= [102.978 Kev] +[116.0643 Kev]+ [102.978 Kev]

= 322.0203 Kev.

= 0. 3220203 Mev

$M = m_d + m_{Li-6} + m_d$

$= [3.3434 \times 10^{-27}\ Kg] + [9.9853 \times 10^{-27}\ Kg] + [3.3434 \times 10^{-27}\ Kg]$

$= 16.6721 \times 10^{-27}\ Kg$

Velocity of compound nucleus

$K.E. = \frac{1}{2} MV^2_{CN} = 0.3220203$ mev

$$V_{CN} = \left(\frac{2 \times 0.3220203 \times 1.6 \times 10^{-13}}{16.6721 \times 10^{-27}\ kg}\right)^{1/2} m/s$$

$$V_{CN} = \left(\frac{1.03046496 \times 10^{-13}}{16.6721 \times 10^{-27}}\right)^{1/2} m/s$$

$V_{CN} = [0.06180774827 \times 10^{14}]^{1/2}$ m/s

$V_{CN} = 0.2486 \times 10^7$ m/s

Components of velocity of compound nucleus

(1). $\overrightarrow{V_x} = V_{CN} \cos \alpha$

$= 0.2486 \times 10^7 \times 0.5$ m/s

$= 0.1243 \times 10^7$ m/s

(2). $\overrightarrow{V_y} = V_{CN} \cos \beta$

$= 0.2486 \times 10^{7} \times 0.866$ m/s

$= 0.2152$ m/s

(3). $\overrightarrow{Vz} = V_{CN} \cos y$

$= 0.2486 \times 10^{7} \times 0$ m/s

$= 0$ m/s

The splitting of the heterogeneous compound nucleus : -

The heterogeneous compound nucleus , due to its instability , splits according to the lines perpendicular to the directionof the velocity of the compound nucleus($\overrightarrow{Vcn}$) into the three particles –beryllium-9, the proton and the reduced mass (Δm) .

Out of them , the two particles (the beryllium-9and the proton) are stable while the third one (reduced mass) is unstable .

According to thelaw of inertia, each particlethat is produced due to splitting of the compound nucleus , has an inherited velocity ($\overrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\overrightarrow{Vcn}$).

So, for conservation of momentum

$M\overrightarrow{Vcn} = (m_{Be-9} + \Delta m + m_p)\overrightarrow{Vcn}$

Where ,

M = mass of the compound nucleus

$\overrightarrow{Vcn}$ = velocity of the compound nucleus

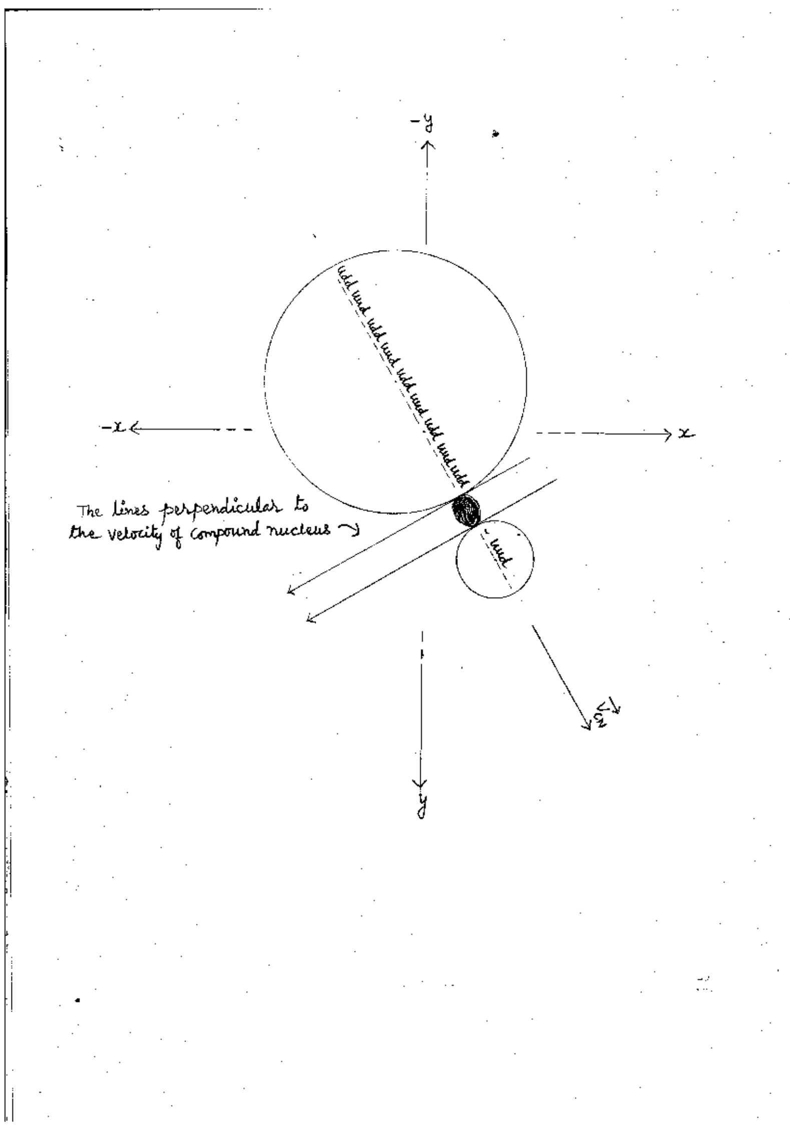
m_{Be-9} = mass of the beryllium-9

m_p = mass of the proton

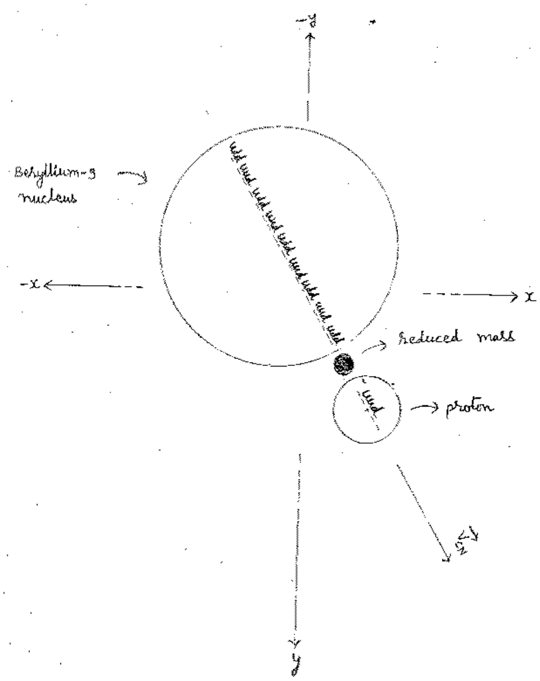
Δm = reduced mass

The splitting of the heterogenous compoundnucleus

The heterogenous compound nucleus to show the linesperpendicular to the$\overrightarrow{Vcn}$



The splitting of the heterogenous compound nucleus



Inherited velocity of the particles (s) : -

Each particles hasinherited velocity ($\underrightarrow{Vinh}$) equal to the velocity of the compound nucleus($\underrightarrow{Vcn}$) .

(I) . Inherited velocity of the particle Beryllium-9

$V_{inh} = V_{CN} = 0.2486 \times 10^7$ m/s

Components of the inherited velocity of the particle Beryllium-9

1.$\underrightarrow{Vx}$= $V_{inh} \cos \alpha = V_{CN} \cos\alpha = 0.1243 \times 10^7$ m/s

2 .$\underrightarrow{Vy}$ = $V_{inh} \cos \beta = V_{CN}\cos \beta = 0.2152 \times 10^7$m/s

3 .$\underrightarrow{Vz}$ = $V_{inh} \cos y = V_{CN} \cos y = 0$ m/s

(II). Inherited velocity of the proton

$V_{inh} = V_{CN} = 0.2486 \times 10^7$ m/s

Componentsoftheinherited velocityof the proton

1.$\underrightarrow{Vx}$ = $V_{inh} \cos \alpha = V_{CN} \cos\alpha = 0.1243 \times 10^7$ m/s

2 .$\underrightarrow{Vy}$ = $V_{inh} \cos \beta = V_{CN}\cos \beta = 0.2152 \times 10^7$m/s

3 .$\underrightarrow{Vz}$ = $V_{inh} \cos y = V_{CN} \cos y = 0$ m/s

(iii) Inherited velocity of the reduced mass

$V_{inh} = V_{CN} = 0.2486 \times 10^7$ m/s

Propulsion of the particles

Reduced mass converts into enrgy and total energy (E_T) propel both the particles with equal and opposite momentum.

Reduced mass

$\Delta m = [m_d + m_{Li-6} + m_d] - [m_{Be-9} + m_p]$

$\Delta m = [2.01355 + 6.01347708 + 2.01355] - [9.00998792 + 1.007276]$ amu

$\Delta m = [10.04057708] - [10.01726392]$ amu

$\Delta m = 0.02331316$ amu

$\Delta m = 0.02331316 \times 1.6605 \times 10^{-27}$ kg

The Inherited kinetic energy of reduced mass (Δm) .

$E_{inh} = \frac{1}{2}\Delta m\, V^2_{CN}$

$\Delta m = 0.02331316 \times 1.6605 \times 10^{-27}$ kg

$V^2_{CN} = 0.06180774827 \times 10^{14}$

$E_{inh} = \frac{1}{2} \times 0.02331316 \times 1.6605 \times 10^{-27} \times 0.06180774827 \times 10^{14}$ J

$E_{inh} = 0.00119633539 \times 10^{-13}$ J

$E_{inh} = 0.000747$ Mev

Released energy (E_R)

$E_R = \Delta mc^2$

$E_R = 0.02331316 \times 931$ Mev

$E_R = 21.704551$ Mev

Total energy (E_T)

$E_T = E_{inh} + E_R$

$E_T = [0.000747 + 21.704551]$ Mev

$E_T = 21.705298$ Mev

Increasedenergy of the particles (s): -

The total energy (E_T) is divided between the particles in inverse proportion to their masses .So,the increased energy (E_{inc}) of the particles are :-

1.For beryllium -9

$$E_{inc} = \frac{m_p}{m_p + m_{Be-9}} \times E_T$$

$$E_{inc} = \frac{1.007276 \text{ amu}}{[1.007276 + 9.00998792] \text{ amu}} \times 21.705298 \text{ Mev}$$

$$E_{inc} = \frac{1.007276}{10.01726392} \times 21.705298 \text{ Mev}$$

$$E_{inc} = 0.10055400437 \times 21.705298 \text{ Mev}$$

$$E_{inc} = 2.182554 \text{ Mev}$$

2.increased energy of the proton

$$E_{inc} = [E_T] - [\text{increased energy of the Be-9}]$$

$$E_{inc} = [21.705298] - [2.182554] \text{ Mev}$$

E_{inc} = 19.522744 Mev

6.Increased velocity of the particles .

(1) For proton

$E_{inc} = {}^{1}/_{2} m_p \; v_{inc}^2$

$V_{inc} = [\, 2 \times E_{inc}/m_p]^{1/2}$

$$= \left(\frac{2 \times 19.522744 \times 1.6\times10^{-13}\ J}{1.6726 \times10^{-27}\ kg} \right)^{1/2} m/s$$

$$= \left(\frac{62.4727808 \times 10^{-13}}{1.6726 \times10^{-27}} \right)^{1/2} m/s$$

$$= [\ 37.350699988 \times 10^{14}\ ]^{1/2}\ m/s$$

$$= 6.1115 \times 10^{7}\ m/s$$

(2)For beryllium-9

$V_{inc} = [\, 2 \times E_{inc} / m_{Be\text{-}9}]^{1/2}$

$$= \left(\frac{2 \times 2.182554 \times 1.6\times10^{-13}\ J}{14.9610 \times 10^{-27}\ kg} \right)^{1/2}$$

$$= \left(\frac{6.9841728 \times 10^{-13}}{14.9610 \times10^{-27}} \right)^{1/2} m/s$$

$$= [\ 0.46682526569 \times 10^{14}\ ]^{1/2}\ m/s$$

$$= 0.6832 \times 10^{7}\ m/s$$

7.Angle of propulsion

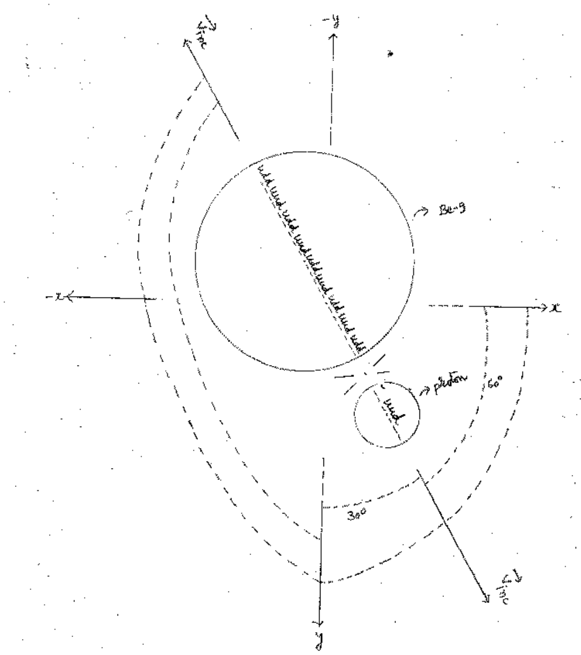
1 As the reduced mass converts into energy , the total energy (E_T) propel both the particles with equal and opposite momentum.

2. We know that when there a fusion process occurs , then we find the lighter nucleus in the forward direction [or in the direction of ion beam or in the direction of the velocity of the compound nucleus($\overrightarrow{Vcn}$) .]

3.. At point ‘ F ‘ , as V_{CN} makes 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis .

so, the proton is propelled making 60° angle with x-axis , 30° angle with y-axis and 90° angle with z-axis . While the beryllium - 9 is propelled making 240° angle with x-axis , 150° angle with y-axis and 90° angle with z-axis .

Propulsion of thte particles



Components of the increased velocity (V_{inc}) of the particles.

(i) For beryllium - 9

1. $\underset{Vx}{\rightarrow}$ = V_{inc} cos α

V_{inc} = 0.6832×10^7 m/s

cos α = cos (240) = -0.5

$\underset{Vx}{\rightarrow}$ = $0.6832 \times 10^7 \times (-0.5)$ m/s

= -0.3416×10^7 m/s

2 . $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β= cos (150) = - 0.866

$\underset{Vy}{\rightarrow}$ = $0.6832 \times 10^7 \times (-0.866)$ m/s

= -0.5916×10^7 m/s

3. $\underset{Vz}{\rightarrow}$ = V_{inc} cos y

Cos y = cos 90^o = 0

$\underset{Vz}{\rightarrow}$ = $0.6832 \times 10^7 \times 0$

= 0 m/s

(ii)For proton

1. $\underset{Vx}{\rightarrow}$ = V_{inc}cos α

V_{inc} = 6.1115×10^7 m/s

cosα= cos(60) = 0.5

$\underset{Vx}{\rightarrow}$ = $6.1115 \times 10^7 \times 0.5$ m/s

= 3.0557×10^7m/s

2 . $\underset{Vy}{\rightarrow}$ = V_{inc} cos β

cos β = cos (30)= 0.866

$\underset{Vy}{\rightarrow}$ = $6.1115 \times 10^7 \times 0.866$m/s

= 5.2925×10^7m/s

3. $\underset{Vz}{\rightarrow}$ = V_{inc}cos y

cos y = cos (90)=0

$\underset{Vz}{\rightarrow}$VzVzVz = $6.1115 \times 10^7 \times 0$ m/s

= 0 m/s

9.. Components of the final velocity(Vf)ofthe particles

IForberyllium- 9

According to-	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Finalvelocity ($\overrightarrow{Vf}$) =($\overrightarrow{Vinh}$+($\overrightarrow{Vinc}$)
X – axis	$\overrightarrow{Vx}$= 0.1243 x10^7m/s	$\overrightarrow{Vx}$ =- 0.3416x10^7m/s	$\overrightarrow{Vx}$ = - 0.2173x10^7m/s
y –axis	$\overrightarrow{Vy}$= 0.2152 x 10^7m/s	$\overrightarrow{Vy}$ = - 0.5916x 10^7m/s	$\overrightarrow{Vy}$=-0.3764 x10^7m/s
z –axis	$\overrightarrow{Vz}$ =0 m/s	$\overrightarrow{Vz}$ = 0m/s	$\overrightarrow{Vz}$=0 m/s

2..Forproton

According to -	Inherited Velocity($\overrightarrow{Vinh}$)	Increased Velocity($\overrightarrow{Vinc}$)	Final velocity ($\overrightarrow{Vf}$)=($\overrightarrow{Vinh}$) +($\overrightarrow{Vinc}$)
X– axis	$\overrightarrow{Vx}$= 0.1243x 10^7m/s	$\overrightarrow{Vx}$=3.0557x10^7m/s	$\overrightarrow{Vx}$ = 3.18x10^7m/s
y– axis	$\overrightarrow{Vy}$= 0.2152 x10^7m/s	$\overrightarrow{Vy}$= 5.2925 x10^7m/s	$\overrightarrow{Vy}$=5.5077 x10^7m/s
z –axis	$\overrightarrow{Vz}$= 0 m/s	$\overrightarrow{Vz}$ = 0 m/s	$\overrightarrow{Vz}$=0m/s

10.. Final velocity (vf) of the beryllium - 9

$V^2 = V_x^2 + V_Y^2 + V_Z^2$

$V_x = 0.2173 \times 10^7$ m/s

$V_y = 0.3764 \times 10^7$ m/s

$V_z = 0$ m/s

$V_f^2 = (0.2173 \times 10^7)^2 + (0.3764 \times 10^7)^2 + (0)^2$ m^2/s^2

V_f^2= (0.04721929X10^{14})+(0.14167696 X10^{14})+0m^2/s^2
V_f^2 = 0.18889625 X 10^{14} m^2/s^2
V_f = 0.4346x10^7m/s

Final kinetic energy of the beryllium - 9

E= ½ $m_{Be-9}V_f^2$

E = ½x14.9610 x 10^{-27} x0.18889625 X 10^{14}J

= 1.41303839812 X 10^{-13} J

= 0.883148Mev

$m_{Be-9}V_f^2$ = 14.9610 x 10^{-27} x 0.18889625 X 10^{14} J

= 2.8260 x 10^{-13} J

10.. Final velocity (vf) of the proton

V^2 = V_x^2 + V_Y^2 +V_Z^2

V_x= 3.18 X 10^7 m/s

V_y = 5.5077 X 10^7 m/s

V_z = 0 m/s

V_f^2 = (3.18 X10^7)^2+ (5.5077X10^7)^2 +$(0)^2$ m^2/s^2
V_f^2 = (10.1124 X10^{14})+(30.33475929X10^{14})+0 m^2/s^2
V_f^2 = 40.44715929 X 10^{14} m^2/s^2
V_f = 6.3598 x10^7 m/s

Final kinetic energy of the proton

E= ½ $m_pV_f^2$

$E = \frac{1}{2} x 1.6726 \times 10^{-27} x 40.44715929 X 10^{14}$ J

$= 33.8259593142 X 10^{-13}$J

= 21.141224 Mev

$m_p V_f^2 = 1.6726 \times 10^{-27} \times 40.44715929 X 10^{14}$ J

$= 67.6519 x 10^{-13}$ J

Forces acting on the beryllium – 9 nucleus

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow} = -0.2173 \times 10^7$ m/s $\underset{Bz}{\rightarrow} = -1.001 x10^{-1}$ Tesla

$q = 4 \times 1.6 \times 10^{-19}$c

$\sin\theta = \sin 90^o = 1$

$Fy = 4x1.6 \times 10^{-19} \times 0.2173 \times 10^7 x 1.001x10^{-1} x 1$ N
$= 1.3921x 10^{-13}$ N

Form the right hand palm rule , the direction of the force $\underset{Fy}{\rightarrow}$ is according to (+) y-axis ,

so ,
$\underset{Fy}{\rightarrow} = 1.3921 \times 10^{-13}$N

2 $F_z = q V_x B_y \sin\theta$

$\underset{By}{\rightarrow} = 1.0013 x10^{-1}$Tesla

$\sin\theta = \sin 90^o = 1$

$Fz = 4 \times 1.6 \times 10^{-19} \times 0.2173 \times 10^7 \times 1.0013 x10^{-1} \times 1$ N
$= 1.3925 \times 10^{-13}$ N
Form the right hand palm rule , the direction of the force $\underset{Fz}{\rightarrow}$ is according to (+) Z- axis ,

so ,
$\underset{Fz}{\rightarrow} = 1.3925 x10^{-13}$N

3 $F_x = q V_y B_z \sin\theta$

$\overrightarrow{V_y}$ = - 0.3764 x 10^7 m/s

$\overrightarrow{B_z}$ = - 1.001x10^{-1} Tesla

sin θ = sin 90^o= 1

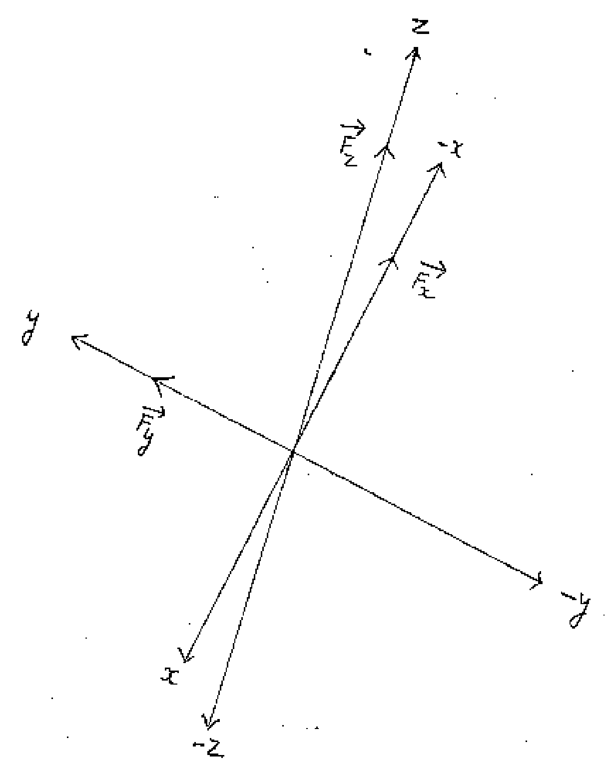
Fx = 4x1.6 x 10^{-19}x 0.3764 x 10^7x 1.001x10^{-1} x 1 N

= 2.4113 x 10^{-13}N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (-) x axis ,

so, $\overrightarrow{Fx}$ = - 2.4113 x 10^{-13}N

Forces acting on the beryllium-9



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 2.4113 \times 10^{-13}$ N

$F_y = 1.3921 \times 10^{-13}$ N

$F_z = 1.3925 \times 10^{-13}$ N

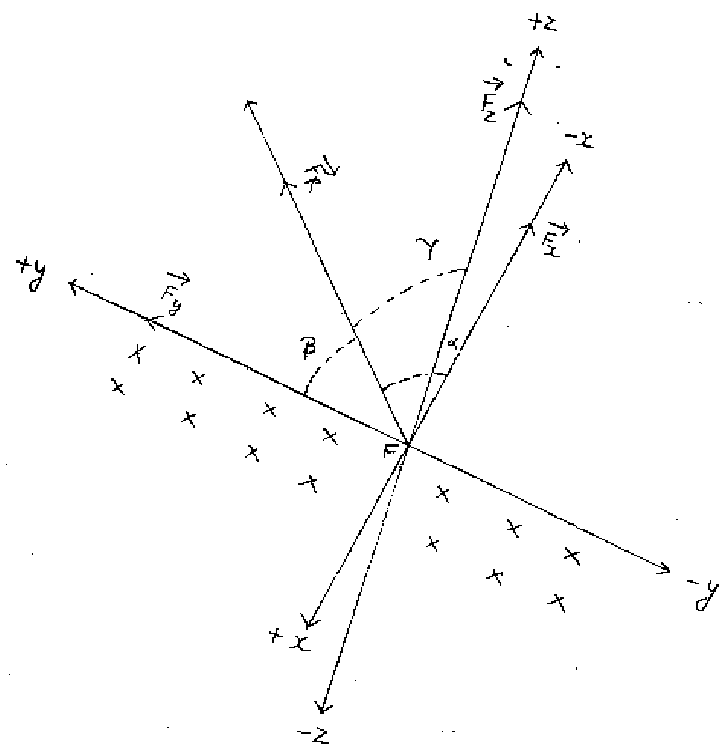
$F_R^2 = (2.4113 \times 10^{-13})^2 + (1.3921 \times 10^{-13})^2 + (1.3925 \times 10^{-13})^2 \; N^2$

$F_R^2 = (5.81436769 \times 10^{-26}) + (1.93794241 \times 10^{-26}) + (1.93905625 \times 10^{-26}) \; N^2$

$F_R^2 = 9.69136635 \times 10^{-26} \; N^2$

$F_R = 3.1130 \times 10^{-13}$ N

Resultant force acting on the beryllium-9



Radius of the circular orbit to be followed by the beryllium - 9

$$r = mv^2 / F_R$$

$$mv^2 = 2.8260 \times 10^{-13}\ J$$

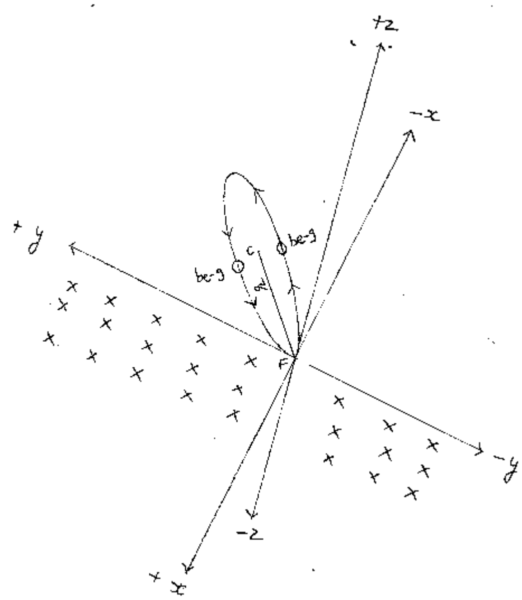
$$F_r = 3.1130 \times 10^{-13}\ N$$

$$r = \frac{2.8260 \times 10^{-13} J}{3.1130 \times 10^{-13}\ N}$$

$$r = 0.9078\ m$$

The circular orbit to be followed by the beryllium - 9 lies in the plane made up of negative x-axis, positive y-axis and the positive z-axis.

C= center of the circular orbit to be followed by the beryllium - 9.


+z
-x
+y
be-g
c
be-g
F
-y
-z
+x

The plane of the circular orbit to be followed by the beryllium -9makes angleswith positive x , y and z-axes as follows:-

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$ /Fr $= \underset{Fx}{\rightarrow}$ / F_r

$\underset{Fx}{\rightarrow}$ = -2.4113 x 10^{-13} N

F_r=3.1130 x 10^{-13} N

Puttingvalues

Cos α = - 0.7745

α= 219.24 degree [∴cos (219.24) = - 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \underset{Fy}{\rightarrow}$ / F_r

$\underset{Fy}{\rightarrow}$ = 1.3921x 10^{-13} N

F_r = 3.1130 x 10^{-13} N

Putting values

Cos β = 0.4471

β = 63.44 degree [∴ cos (63.44) =0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \underset{Fz}{\rightarrow}$ / F_r

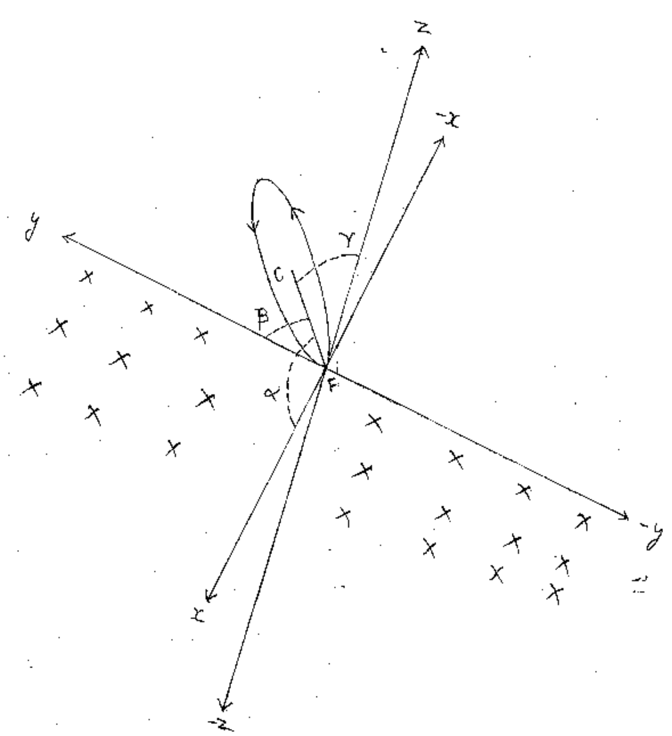
$\underset{Fz}{\rightarrow}$ = $\underline{1.3925 \text{x } 10^{-13} N}$

F_r = = 3.1130 * 10^{-13} N

Putting values

Cos y = 0.4473
y = 63.425 degree

The Plane of the circular orbit to be followed by the beryllium -9 makes angles withpositive x , y , and z axesas follows :-



Where,

α = 219.24 degree

β =63.44degree

γ = 63.425 degree

The cartesian coordinates of the points $P_1(x_1, y_1, z_1)$ and P_2 (x_2, y_2, z_2) located on the circumference of the circle to be obtained by the beryllium – 9.

$\cos \alpha = \frac{x_2 - x_1}{d}$

$d = 2 \times r$

$= 2 \times 0.9078$ m

$= 1.8156$ m

$\cos \alpha = -0.7745$

$x_2 - x_1 = d \times \cos \alpha$

$x_2 - x_1 = 1.8156 \times (-0.7745)$ m

$x_2 - x_1 = -1.4061$ m

$x_2 = -1.4061$ m [$\therefore$ $x_1 = 0$]

$\cos \beta = \frac{y_2 - y_1}{d}$

$\cos\beta = 0.4471$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 1.8156 \times 0.4471$ m

$y_2 - y_1 = 0.8117$ m

$y_2 = 0.8117$ m [$\therefore$ $y_1 = 0$]

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = 0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 1.8156 \times 0.4473$ m

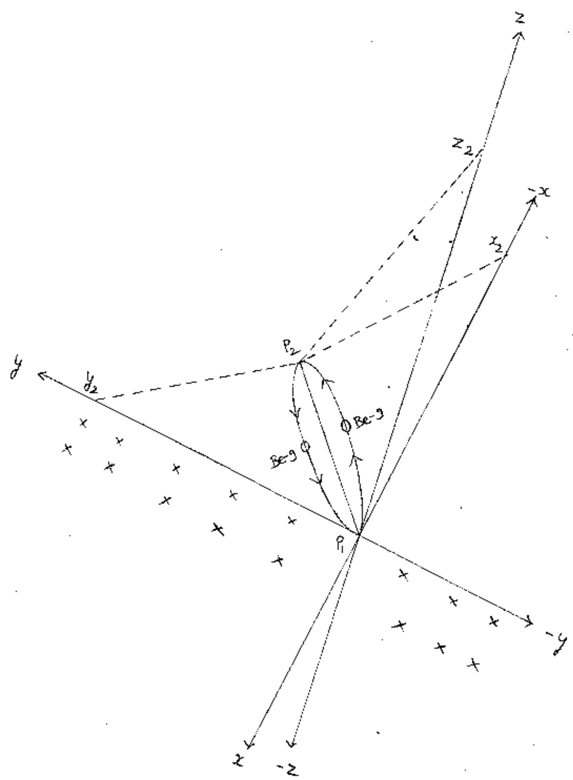
$z_2 - z_1 = 0.8121$ m

$z_2 = 0.8121$ m [$\therefore$ $z_1 = 0$]

The cartesian coordinates of the point p_1 (x_1, y_1 , z_1) and p_2 (x_2 , y_2 , z_2) located on the circumfrence of the circle to be obtained by the beryllium-9 are as shown below.

The line ___is the diameter of the circle .

P_1P_2


z
z_2
-x
x_2
P_2
y
y_2
Be-9
Be-9
P_1
-y
z
-z

Conclusion :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}]$ ofthe resultant force$(\underset{Fr}{\rightarrow})$that are acting on the beryllium-9 nucleus are along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the beryllium -9 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the beryllium-9 nucleus to undergo to a circular orbit of radius 0.9078 m . It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-1.4061m,0.8117 m,0.8121 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-9 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

The beryllium-9nucleus is not confined within into the tokamak.

Forces acting on the proton

1 $F_y = q V_x B_z \sin\theta$

$\underset{Vx}{\rightarrow}$ = 3.18×10^7 m/s

$\underset{Bz}{\rightarrow}$ = -1.001×10^{-1} Te

q = 1.6×10^{-19} c

$\sin\theta = \sin 90^o = 1$

Fy = $1.6 \times 10^{-19} \times 3.18 \times 10^7 \times 1.001 \times 10^{-1} \times 1$ N
= 5.0930×10^{-13} N

Form theright hand palm rule , thedirection of the force $\overrightarrow{Fy}$ is according to (-) y-axis ,

so ,

$\overrightarrow{Fy}$ = - 5.0930 x 10^{-13}N

2 F_z =q V_x B_y sin θ

$\overrightarrow{By}$ = 1.0013 x10^{-1}Tesla

sin θ = sin 90° = 1

Fz = 1.6 x 10^{-19}x 3.18 x 10^{7} x 1.0013 x10^{-1} x 1 N

= 5.0946 x 10^{-13} N

Form theright hand palm rule , the direction of the force $\overrightarrow{Fz}$ is according to (-) Z- axis ,

so ,

$\overrightarrow{Fz}$ = - 5.0946x 10^{-13}N

3 F_x = q V_y $B_z$sin θ

$\overrightarrow{Vy}$ =5.5077 x 10^{7} m/s

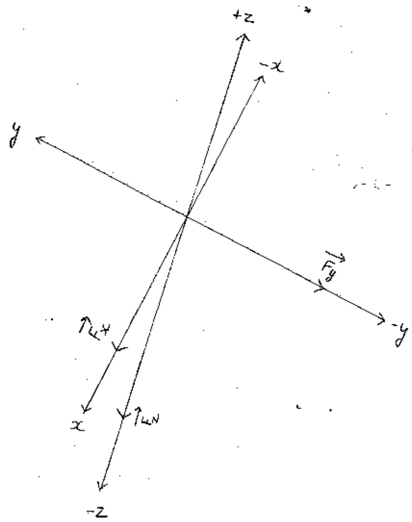
$\overrightarrow{Bz}$ = - 1.001x10^{-1} Tesla

sin θ = sin 90° = 1

Fx = 1.6 x 10^{-19} x5.5077x 10^{7}x 1.001x10^{-1} x 1 N

= 8.8211 x 10^{-13} N

Form the right hand palm rule , the direction of the force $\overrightarrow{Fx}$ is according to (+) x axis , so , $\underset{Fx}{\rightarrow}$ = 8.8211 x 10^{-13}N



Resultant force (F_R) :

$F_R^2 = F_x^2 + F_Y^2 + F_Z^2$

$F_x = 8.8211 \times 10^{-13}$ N

$F_y = 5.0930 \times 10^{-13}$ N

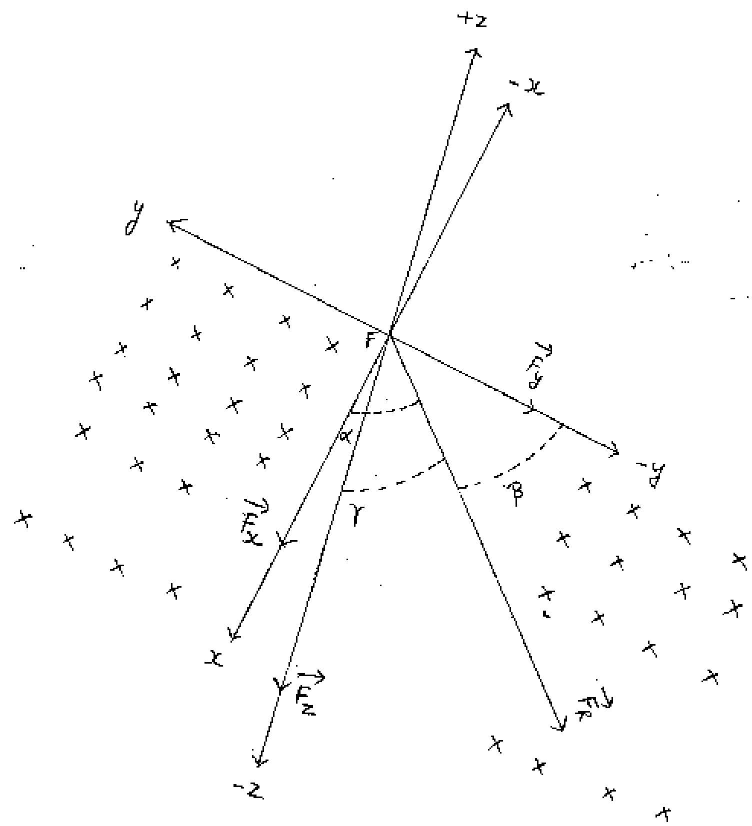
$F_z = 5.0946 \times 10^{-13}$ N

$F_R^2 = (8.8211 \times 10^{-13})^2 + (5.0930 \times 10^{-13})^2 + (5.0946 \times 10^{-13})^2$ N^2

$F_R^2 = (77.81180521 \times 10^{-26}) + (25.938649 \times 10^{-26}) + (25.95494916 \times 10^{-26})$ N^2

$F_R^2 = 129.70540337 \times 10^{-26}$ N^2

$F_R = 11.3888 \times 10^{-13}$ N


+z
-x
y
F
α
γ
β
-y
x
-z

Radius of the circular orbitto be followed by the proton

$r = mv^2 / F_R$

$mv^2 = 67.6519 \times 10^{-13}$ J

$F_r = 11.3888 \times 10^{-13}$ N

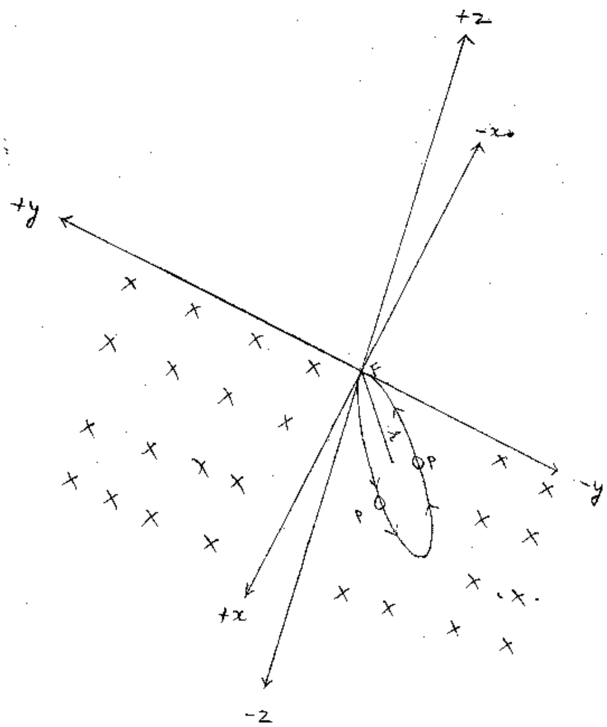
$r = 67.6519 \times 10^{-13}$ J

11.3888×10^{-13} N

$r = 5.9402$ m

The circular orbit to be followed by the proton lies in the plane madeup of positive x-axis, negative y-axis and the negative z-axis.

C_p = center of the circular orbit by the proton.



Angles that make the resultant force (F_R)

[acting on the proton when the proton is at point ' F '] with positive x ,y and z-axes .

1 withx- axis

Cos α = $\underline{F_R \cos \alpha}$/Fr $= \overrightarrow{Fx} / F_r$

$\overrightarrow{Fx} = 8.8211 \times 10^{-13}$ N

$F_r = 11.3888 \times 10^{-13}$ N

Puttingvalues

Cos α = 0.7745

α= 39.24 degree [∴cos (39.24) = 0.7745]

2 with y- axis

Cos β = $\underline{F_R \cos \beta}$ / $F_r = \overrightarrow{Fy} / F_r$

$\overrightarrow{Fy} = -5.0930 \times 10^{-13}$ N

$F_r = 11.3888 \times 10^{-13}$ N

Putting values

Cosβ= - 0.4471

β= 243.44 degree [∴ cos (243.44) = - 0.4471]

3 with z- axis

Cos y = $\underline{F_R \cos y}$/ $F_r = \overrightarrow{Fz} / F_r$

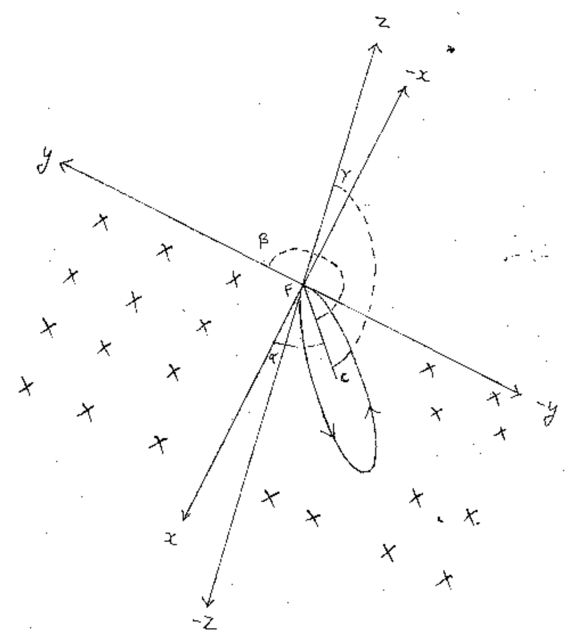
$\overrightarrow{Fz} = \underline{-5.0946 \times 10^{-13} N}$

$F_r = = 11.3888 \times 10^{-13}$ N

Putting values

Cos y = - 0.4473
y =243.425 degree

Angles that make the resultant force($\overrightarrow{Fr}$) at point 'F' with positive x , y , and z axes.



Where,

α = 39.24 degree

β = 243.44 degree

Y = 243.425 degree

The cartesian coordinates of the points P_1 (x_1 , y_1 , z_1) and P_2 (x_2 , y_2 , z_2) located on the circumference of the circle to be obtained by the proton.

$$\cos \alpha = \frac{x_2 - x_1}{d}$$

$d = 2 \times r$

$= 2 \times 5.9402 m$

$= 11.8804$ m

$\cos\alpha = 0.7745$

$x_2 - x_1 = d \times \cos\alpha$

$x_2 - x_1 = 11.8804 \times 0.7745$ m

$x_2 - x_1 = 9.2013$ m

$x_2 = 9.2013$ m $[\therefore x_1 = 0]$

$\cos\beta = \frac{y_2 - y_1}{d}$

$\cos\beta = -0.4471$

$y_2 - y_1 = d \times \cos\beta$

$y_2 - y_1 = 11.8804 \times (-0.4471)$ m

$y_2 - y_1 = -5.3117$ m

$y_2 = -5.3117$ m $[\therefore y_1 = 0]$

$\cos y = \frac{z_2 - z_1}{d}$

$\cos y = -0.4473$

$z_2 - z_1 = d \times \cos y$

$z_2 - z_1 = 11.8804 \times (-0.4473)$ m

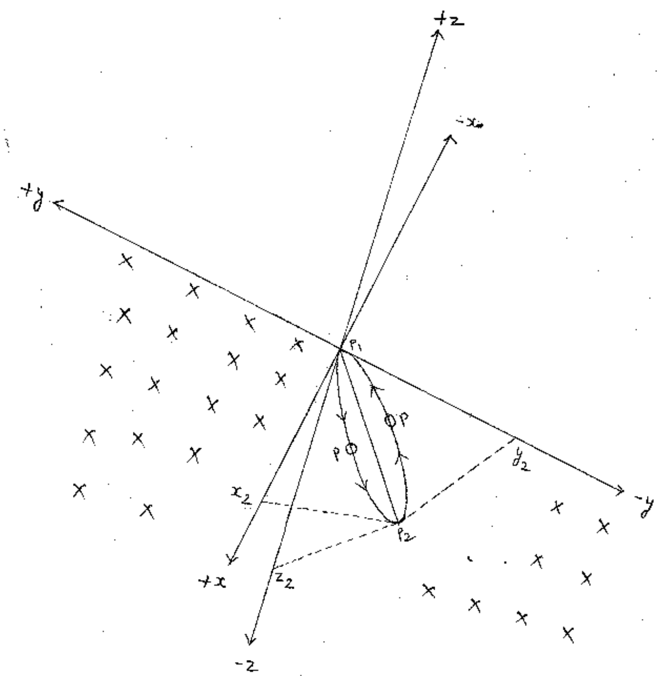
$z_2 - z_1 = -5.3141$ m

$z_2 = -5.3141$ m $[\therefore z_1 = 0]$

The cartesian coordinates of the point p_1 (x_1, y_1, z_1) and p_2 (x_2, y_2, z_2)located on the circumfrence of the circle to be obtained by the proton are as shown below.

The line___ is the diameter of the circle .

P_1P_2


+z
-x
+y
P_1
P
P
y_2
-y
x_2
P_2
+x
z_2
-z

Conclusion :-

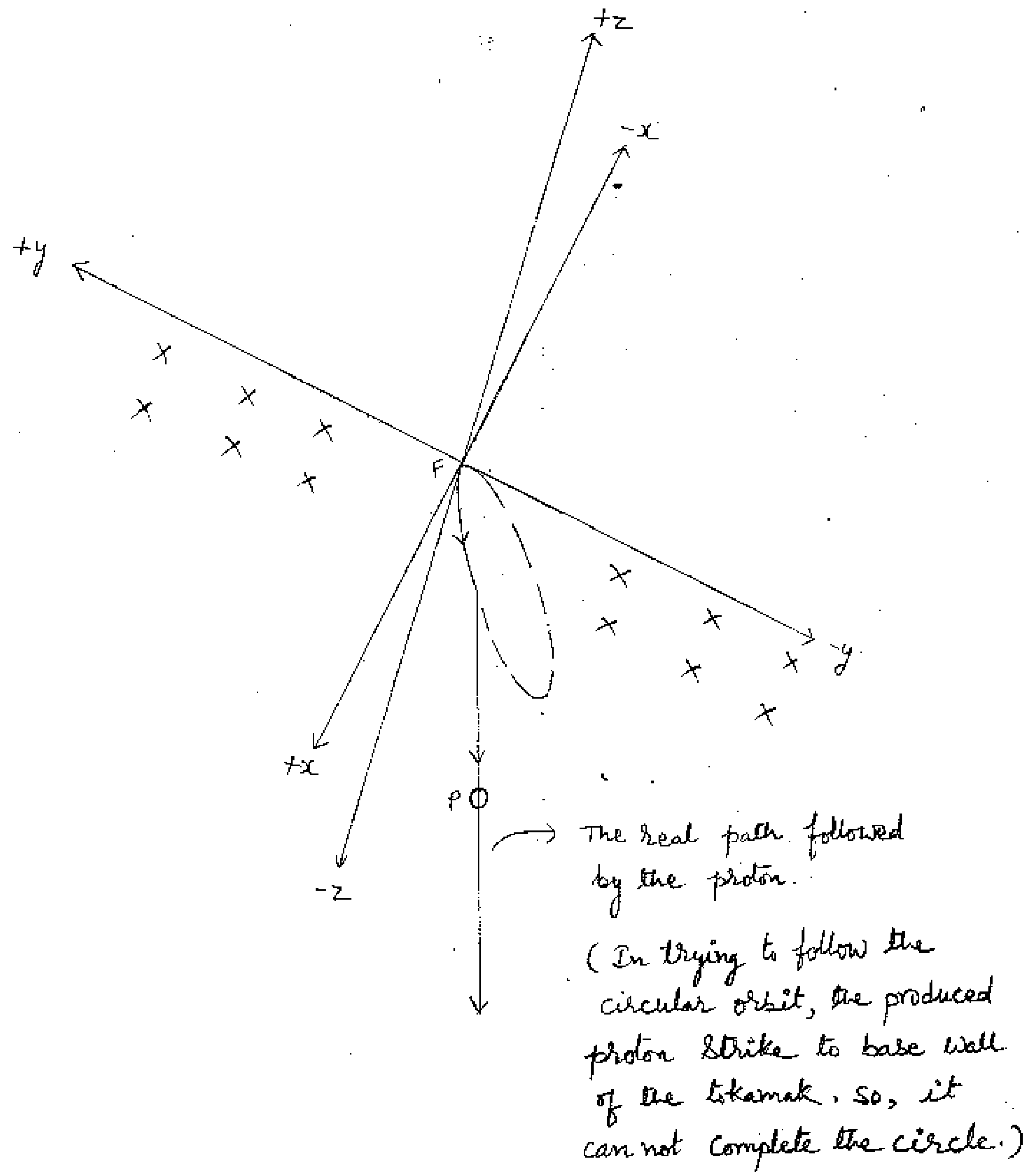
The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the proton are along **+x , -y and -z** axes respectively .

So by seeing the direction ofthe resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the proton lies in the plane made upof positive x- axis, negative y-axis and negative z-axis where the magnetic fields are applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the proton to undergo to a circular orbit of radius 5.9402 m.

It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2(9.2013 m,- 5.3117 m ,- 5.3141m). in trying to complete its circle , dueto lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.


+z
-x
+y
F
-y
+x
P
-z
The real path followed by the proton.
(In trying to follow the circular orbit, the produced proton Strike to base wall of the tokamak, so, it can not complete the circle.)

Summary

The confinement and the extraction of the particles :-

Eitherthe charged particles will remain confined withininto the tokamak or not. As, due to applied magnetic fields, each charged particle will have to go through a circular motion. So to take decision about confinement of each charged particle, we will consider the Cartesian coordinates to be achieved by the each charged particle(either it is injected or produced during fusion reactions) during its circular motion. With the help of Cartesian coordinates to be achieved by each particle, we will come to know that either the charged particle will remain confined withininto the tokamak or due to lack of spacewithin into the tokamak , will have to strike to wall of tokamak. If the charged particle, strike to the wall of the tokamak, it will transfer its energy to the tokamak and thus will attain a gaseous state. Then the vacuum pumps attached to tokamak, will extract all these undesired particles (gases).

€ Conclusionforthe injected deuteron

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the deuteron are along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed bythe deuteron lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields areapplied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the deuteron to undergo to a circular orbit of radius of 0.7160 m. It starts its circular motion from point P_1 (0,0,0) andreaches at point P_2 (1.1092 m , -0.6403 m,-0.6406 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak. And uninterruptedly goes on completing its circle until it fuses with the deuteron of later injected bunch (that reaches at point"F") at point "F

€1.Whenwe Consider the fusion reaction(1)

1.^2_1H + $^2_1$ H $\rightarrow {}_2^3$ He + 1_0 n

[injected] [confined]

Conclusion forthe producedhelium -3 nucleus :-

The directions components$\left[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}\right]$ of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$that are acting on the helium-3 nucleus are along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force$\left(\underset{Fr}{\rightarrow}\right)$ we come to know that the circular orbit to be followed bythe helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$\left(\underset{Fr}{\rightarrow}\right)$ tends the helium-3nucleus to undergo to a circular orbit of radius 0.4842 m.

It starts itscircular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-0.7501 m, 0.4329 m,0.4331m) where themagnetic fields are not applied.

So , It startsits circular motion from point P_1 (0,0,0) and as it travel along a negligible circularpath (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is not confined.

€2.When we consider the fusion reaction(2)

2.$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H$

[injected] [confined]

Conclusionfor the produced proton :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the proton are along **+x , -y and -z**axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the protonlies in the plane made up of positive x- axis, negative y-axis andnegative z-axis.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the protonto undergo to a circular orbit of radius 2.5977 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.0238 m,- 2.3233 m ,-2.3239m). intrying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.

Conclusionforthe produced triton :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ ofthe resultant force$(\underset{Fr}{\rightarrow})$that are acting on thetritonare along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the triton lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$tends the triton to undergo to a circular orbit of radius1.1918m . It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-1.8463 m, 1.0659 m,1.0661 m) where the magnetic fields are not applied.

So , It startsits circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the tirton gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence thetriton is not confined.

€ 3.When we consider fusion reacton (3)

3.$^2{}_1$H + $^2{}_1$ H →$_2{}^4$ He + y says

[injected] [confined] (Confined)

Conclusion for the producedhelium -4 nucleus :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the helium-4 nucleusare along**+x , -y and -z** axes respectively.

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axiswhere the magnetic fields are applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the helium-4 nucleus to undergo to a circular orbit of radius of 0.6997 m. It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.0838 m, -0.6258 m,-0.6259 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circleuntil it fuses with the confined deuteron or deuteron of later injected bunch (that reaches at point "F") at point "F"

€4. When we consider the fusion reacton (4)

4.$^2{}_1$H +4$_2$He →$_3{}^6$ Li + y says

[injected][confined][confined]

Conclusion for the produced lithium -6 nucleus :-

Thedirections components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the lithium-6 nucleusare along **+x , -y and -z** axes respectively

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the lithium-6nucleus lies in the plane made up of positive x- axis, negative y-axisand negative z-axis where the magnetic fields are applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the lithium-6 nucleusto undergo to a circular orbitof radius of 0.6557 m. It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.0158 m,-0.5863 m, -0.5865 m) and again reaches at point P_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circle until it fuses with the confined deuteron or deuteron of later injected bunch (that reaches at point "F") atpoint "F"

€ 5. when we consider fusion reaction (5)

5.$^{2}_{1}H$+ $^{6}_{3}Li$→ [$_{4}^{8}$ Be]→$_{3}^{7}$ Li + $^{1}_{1}$ H

[injected] [confined]

Conclusionfor the producedlithium -7 nucleus:-

Thedirections components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}$] ofthe resultant force$(\underset{Fr}{\rightarrow}$)that are acting on the lithium-7 nucleus are along **-x ,+y and +z** axes respectively.

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow}$) we come to know thatthe circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow}$) tends the lithium-7 nucleus to undergo to a circular orbit of radius 0.2645 m. It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.4098 m,0.2364m,0.2365 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1(0,0,0) and as it travel along a negligible circular path (distance), it gets rid ofthe region covered-up by the applied magnetic fields. so as the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion .so , inspite of completing its circle , ittravel upward and strike to the roof wall of the tokamak.

So the lithium-7 nucleus is not confined.

Conclusionfor the produced proton :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}$] ofthe resultant force$(\underset{Fr}{\rightarrow}$)that are acting on the proton

are along **+x , -y and -z** axes respectively.

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis

The resultant force$(\underset{Fr}{\rightarrow}$) tends the proton to undergo to a circular orbit of radius2.9812m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (4.6178 m,- 2.6657 m ,-2.6669 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.

€ 6.When we consider thefusion reaction (6):-

6.$^{2}_{1}H$+$^{6}_{3}Li$→[$_{4}^{8}$ Be]→$_{4}^{7}$ Be + $^{1}_{0}$ n

(injected) (confined)

Conclusionfor the producedberyllium -7 nucleus :-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the beryllium-7 nucleusare along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we cometo know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the beryllium-7 nucleus to undergo to a circular orbit of radius 0.0773 m .

It startsits circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-0.1198 m,0.0690 m, 0.0690m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1(0,0,0) andas it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of thetokamak.

Hence the beryllium-7 nucleusis notconfined.

€ 7.When we consider the fusionreaction (7)

7.$^{2}_{1}H$ +$^{6}_{3}Li$→[$_{4}^{8}$ Be] →$_{2}^{4}$ He + $_{2}^{4}$ He

(injected) (confined)

Conclusionfor the produced right hand side propelledhelium -4 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that areacting on theright hand side propelled hellion-4are along**+x , -y and -z** axes respectively

So by seeing the direction ofthe resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed bythe right hand side propelled hellion-4 lies in the plane made up of positivex- axis, negative y-axis and negative z-axis

The resultant force($\underset{Fr}{\rightarrow}$) tends the right hand side propelled hellion-4to undergo to acircularorbit of radius 4.8509 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (7.5140 m,- 4.3376 m ,-4.3396 m). in trying to complete its circle , due to lack of space ,it striketo the base wallof the tokamak.

Hence the right hand side propelled hellion-4 is not confined.

Conclusionfor the left hand side propelled helium -4 nucleus :-

The directions components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)thatare acting on the left hand side propelled helium-4 nucleusare along **-x , +y and +z**axes respectively

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the left hand side propelled helium-4 nucleus. lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the left hand side propelled helium-4 nucleus to undergo to a circular orbit of radius 3.7601m

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (-5.8243 m , 3.3630 m, 3.3637 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the left hand side propelled helium-4 nucleus gets rid of magneticfields, it leaving its circular motion, starts its linear motion . so , inspite of completingits circle , it travel upward and striketo the roof wall of the tokamak.

So theleft hand side propelled helium-4 nucleusis not confined.

€ 8.When we consider the fusion reaction (8)

8. ${}^{2}_{1}H + {}^{6}_{3}Li \rightarrow [{}^{8}_{4}Be] \rightarrow {}^{3}_{2}He + {}^{4}_{2}He + {}^{1}_{0}n$

Conclusion for the producedhelium -3 nucleus :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the helium-3 nucleus are along **-x , +y and +z**axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axiswhere the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the helium-3 nucleus to undergo to a circular orbit of radius 0.3899 m.

It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-0.6039 m, 0.3487 m,0.3488 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as ittravel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the helium-3 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upward and strike to the roof wall of the tokamak.

Hence the helium-3 nucleus is not confined.

Conclusionfor the produced helium -4 nucleus :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},\text{and}\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the helium-4 nucleusare along **+x , -y and -z** axes respectively .

So by seeing the direction ofthe resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium-4 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the helium-4 nucleus to undergo to a circular orbitof radius of 0.7980 m.

It starts its circular motion from point P_1 (0,0,0) and reaches at point P_2 (1.2362 m ,-0.7135 m,-0.7137m) and again reaches at pointP_1.

Thus it remains confined within into the tokamak and uninterruptedly goes on completing its circleuntil it fuses with the confined deuteronor deuteron of later injected bunch (that reaches at point"F") at point "F" .

€ 9.When we consider the fusion reaction (9)

9.${}^{2}_{1}H$ + ${}^{6}_{3}$ Li+${}^{2}_{1}H$→[${}_{5}{}^{10}B$] →${}_{3}{}^{7}$ Li + ${}^{3}_{2}$ He

(injected) (confined) (confined)

Conclusion for the produced lithium-7 nucleus :-

Thedirections components[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force($\underset{Fr}{\rightarrow}$)that areacting on the lithium-7 nucleus are along **-x , +y and +z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the lithium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force($\underset{Fr}{\rightarrow}$) tends the lithium-7 nucleus to undergo to a circular orbit ofradius 1.4805 m. It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-2.2935 m,1.3238 m,1.3241 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the lithium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so ,inspite of completingitscircle , ittravel upward and strike to the roof wall of the tokamak.

The lithium-7 nucleus is not confined withininto the tokamak.

Conclusionfor the produced helium -3 nucleus:-

The directionscomponents[$\underset{Fx}{\rightarrow}$,$\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force($\underset{Fr}{\rightarrow}$)that are acting on the helium-3 nucleusare along**+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force($\underset{Fr}{\rightarrow}$) we come to know that the circular orbit to be followed by the helium-3 nucleus lies in the plane made up of positive x- axis, negative y-axis and negative z-axis

The resultant force($\underset{Fr}{\rightarrow}$) tends the helium-3 nucleus to undergo to a circular orbit of radius 3.3766 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (5.2303 m,- 3.0200 m ,-3.0207 m). in trying to completeits circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the helium-3 nucleusisnot confined.

€ 10.When we consider the fusion reaction (10)

10.$^{2}_{1}H$ + $^{6}_{3}$ Li+ $^{2}_{1}H \rightarrow [_5{}^{10}B] \rightarrow {}_4{}^7$ Be + $^{3}_{1}$ T

Conclusionfor the produced beryllium -7nucleus :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] of the resultant force$(\underset{Fr}{\rightarrow})$that are actingon theberyllium-7 nucleus are along **-x, +y and +z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the beryllium-7 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis wherethe magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the beryllium-7 nucleus to undergo to a circular orbit of radius 1.0458 m . It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (-1.6201 m,0.9351 m,0.9353 m) where the magneticfields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-7 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upwardand strike to the roof wall of the tokamak.

The beryllium-7 nucleus is notconfined within into the tokamak.

Conclusionfor the produced triton :-

The directions components$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow}$,and$\underset{Fz}{\rightarrow}$] ofthe resultant force$(\underset{Fr}{\rightarrow})$that are acting on the triton

are along **+x , -y and -z**axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the triron lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis

The resultant force$(\underset{Fr}{\rightarrow})$ tends the triron to undergo to a circular orbit of radius 6.4952 m.

It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2 (10.0610 m,- 5.8093 m ,-5.8106 m). in trying tocomplete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the tritonis not confined.

€ 11.When we consider fusion reaction (11)

11.$^{2}_{1}H$ + $^{6}_{3}$ Li+ $^{2}_{1}H \rightarrow [_5{}^{10}B] \rightarrow {}_4{}^9$ Be +$^{1}_{1}$ P

Conclusionfor the produced beryllium -9 nucleus :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on theberyllium-9 nucleus are along **-x , +y and +z** axes respectively .

Soby seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the helium -3 nucleus lies in the plane made up of negative x- axis, positive y-axis and positive z-axis where the magnetic fields are not applied.

The resultant force$(\underset{Fr}{\rightarrow})$ tends the beryllium-9 nucleus to undergo to a circular orbit of radius 0.9078 m . It starts its circular motion from point P_1(0,0,0) and tries to reach at point P_2(-1.4061 m,0.8117 m,0.8121 m) where the magnetic fields are not applied.

So , It starts its circular motion from point P_1 (0,0,0) and as it travel along a negligible circular path (distance), it gets rid of the region covered-up by the applied magnetic fields. so as the beryllium-9 nucleus gets rid of magnetic fields, it leaving its circular motion, starts its linear motion . so , inspite of completing its circle , it travel upwardand strike to the roof wall of the tokamak.

The beryllium-9 nucleus is notconfined within into the tokamak.

Conclusionfor the produced proton :-

The directionscomponents$[\underset{Fx}{\rightarrow},\underset{Fy}{\rightarrow},and\underset{Fz}{\rightarrow}]$ of the resultant force$(\underset{Fr}{\rightarrow})$that are acting on the proton are along **+x , -y and -z** axes respectively .

So by seeing the direction of the resultant force$(\underset{Fr}{\rightarrow})$ we come to know that the circular orbit to be followed by the proton lies in the plane made up of positive x- axis, negative y-axis andnegative z-axis

The resultant force$(\underset{Fr}{\rightarrow})$ tends the proton to undergo to a circular orbit of radius 5.9402 m.

It starts its circular motion from point P_1 (0,0,0) and tries to reach at point P_2 (9.2013 m,- 5.3117 m ,- 5.3141 m). in trying to complete its circle , due to lack of space ,it strike to the base wall of the tokamak.

Hence the proton is not confined.

The power produced :

To calculate the heat energy produced we will consider the main fusion reactions only. To calculate the heat energy we wll consider thereleased energy (E) of the each particle that has produced due to fusion reactions .

1. ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{2}^{3}He + {}_{0}^{1}n$ + 3.265948 Mev

2. ${}_{1}^{2}H + {}_{1}^{2}H \rightarrow {}_{1}^{3}H + {}_{1}^{1}H$ + 4.03123 Mev

$E_{produced} = 2\,{}_{1}^{2}H \rightarrow {}_{2}^{3}He + {}_{1}^{3}H + {}_{1}^{1}H + {}_{0}^{1}n$ + 7.297178 Mev

Conclusion : 4 deuterons fuse to produce onehelium-3 nuclei ,one triton, one proton and one neutron and 7.297178 Mev energy.

Total input energy :

Each deuteron is injected with 153.6Kev or with 0.1536 Mev energy.
So, the total input energy that is carried by the $6X10^{19}$injected deuterons is –

E_{input} = $0.1536X1.6X10^{13}$ $JX6X10^{19}$per second
E_{input} = $1.474X10^{5}$ W
= 0.1474 MW

Net yield energy :

Net yield = $E_{produced}$ - E_{input}

Net yield = 1.7513MW – 0.1474 Mev
Net yield = 1.6039 MW

VBM fusion reactor and the power produced

The 4 deuteron fuse to yield 7.297178 Mev or the 4 deuteron fuse to yield 7.297178 x 1.6 x 10^{-13} J.

Then if the 6 x 10^{18} deuterons fuse per second then the power produced is –

P = 7.297178 x 1.6 x 10^{-13} x 6 x 10^{19} J

4s

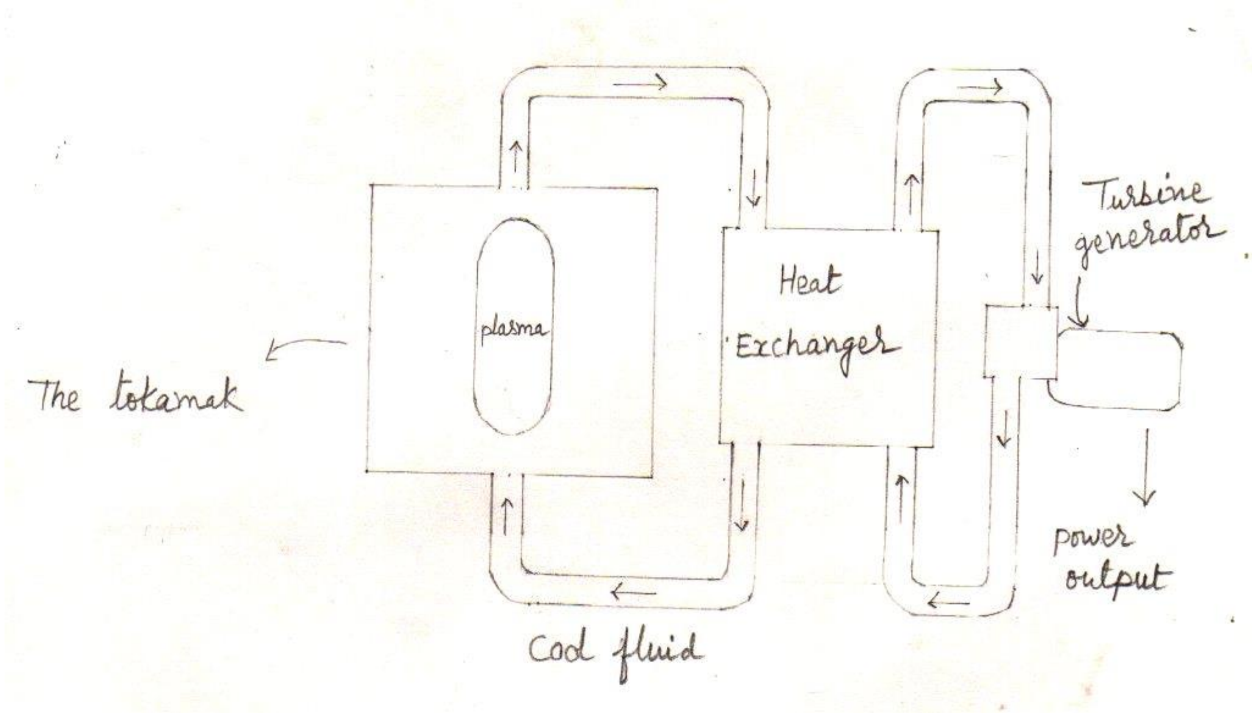
P = 17.5132272 x 10^{5} J/s
P = 1.751322 x 10^{6} J/s
P = 1.751322 MW

VBM fusion reactor and the lawson criterion

For a deuteron – deuterium fusion reaction the,
$n_e T_e \geq 10^{22}$ s/m^{3}

As in VBM fusion reactor , there the identical bunches of deuterons are being injected ,there the injected bunches during their linear path from particle accelerator to the point "F" follow one another and similarly the later injected bunch also follows the earlier injected bunch in their circular path and again pass through the point "F" one by one where they (deuterons) will have to meet (fuse) with the injected deuteron reaching at point "F". So, the VBM Fusion Reactor always achieves the Lawson criterion.

Mode of output



The heat is transferred by a water – cooling loop from the tokamak to a heat exchanger to make steam.
The steam will drive electrical turbines to produce electricity .
The steam will be condensed back into water to absorb more heat from tokamak.