Shape of ^8Be nucleus in $^8Be_{(g.s.)}$, ^9Be, $^{12}C^*$ and $^{24}Mg_{(g.s.)}$, $^{24}Mg^*$ nuclei.

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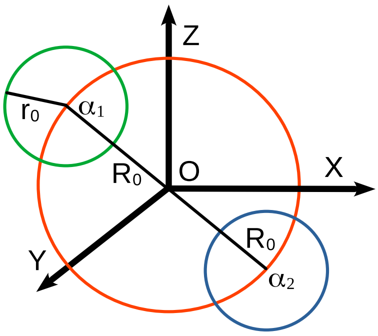

FIG. 1: Spherical $^8Be_{(g.s.)}$ is formed by two α particles (of radius r_0) separated by $2R_0$.

There have been numerous investigations on clustering in various nuclei using cluster knockout reactions and cluster models. It has been shown [1–5] that $^8Be_{(g.s.)}$ nucleus is present in $^9Be_{(g.s.)}$ $^{12}C^*$ and $^{24}Mg_{(g.s.)}$, $^{24}Mg^*$ nuclei. $^8Be_{(g.s.)}$ being unstable nucleus ($\tau \sim 10^{-16}$ Sec), it is surprising that $^8Be_{(g.s.)}$ forms part of some nuclei. While in the formation stage of these nuclei the loosely bound $^8Be_{(g.s.)}$ nucleus feels not only the strong nuclear forces but also the Coulomb force. How under these forces the shape of $^8Be_{(g.s.)}$, a loosely bound structure of 2-α system evolves in various nuclei?.

In the shell model it is easy to visualize that $^8Be_{(g.s.)}$ has 4 quanta of energy, i.e $4\hbar\omega$. It has quantum number n=2 (the radial quantum number) and ℓ=0 (the angular momentum quantum number). It is thus a spherical nucleus.

The $^9Be_{(g.s.)}$ nucleus, is however, a stable nucleus formed of a neutron n and a $^8Be_{(g.s.)}$ nucleus. Now in an $n{+}\alpha{+}\alpha \rightarrow n +^8 Be_{(g.s.)})$ nucleus there are two representative configurations shown in Fig2 and Fig.3.

As there is only short range n-α attractive nuclear force $|\vec{F}_{n\alpha2}(r_{n\alpha2})|{>}|\vec{F}_{n\alpha1}(r_{n\alpha1})|$, see Fig.2. We now decompose these $\vec{F}_{n\alpha1}(r_{n\alpha1})$ and $\vec{F}_{n\alpha2}(r_{n\alpha2})$ forces into $\vec{F}_{nO}$, the n-^8Be force at the center of mass of ^8Be and forces between $\alpha1$ and $\alpha2$ induced by the neutron, n Thus,

From Fig.2, the first configuration of ^9Be we see that,

$$\vec{F}_{n\theta O}(r_{nO}) = \vec{F}_{n\alpha1}(r_{n\alpha1}) + \vec{F}_{n\alpha2}(r_{n\alpha2}) \quad (1)$$

We now define new forces $\vec{f}_{\alpha_1}$ and $\vec{f}_{\alpha_2}$ representing forces components on α_1 and α_2 when seen from a non accelerating (under the force

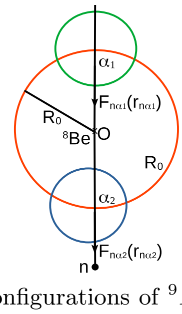

FIG. 2: First configurations of ^9Be as $n{+}\alpha{+}\alpha$ a linear configuration.

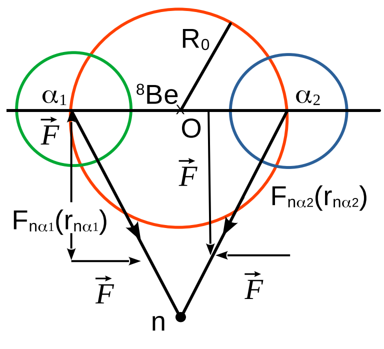

FIG. 3: Second configuration of ^9Be as n-2α $\perp$ to each other.

$\vec{F}_{no}$ ^8Be, i.e

$$\vec{f}_{\alpha_1} = \vec{F}_{n\alpha_1}(r_{n\alpha_1}) = \frac{1}{2}\vec{F}_{no}(r_{no})$$
$$= \frac{1}{2}[\vec{F}_{n\alpha_1}(r_{n\alpha_1}) - \vec{F}_{n\alpha_2}(r_{n\alpha_2})]$$

Similarly,

$$\vec{f}_{\alpha_1} = \vec{F}_{n\alpha_1}(r_{n\alpha_1}) = \frac{1}{2}\vec{F}_{no}(r_{no})$$
$$= \frac{1}{2}[\vec{F}_{n\alpha_1}(r_{n\alpha_1}) - \vec{F}_{n\alpha_2}(r_{n\alpha_2})]$$

It is to be noticed that the force $\vec{\alpha}_1$ and $\vec{\alpha}_2$ are equal in strength but opposite in direction. Besides this while $\vec{f}_{\alpha_1}$ is directed in $o\alpha_1$ direction the $\vec{f}_{\alpha_2}$ is directed in the opposite direction. i.e. in the $o\alpha_2$ direction. These forces lead to stretching of ^8Be in the (n-α_1=α_2 in-line configuration.

Now in Fig.3 we see that the second configuration has force on O, the c.m. of ^8Be, $F_{no}(r_{no})$ is,

$$\vec{F}_{no}(r_{no}) = \vec{F}_{n\alpha_1}\cos(\theta_{\alpha_1 no}) + \vec{F}_{n\alpha_2}\cos(\theta_{\alpha_2 no}) = \vec{F}^z_{\alpha_1} + \vec{F}^z_{\alpha_2}$$

while the forces $\vec{f}_{\alpha_1 x}$=$\vec{f}_{\alpha_2 x}$ are given by

$$= \vec{F}_{\alpha_1 x} = \vec{F}_{n\alpha_1}(r_{n\alpha_1})\sin\theta_{\alpha_1 no}$$

and

$$= \vec{F}_{\alpha_2 x} = \vec{F}_{n\alpha_2}(r_{n\alpha_2})\sin\theta_{\alpha_2 no} = -\vec{f}_{\alpha_1 x}$$

Both these $\vec{f}_{\alpha_1}$ and $\vec{f}_{\alpha_2}$ are equal and in opposite directions and both are directed towards o, i.e. in $\alpha_1 o$ and $\alpha_2 o$ directions. Similar arguments hold for the Y-direction. Thus under the 2^{nd} configuration the ^8Be nucleus is compressed. Thus Figs.2 and 3 lead us to a ^8Be nucleus of prolate shape in ^9Be.

Similar to Figs2 and 3 we have Figs.4 and 5 for the $^{12}C^*$ and $^{24}Mg_{(g.s.)}$ and $^{24}Mg^*$ nuclei, where S represents α or ^{16}O in place of n of Figs.2 and 3 respectively. The other difference is that being broad structure the nuclei $^{12}C^*$, ^{24}Mg and $^{24}Mg^*$ make the Coulomb force dominate as far as the interaction of α-^8Be and ^{16}O-^8Be is concerned. Hence the direction of all the forces are reversed compared to Fig.2 and 3 of ^8Be configuration. Therefore in the case of $^{12}C^*$, $^{24}Mg_{(g.s.)}$ and $^{24}Mg^*$ we except shrinkage of ^8Be for z-direction in the S-α_1-α_2 being in same line configuration of Fig.4. For the x and y-directions seen in Fig.5 we see a stretching of^8Be in $^{12}C^*$, $^{24}Mg_{(g.s.)}$ and $^{24}Mg^*$.That is the reason that Pilt and wheatly[5] considered a Helicopter form of ^{24}Mg with oblate ^8Be+^{16}O configuration.

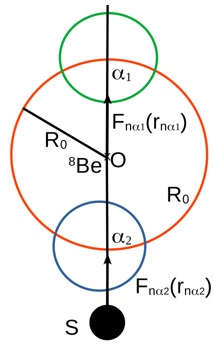

FIG. 4: First configurations of $^{12}C^*$ and ^{24}Mg, $^{24}Mg^*$, where S represents α or ^{16}O nuclei while S and 2α are in a line.

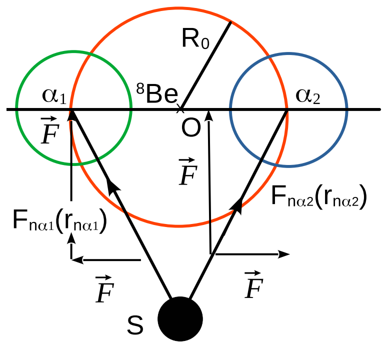

FIG. 5: Second configuration of ^9Be as n-2α $\perp$ to each other.

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