Cluster decay of ^{24}Mg nuclei in the region Z=128

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I. Introduction:

Cluster radioactivity is the phenomenon of spontaneous emission of fragments heavier than alpha particles but lighter than the lightest fission fragment. Such emissions were initially predicted theoretically by Sandulescu et al. [1]. The first experimental observation was made by Rose and Jones [2]. Two types of models exist in explaining the exotic decay process. One is the preformed cluster model [3], in which the cluster is assumed to be preborn in a parent nucleus before it penetrates the barrier. Another one is the fission model [4]. Numerous writers have assessed the effect of deformation on half lives in cluster decay using various theoretical models. In this paper we have calculated the half-life of ^{24}Mg cluster emission for Z=128 parent isotopes using Cubic plus Yukawa plus Exponential Model. Finally, the findings and analysis are presented.

II. Cubic plus Yukawa plus Exponential Model:

This potential as a function of r which is the center of mass distance of the two fragments for the post scission region is given by, [5]

$V(r) = V_c(r) + V_n(r) - V_{df}(r) - Q;$ $r \geq r_t$ If the nuclei have spheroid shape, the radius vector R (ɵ) making an angle ɵ with the axis of symmetry locating sharp surface of a deformed nuclei is given by

$$R(\theta) = R_0\left[1 + \sum_{n=0}^{\infty}\sum_{m=-n}^{n}\beta_{nm}Y_{nm}(\theta)\right]$$

A third order polynomial in r provides an approximation of the potential barrier's shape in the overlapped region between the ground state and the contact point.

$$V(r) = -E_v + [V(r_t) + E_v]\left\{s_1\left[\frac{r-r_i}{r_t-r_i}\right]^2 - s_2\left[\frac{r-r_i}{r_t-r_i}\right]^3\right\} \quad ; \quad r_i \leq r \leq r_t$$

And if the Nilsson's hexadecapole deformation β_4& β_6 is also included in the deformation,

$$R(\theta) = R_0\left[1 + \beta_2\left(\frac{5}{4\pi}\right)^{\frac{1}{2}}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right) + \beta_4\left(\frac{9}{4\pi}\right)^{\frac{1}{2}}\frac{1}{8}(35\cos^4\theta - 30\cos^2\theta + 3) + \beta_6\sqrt{\frac{13}{4\pi}}\left(\frac{1}{16}(231\cos^6\theta - 315\cos^4\theta + 105\cos^2\theta - 5\right)\right]$$

The life time of the decay system is calculated we use the formula

$$T = \frac{1.433\times10^{-21}}{E_v}(1 + \exp K)$$

K- is the action integral

$$K = \frac{2}{\hbar}\{\int_{r_a}^{r_t}[2B_r(r)V(r)]^{\frac{1}{2}}dr + \int_{r_t}^{r_b}[2B_r(r)V(r)]^{\frac{1}{2}}\}dr$$

Ev – is the zero-point vibration energy

$$E_v = \frac{\pi\hbar}{2}\frac{\left(2Q/\mu\right)^{\frac{1}{2}}}{(C_1 + C_2)}$$

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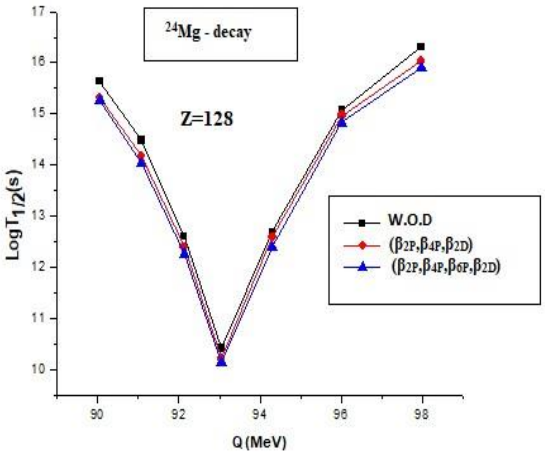
Table 1: The Q- value and the half values for

Cluster emission of $^{24}_{12}Mg$ for Z=128 even isotopes.

Parent Nuclei	Q_{Mg} (MeV) [6]	$LogT_{1/2}(s)$		
		CYEM		
		WOD	WD (β_{2P},β_{4P},β_{2D})	WD (β_{2P},β_{4P},β_{6P},β_{2D})
^{330}128	97.97	16.31	16.03	15.90
^{331}128	96.95	16.85	16.48	16.37
^{332}128	96.02	15.07	14.97	14.83
^{333}128	95.12	14.36	14.19	14.03
^{334}128	94.31	12.69	12.59	12.38
^{335}128	93.56	11.76	11.47	11.32
^{336}128	93.05	10.41	10.21	10.13
^{337}128	92.13	12.60	12.39	12.27
^{338}128	91.08	14.49	14.17	14.04
^{339}128	90.06	15.64	15.32	15.26

Figure1: Comparison of the predicted half lives of $^{24}_{12}Mg$ cluster decay from Z=128 parent nuclei with and without deformation using CYE model.



III. Results and Discussions:

We have computed the half lives for cluster emission $^{24}_{12}Mg$ for Z=128 using CYE model by incorporating hexacontatetrapole (β_6) parameter in the parent nucleus along with the quadrupole (β_2) and hexadecapole (β_4) deformations. The inclusion of deformation effects decreases the half-life time values and it reduces the height of the barrier and hence the barrier penetrability gets increased. Table 1 gives the Logarithmic half-lives for $^{24}_{12}Mg$ cluster from Z=128 parent isotopes including deformation effects. Fig1 represents the comparison of computed logarithmic half lives (with & without) deformation for cluster with available data. The deformation parameter values are taken from these tables of Moller et al [7]. We hope that the studies will be useful for future experimental investigations.

References:

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