Study of Heavy Particle Decay from Superheavy elements by SK Model

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Heavy nuclei usually decay by alpha decay or spontaneous fission. These two decay modes are generally the most probable competing processes. Another less probable decay process is cluster radioactivity in which nuclei from carbon to silicon are emitted from Radium to Californium leading to the most stable daughter nucleus, lead. Recently Poenaru et. al. [1] have identified the heavy particle decay from superheavy nuclei with the emission of nuclei with Z>28. Such unexpected emission from superheavy nuclei Z>110 leading to the daughter, lead, with Z=82 has been studied by Poenaru et. al. using their Analytical Super Asymmetric Fission (ASAF) model [2].

This work reports such a study using the cubic plus Yukawa plus exponential model of Shanmugam and Kamalaharan (SK) [3]. In this model we use a cubic potential in the pre-scission region connected by Coulomb plus Yukawa plus exponential potential in the post-scission region. Apart from using such a realistic potential this model has many more virtues. They are the inclusion of the zero point vibration energy, usage of correct barrier heights including centrifugal contribution and no adjustable parameters. The advantage of this model is further enhanced by its versatility in incorporating the deformation of the decaying parent and the daughter and also their shapes and spins which turn out to be very important now because of the hindrance they can cause, aiding to longevity and stability of superheavy nuclei. One other advantage of this model is that it can naturally be applied to the study of the terminating spontaneous fission events.

So far in our study of cluster radioactivity we consider the emission of clusters Z<29. Because of the emergence of superheavy nuclei upto Z=118, it will be nice to consider heavy particle decay from them.

Table I shows the life times of heavy particle ($Z_e > 28$) decay from superheavy nuclei ($Z_p > 110$) using our model. In order to check our results we first calculated the lifetime of ^{66}Ni decay from the superheavy nucleus ^{274}110. The value obtained by our model for $\log_{10}T_e$ is 12.9 comparable with the value 13.1 of Poenaru et. al. using their ASAF model. We then extend our calculations to cover heavy particle emitters with Z_e=28-36 from superheavy nuclei Z_p=110-118. The results obtained are shown in Table I.

The obtained values are found to be comparable with those of Poenaru et. al. It is thus gratifying to note that our unified fission model can be successfully applied to the new heavy particle radioactivity from superheavy nuclei. To conclude a new possible decay mode known as heavy particle decay can emerge along with alpha decay and spontaneous fission process in superheavy nuclei.

To depict the comparable features of such heavy particle decays from superheavy nuclei we have shown in Fig. I the logarithm of lifetimes against the released energies Q (MeV).

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References

[1] D.N.Poenaru, R.A.Gherghescu and W.Greiner, Phys.Rev.Lett. **107**, 062503(2011).

[2] D.N.Poenaru, D.Schnabel, W.Greiner, D.Maziluand I.Cata, Report No. GSI-90-28, 1990.

TABLE I: The life-time values of heavy particle decay from superheavy nuclei

A_e	Z_e	A_p	Z_p	Q (MeV)	$\log_{10}$ T_e
68	28	276	110	229.08	10.66487
69	28	277	110	228.5	11.006616
70	28	278	110	228.67	10.417837
71	28	279	110	227.77	11.208538
72	28	280	110	227.44	11.290169
73	28	281	110	226.05	12.765712
69	29	277	111	236.75	12.526744
71	29	279	111	237.4	10.9362
72	29	280	111	236.99	11.062592
73	29	281	111	236.82	10.898799
74	29	282	111	236.05	11.524725
75	29	283	111	235.52	11.86276
72	30	280	112	246.81	10.626693
74	30	282	112	247.19	9.268372
76	30	284	112	246.33	9.549792
77	30	285	112	245.31	10.504439
75	31	283	113	255.82	9.915903
77	31	285	113	255.6	9.284107
78	31	286	113	254.98	9.671004
79	31	287	113	254.66	9.671088
78	32	286	114	265.28	8.625387
80	32	288	114	264.84	8.273727
81	32	289	114	264.25	8.5943
81	33	289	115	273.91	8.345216
83	33	291	115	274.14	7.078981
82	34	290	116	283.52	7.738546
84	34	292	116	284.51	5.308326
85	34	293	116	282.65	7.34326
85	35	293	117	293.62	5.380033
86	35	294	117	292.24	6.622481
86	36	294	118	303.29	4.766339
87	36	295	118	302.11	5.713725

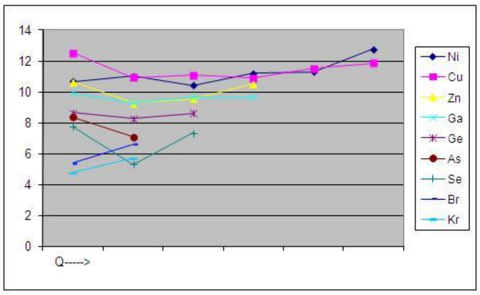

FIG. 1: Q (MeV) Vs $\log_{10}T_e$ for different emitters

[3] G.Shanmugam and B.Kamalaharan, Phys.Rev.C **38**, 1377(1988).