Search for Long lived superheavy nuclei

A. S.I.A. Philominraj B. G.Bella Jeevamani
Department of Physics, Madras Christian College,
Chennai-600059.
e-mail: philominrajmcc@yahoo.com

Introduction

Study of nuclear decay paves way for understanding nuclear structure and alpha decay is a major tool to obtain the details of nuclear structure. Improved experimental techniques have encouraged more experimentalists to report half lives of new isotopes.

Recently J. Kurcewicz et al [1] have reported experimental half-lives for translead isotopes and H.F.Zhang et al [2] have evaluated half lives for newly observed heavy nuclei. P.Roy Chowdhury et al [3] have used their theoretical model to search for long lived heavy nuclei. They have selected isotopes which decay predominantly by alpha emission.

Present Work

The present work involves theoretical evaluation of half lives using the model proposed by Shanmugam and Philominraj (SP) [4]. This model is an analytical model for alpha decay and cluster radioactivity.

Features of SP model

This model assumes preformed cluster within the parent nucleus. Let r be the distance between the centres of mass of the parent nucleus and the cluster. When the cluster is within the parent nucleus, the distance $r = r_i$ which is the inner turning point corresponding to the inner wall of the barrier.

As the cluster emerges out of the parent nucleus and the two fragments are just touching, the distance $r = r_t$ which is the touching distance of the fragments. At r_t the height of the barrier is maximum. Now as the fragments separate, the potential energy decreases and the kinetic energy increases. The distance where the potential energy equals the kinetic energy is $r = r_o$ which is the other turning point corresponding to the outer wall of the barrier. At r_o the coulomb potential energy equals the kinetic energy Q of the fragments.

Table 1: Alpha Decay Half lives of superheavy elements

S. no	Parent		Q in MeV	$\log_{10}T_{1/2}$ (sec)	
	Z	A		Present	Reference [3]
1	106	266	8.91	2.1815	1.7924
2	107	267	9.26	1.3974	1.2304
3	108	266	10.356	-1.4720	-2.6383
4	108	267	9.998	-0.4818	-1.2366
5	108	269	9.337	1.4937	0.9896
6	108	270	9.05	1.4166	1.3424
7	109	266	11.021	-2.8765	-2.7696
8	109	268	10.521	-1.6101	-1.6778
9	110	267	12.39	-5.7610	-5.5528
10	110	269	11.65	-3.1432	-3.7471
11	110	270	11.25	-3.1993	-4.0000
12	110	271	10.919	-2.3824	-2.7878
13	110	273	11.42	-3.6844	-3.7696
14	111	272	11.185	-2.7408	-2.4202
15	112	277	11.649	-3.6583	-3.1612
16	112	283	9.719	1.5022	0.8389
17	116	290	11.00	-2.4786	-2.1487
18	116	292	10.66	-1.5822	-1.7447
19	118	294	11.81	-4.0007	-3.0506

Thus ($r_o - r_i$) is the barrier width. From r_i to r_t the form of the potential is cubic and from r_t to r_o coulomb potential plays the role. The penetration integral involves cubic potential and coulomb potential. The integral is solved analytically in SP model. When the cluster is big, r_i and r_t are well separated and the potential well is cubic. When the cluster is small, r_i coincides with r_t and the potential well becomes approximately a square well. Thus the size of the cluster decides the shape of the potential barrier.

As the preformed cluster emerges out of the parent nucleus, the model assumes cubic form of potential, and when the cluster has completely emerged out, coulomb potential forms the barrier.

While dealing with bigger clusters like Carbon, Oxygen and Neon, the inner cubic potential is well pronounced and for small cluster like alpha, inner potential reduces to an appropriate square well potential.

Table 2 Long lived super heavy alpha emitters

S. No.	Parent		$T_{1/2}$ (sec)
	Z	A	
1	106	266	151.88
2	107	267	24.97
3	108	269	31.17
4	108	270	26.10
5	112	283	31.78

Results

Using SP model the decay rates have been evaluated for the new isotopes reported recently. Half lives of alpha emitting superheavy elements are presented in Table 1.

Most of the superheavy elements have high decay rate as expected, but however a few of them are found to be comparatively stable. These comparatively long lived superheavy elements are presented in Table 2.

For heavy cluster, one has to consider shell effect, deformation and suitable form of barrier potential. For alpha emission square well potential is found to be quite sufficient. Superheavy elements are generally expected to be highly unstable with short half lives. However, we note from Table 2 that some of the superheavy elements are comparatively long lived. The element $^{266}106$ has $T_{1/2}$ = 151.88 sec.

Refrences

[1] J.Kurcewicz, W. Czarnacki, M. Karny, M.Kasztelan, M.Kisielinski and A. Korgul, Phys. Rev. C**76** (2007)

[2] H.F. Zhang and G. Royer, Phys. Rev. C**77** (2008)

[3] P.Roy Chowdhury, C.Samanta and D.N.Basu, Phys. Rev. C**77** (2008)

[4] S.I.A.Philominraj, Ph.D Thesis, University of Madras (1997)