Fission decay width of $^{302}120$

N. Manjunatha[1,2], ,H.C. Manjunatha[1*], N. Sowmya[1*]
[1]Department of Physics, Government College for Women, Kolar, Karnataka, India.
[2]Department of Physics, Rajah Serfoji Government College, Thanjavur-613005, Affiliated to Bharathidasan University, Tiruchirappalli-TamilNadu.
Corresponding Author: manjunathhc@rediffmail.com, sowmyaprakash8@gmail.com

Introduction:

Fusion reactions that produce the superheavy elements with Z > 110 are severely hampered by other faster and competing processes. The fission barriers evaporate at bombardment energy much above the fusion barrier as a result of spin effects, which causes the compound systems to split apart quickly [1]. Nuclear fission was the subject of a standard model proposed by Bohr and Wheeler [2], and this process predominantly competes with neutron evaporation. The nuclear temperature of compound nuclei significantly decreases during each neutron evaporation, lengthening the lifespan of fission [3]. Near the fusion barrier, the binary splitting of complex nuclei predominates [4-6]. Both the cold [7] fusion reaction and the hot [8] fusion reaction were effective in synthesising the superheavy elements up to Z=118. Since targets heavier than Z=98 are not available, heavier than ^{48}Ca projectiles must be employed to synthesize the superheavy element Z>118 [9].

Earlier researchers [10-16] investigated decay width of neutron to fission width in the heavy ion fusion reactions. As the tendency of Coulomb repulsion force is larger, it can lead to decay before forming a compound nuclei. The fission lifetimes of Thorium nuclei have been measured using crystal blocking technique [17] and measured lifetimes were found to be longer than 10 as. Since, many attempts failure to synthesize the superheavy element Z=120, we have motivated to study fission decay width of superheavy nuclei $^{302}120$.

Theoretical Frame work

The decay width of fission[18] with dynamical effects[19] is calculated using the following equation;

$$\Gamma_F = \frac{\hbar\omega_g}{2\pi}\exp\left(-V_B/T\right)\left[\sqrt{1+\left(\frac{\beta}{2\omega_s}\right)}-\frac{\beta}{2\omega_s}\right] \qquad (1)$$

where $\beta = \eta/m$ (where η is the dissipation coefficient and m is collective inertia) and ω_s denotes the frequency of an inverted harmonic potential.

Results and Discussions:

The fission decay width of $^{302}120$ have been studied using statistical model with modified back-shifted microscopic level density [19]. A plot of fission decay width verses excitation energy for different projectile-target combinations experimented to synthesize the superheavy element as shown in figure 1. From the figure 1, it is clear that the fusion reaction ^{58}Fe+^{244}Pu has higher value of fission decay width when compared to other fusion reactions which were studied.

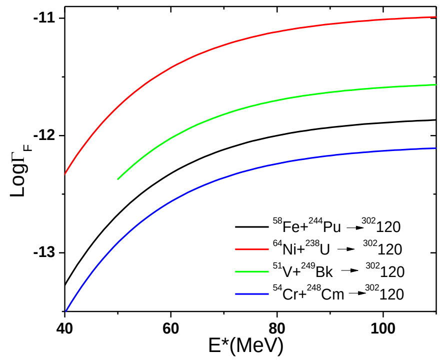

Fig 1: Variation of Logarithmic fission decay width with the excitation energy.

Furthermore, we have also investigated role of entrance channel parameters on fission decay width. Variation of fission decay width with entrance channel effects like Coulomb interaction parameter(z), mass asymmetry(η_A), compound nucleus fissility(χ_{eff}) and the mean fissility(χ_m) were plotted in figure 2. In this figure each filled circle represents(from left to right) the decay width of compound nucleus $^{302}120$ with fusion reactions of $^{58}Fe + ^{244}Pu$, $^{64}Ni + ^{238}U$, $^{51}V + ^{249}Bk$, $^{54}Cr + ^{248}Cm$ respectively. We have also evaluated the decay times for the fusion reactions such as $^{58}Fe + ^{244}Pu$, $^{64}Ni + ^{238}U$, $^{51}V + ^{249}Bk$, $^{54}Cr + ^{248}Cm$ and tabulated in the table 1.

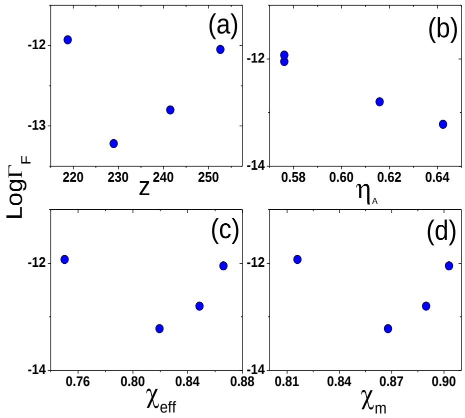

Fig 2: Variation of logarithmic fission decay width with Coulomb interaction parameter, mass asymmetry, compound nucleus fissility, the mean fissility.

Table 1: Calculated decay times of fission fragments of $^{302}120$.

Reaction	T_F(zs)
$^{58}Fe + ^{244}Pu \rightarrow ^{302}120$	2.330
$^{64}Ni + ^{238}U \rightarrow ^{302}120$	2.998
$^{51}V + ^{249}Bk \rightarrow ^{302}120$	1.555
$^{54}Cr + ^{248}Cm \rightarrow ^{302}120$	3.671

Conclusions

The fission decay width of $^{302}120$ has been studied using present model. As excitation energy increases decay width of fission also increases. The different entrance channel parameters such as mass asymmetry, charge asymmetry, effective fissility and mean fissility were investigated for fission decay width. Variation of decay width with entrance channel parameters like z, η_A, χ_{eff} and χ_m were studied. The decay times of ^{302} 120 was evaluated using present model and they are found to be at an order of zeptosecond (zs). These results find an importance in the study of fission decay width.

References:

[1] M. Morjean et al.,, Phys. Rev. Lett. 101, 072701 (2008).
[2] N. Bohr and J. A. Wheeler, Phys. Rev. 56, 426 (1939).
[3] J. U. Andersen, et al., Phys.Rev. Lett. 99, 162502 (2007).
[4] R. Bock, et al., Nuclear Physics A 388, 334 (1982).
[5] J. Toke, et al., Nuclear Physics A 440, 327 (1985).
[6] W. Q. Shen, et al.,Phys. Rev. C 36, 115 (1987).
[7] R. Smolanczuk, Phys. Rev. C 63, 044607 (2001).
[8] H. C. Manjunatha, et al., Phys. Rev. C 102, 064605 (2020).
[9] S. Hofmann et al., The European Physical Journal A 52, 1 (2016).
[10] H.C. Manjunatha et al., Eur. Phys. J. Plus 133: 227 (2018).
[11] P.S.Damodara Gupta, et al., Pramana – J. Phys. 96:146 (2022).
[12] H. C. Manjunatha et al., Phys Rev C, 98, 024308 (2018).
[13] H.C.Manjunatha et al., Nuclear Physics A 987 (2019) 382–395.
[14] H.C.Manjunatha et al., Canadian Journal of Physics 99:16-23 (2021).
[15] H.C. Manjunatha et al., Phys. Rev. C 103, 024311 (2021).
[16] H. C. Manjunatha et al., Phys. Rev. C 104, 024622 (2021).
[17] S. Karamian et al., The European Physical Journal A-Hadrons and Nuclei 17, 49 (2003).
[18] S. Pal, Pramana 85, 251 (2015).
[19] A. Rahmatinejad, et al., Phys. Rev. C 103, 034309 (2021).