Role of temperature dependent binding energies in fission like fragments emission of ^{56}Ni* nucleus

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Introduction

Fusion-fission reaction studies were made extensively on light ^{56}Ni* compound system formed from different entrance channels ^{16}O+^{40}Ca, ^{28}Si+^{28}Si and ^{32}S+^{24}Mg and at different incident energies by Sanders et al. [1]. Using the Dynamical Cluster Model (DCM), Gupta et al. [2] have studied the fusion-fission reaction of ^{56}Ni* formed in ^{32}S+^{24}Mg, at the incident energies $E_{c.m.}$=51.6 and 60.5 MeV. In this model, the light particles emission and intermediate mass fragments and/or fission like fragments emission are treated in a cluster picture. One of the main ingredient of the model is the use of temperature dependent binding energies, which occurs in the fragmentation potential as defined below.

$$V(R,\eta,T) = \sum_{i=1}^{2}[V_{LDM}(A_i,Z_i,T)] + \sum_{i=1}^{2}[\delta U_i] \times exp\left(-\frac{T^2}{T_0}\right) + V_c(T) + V_p(T) + V_\ell(T) \quad (1)$$

Here, the temperature dependent V_{LDM} is due to Davidson et al., [3] which was refitted with the g.s. experimental binding energies [4]. δU is the empirical shell correction of Myers and Swiatecki which vanishes exponentially as the temperature increases. V_c, V_p and V_ℓ are the temperature dependent Coulomb, proximity and centrifugal potentials. The temperature dependence in these terms comes through the radius expression.

In DCM the decay cross section, in terms of partial waves is defined as,

$$\sigma = \frac{\pi}{k^2}\sum_{\ell=0}^{\ell_{max}}(2\ell+1)P_0P; k = \sqrt{\frac{2\mu E_{c.m.}}{\hbar^2}} \quad (2)$$

where P_0 is the preformation probability referring to η motion and P the penetrability referring to R motion. In the present work, we recalculated the cross-section of fission like fragments emitting from $^{56}Ni^*$ formed in $^{32}S +^{24} Mg$ reaction at the incident energy $E_{c.m.}$=51.6 MeV. In the present calculation, instead of the Davidson et al., formula for the V_{LDM} part we used the formula due to Krappe [5], which is also refitted to give the g.s. experimental binding energies. In Davidson model, one of the drawback is the temperature dependent LDM coefficients, which

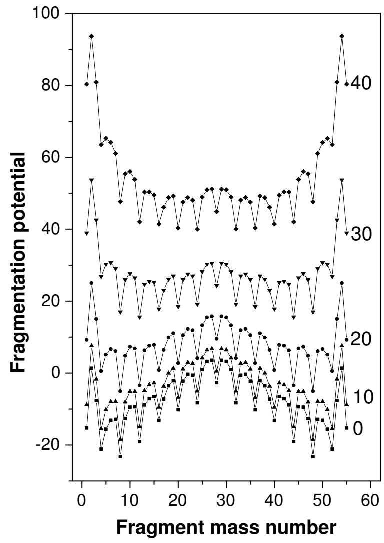

FIG. 1: Fragmentation potential as a function of fragment mass number and angular momentum

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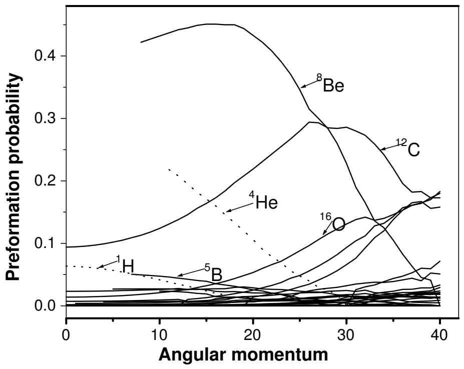

FIG. 2: P_0 as a function of angular momentum for different exit channel

are to be retrieved from some plots whereas in Krappe model, the temperature dependent coefficients are given in analytical expression, leading to accurate extraction of the coefficients for a given temperature. The free energy minimization of these models also differs. In the former it is Helmholtz free energy and in the later it is Gibbs free energy.

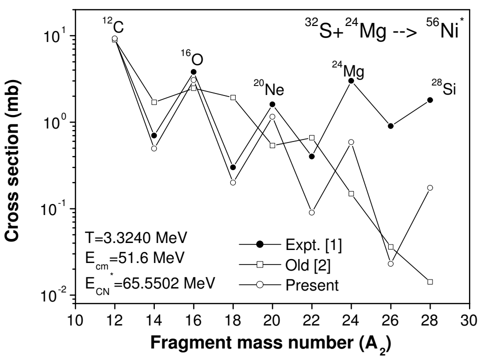

FIG. 3: Calculated cross section compared with experimental data [1]and earlier calculation [2].

For the use Krappe's expression in the V_{LDM} of Eq. (1), the fragmentation potentials are calculated and is presented as a function of fragment mass number A_2 and angular momentum in Fig. 1. It is very interesting to see that, the vanishing of α-structure seen in the earlier calculation [2] are not present, rather, the potential has strong minima only at α-structured nuclei. Though, the preference of asymmetric fragments at lower angular momentum states, and the competition of symmetric fragments with asymmetric ones at higher angular momentum states are present as earlier. But, fragments like, ^{8}Be and ^{12}C are shown to compete with light particles even in low angular momentum states. For the use of the fragmentation potential of Fig.1, the preformation probability of all the exit channels are calculated and are presented in Fig.2 as a function of angular momentum. The P_0 for ^{4}He, ^{8}Be and $^{1}2C$ are start to show up right from the lower angular momentum states and for rest of the fragments P_0 values starts beyond certain angular momentum.

Our results for the cross-section (open circles) of even fragments from A_2=12 are compared with the earlier calculation (open square) and with the experimental values (solid circle) in Fig. 3. Our results exactly reproduces the experimental trend and is in good agreement with experimental data at least up to A_2=20. In the present calculation no parameter is used, whereas neck length is used as a free parameter to fit with the experimental data in the earlier calculation. The poor agreement for the symmetric fragments needs further analysis. Concluding, the preliminary results suggests that the use of Krappe's temperature dependent binding energy over Davidson's formula may give a better estimate of cross-sections in the Dynamical cluster model.

References

[1] S. J. Sanders et al., Phys. Rev. C **40** 2091 (1989).

[2] R. K. Gupta et al., Phys. Rev. C **71** 014601 (2005). (and references therein)

[3] N.J. Davidson, et al., Nucl. Phys. A **570**, 61c (1994).

[4] G. Audi et al., Nucl. Phys. A **595**, 409 (1995).

[5] H. J. Krappe Phys. Rev. C **59** 2640 (1999).