Giant dipole resonances for Sm-isotopes

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Introduction

The structure of neutron drip-line nuclei is a facinating topic in present day research for Nuclear Physics community. This is possible due to the development of accelerator techniques all over the globle. Specially the structure of rare-earth nuclei like Sm region attracts considerable theoretical[1] and experimental [2] attraction. In addition to the Sm region, the drip-line nuclei of Pt and Th are also considered to be interesting for the new island of stability [1]. The structure of ^{162}Sm, ^{228}Pt and ^{254}Th have special features, because of the state dependent nature of the repulsive nuclear force singlet-singlet and triplet-triplet. The repulsive part of the nuclear force makes the nucleus more instability with larger N/Z ratio. The shell effect plays a dominant role to stabilize these nuclei and hence gives a new set of magic numbers and an associated island of stability near the drip-line [1]. This phenomenon can be compared with the repulsive Coulomb interaction with the attractive shell effect along the valley of $\beta-$stability in the superheavy nuclei[1]. It is thus interesting to study the ground state as well as the high-spin structure of these nuclei. Recently Ghorui et al [3] has done a detailed calculation for Sm isotopes. In the present paper we have investigated the Giant Dipole Resonances (GDR) for some of the Sm nuclei in the drip-line region.

Theoretical Formalism

The nuclear shapes are related to the giant dipole resonances (GDR) [4]. The GDR frequencies in laboratory frame are obtained as

$$\widetilde{\omega}_z = (1+\eta)^{1/2}\omega_z \; , \qquad (1)$$

$$\widetilde{\omega}_2 \mp \Omega = \left\{ (1+\eta)\frac{\omega_y^2+\omega_x^2}{2} + \Omega^2 + \frac{1}{2}\left[(1+\eta)^2(\omega_y^2-\omega_x^2)^2 + 8\Omega^2(1+\eta)(\omega_y^2+\omega_x^2)\right]^{\frac{1}{2}} \right\}^{\frac{1}{2}} \mp \Omega, \qquad (2)$$

$$\widetilde{\omega}_3 \mp \Omega = \left\{ (1+\eta)\frac{\omega_y^2+\omega_x^2}{2} + \Omega^2 - \frac{1}{2}\left[(1+\eta)^2(\omega_y^2-\omega_x^2)^2 + 8\Omega^2(1+\eta)(\omega_y^2+\omega_x^2)\right]^{\frac{1}{2}} \right\}^{\frac{1}{2}} \mp \Omega, \qquad (3)$$

where Ω is the cranking frequency, ω_x, ω_y, ω_z are the deformed oscillator frequencies of the nucleus and η is a parameter that characterizes the isovector component of the neutron and proton average field [4]. The GDR cross sections are constructed as a sum of Lorentzians as given by

$$\sigma(E_\gamma) = \sum_i \frac{\sigma_{mi}}{1+\left(E_\gamma^2-E_{mi}^2\right)^2/E_\gamma^2\Gamma_i^2} \qquad (4)$$

Where Lorentz parameters E_m, σ_m and Γ are the resonance energy, peak cross-section and full width at half mum respectively. Here i represents the number of components of the

GDR and is determined from the shape of the nucleus [4]. The energy dependence of the GDR width can be approximated by [5]

$$\Gamma_i \approx 0.026 E_i^{1.9} . \quad (5)$$

The peak cross section σ_m is given by

$$\sigma_m = 60 \frac{2}{\pi} \frac{NZ}{A} \frac{1}{\Gamma} \, 0.86(1+\alpha) . \quad (6)$$

The sum rule parameter α is fixed at 0.3 for all the Sm-isotopes. This parameter has more effect on the peak cross section. The other parameter η varies with nucleus so that the ground state GDR centroid energy is reproduced. The choice for Sm is $\eta = 2.6$. For calculating the GDR width, only the power law (5) is used in this work and no ground state width is assumed.

Results and Discussions

The giant dipole resonances (GDR) cross-section σ for some of the representative Sm isotopes are plotted in Figures 1 and 2. In Fig. 1, the GDR cross-section for $^{150-162}$Sm (at zero spin I=0) are shown at various temperature T as a function of energy E_γ. Although ^{162}Sm is considered as a special nucleus in some microscopic calculations [1], because of the collective nature of GDR cross-section the special feature does not appear in the present calculations. For this further investigation is needed and which will be reported some whe-realse [6]. Similarly, the GDR cross-section for $^{150-162}$Sm at different spin I and temperature T are compared in Figure 2. It is clear from the figure that σ varies marginally at the peak with mass number.

Summary

In summary, we calculate the GDR cross section for $^{150-162}$Sm at various spin and temperature. We found a remarkable change in the peak value of σ. A detail study in this regard is needed because of the importance of the drip-line ^{162}Sm nucleus. Work in this direction is in progress[6].

Acknowledgments

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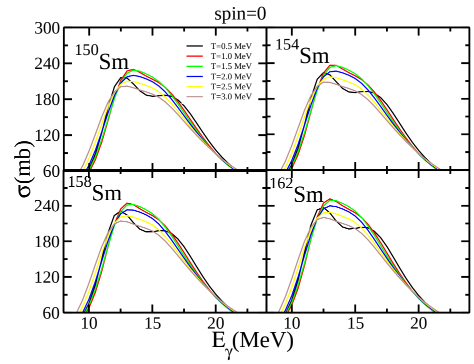

FIG. 1: GDR cross-section as a function of excitation energy E_γ at various T (with I=0).

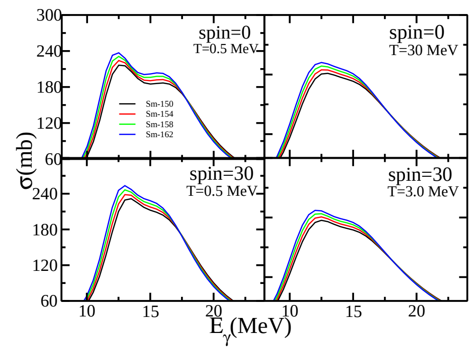

FIG. 2: GDR cross-section as a function of excitation energy E_γ at various T (with I=0).

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