Theoretical study of photon strength functions using different nuclear level density models

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Introduction

Neutron scattering [1, 2], nuclear reaction [3–5] and nuclear structure [6, 7] are different probes to understand nuclear dynamics experimentally. Nuclear level densities [8], optical model parameters and photon strength functions [9] are different tools to understand nuclear dynamics theoretically.
The photon strength functions (GSF) has garnered significant experimental and theoretical attention in recent times due to its essential function in γ transitions. The (n,γ) and (γ,n) reaction channels are governed by the GSF. Though γ rays can generally accompany the emission of any other emitted particle and γ transitions occur for both the continuum and discrete levels, the GSF can be regarded as an important factor in reaction modelling.
In the present work, we aim to study different photon strength functions using six level density models and compare experimental cross-section with the theoretical model prediction.

Theoretical Study

To evaluate the photon strength functions and nuclear level densities for a system, we have employed TALYS-1.96 [10]. For experimental data, we have chosen ^{98}Mo(n,γ)^{99}Mo nuclear reaction, which was performed at FOTIA, BARC, Mumbai. More details about the experiment can be found in Ref. [11]. The cross-section was measured at 1.67 $\pm$ 0.14, 2.06 $\pm$ 0.14 and 2.66 $\pm$ 0.16 MeV. In the present work, we have utilized different photon strength functions available in the TALYS-1.96 for different nuclear level density models and compared with the experimental data. We also computed the cross-section by modifying width of the giant dipole resonance, using TALYS-1.96.

Results and Discussions

The cross-section of ^{98}Mo(n,γ)^{99}Mo reaction with different photon strength functions (GSF-1-8) for different nuclear level density models (LDM-1-6) is presented in Fig. 1. The photon strength functions are shown as GSF-1 (green), GSF-2 (olive), GSF-3 (wine), GSF-

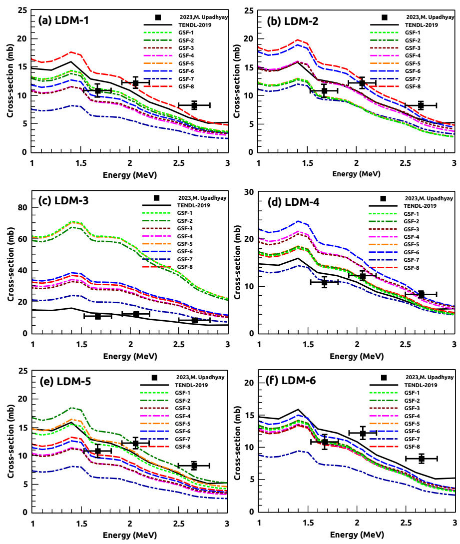

FIG. 1: Cross-section of ^{98}Mo(n,γ)^{99}Mo reaction with different photon strength functions (GSF-1-8) for different nuclear level density models (LDM-1-6).

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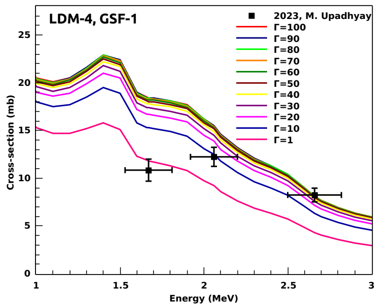

FIG. 2: Cross-section of ^{98}Mo(n,γ)^{99}Mo reaction with different widths of GDR for the same photon strength function GSF-1 and level density LDM-4.

4 (magenta), GSF-5 (orange), GSF-6 (blue), GSF-7 (royal), GSF-8 (red) and the present cross-section data is depicted by a black rectangle. The evaluated data by TENDL-2019 is in trend with the experimental results. We can observe that the results of eight GSFs is changed by using different nuclear level density models. The photon strength functions are primarily characterized by their dependence on both the temperature and the γ energy of the state to which the transition occurs. As we modify the nuclear level densities, the temperature sensitive photon strength functions are changed.

The results by TALYS-1.96 for nuclear level density models LDM-1, LDM-2, LDM-4, LDM-6 with four photon strength functions GSF-1, GSF-2, GSF-5, GSF-8 are close to the experimental cross-sections. As per Ref. [11], experimental data at 1.67 MeV is best in agreement with the result of LDM-4 and similar is observed in Fig. 1 (d). The data at this point is favourable with the results of GSF-1, GSF-2, GSF-5, GSF-8.

In order to check the cross-section dependence on width of GDR, we have changed the width from 1 to 100 at intervals of 10. The result is plotted and illustrated in Fig.2. The cross-section has been varied by varying the width of giant dipole resonance for the same photon strength function, GSF-1. This shows the dependency of the cross-section on the width of GDR.

Summary

Fig. 1 demonstrated that the outcome of TALYS-1.96 is highly subtle to the nuclear level density models and photon strength functions chosen. Different model parameters like energy, width, strength of the giant dipole resonance will be discussed and the results of this investigation will be addressed in further depth during the symposium.

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