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Neutron Spectroscopic Measurement for Studying Nuclear Level Density via the Fusion Evaporation Route

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Nuclear level density (NLD) can be determined through various experimental techniques, including nuclear level counting, neutron capture reactions (via nuclear resonance widths), gamma-ray spectroscopy in the OSLO method, and particle spectroscopy in the fusion evaporation method.
NLD is strongly influenced by nuclear structure effects such as shell corrections, pairing interactions, deformation, and isospin. In deformed nuclei, numerous rotational states contribute significantly to NLD at low excitation energies, leading to values much higher than those predicted by the single-particle Fermi Gas model. The ratio of total NLD to the single-particle estimate at a given excitation energy is referred to as the collective enhancement factor. As excitation energy increases, collective contributions gradually diminish and eventually vanish beyond a certain threshold known as the critical energy. This energy is associated with nuclear shape transitions and varies across different nuclei. While recent experiments have focused on measuring both the collective enhancement factor and the critical excitation energy [1–8], further measurements across the nuclear chart are needed to obtain conclusive data on these quantities.
Another key challenge in NLD studies is understanding its isospin dependence. The conventional approach to NLD in exotic nuclei with extreme neutron-to-proton (N/Z) ratios assumes behavior similar to that of stable nuclei, which may not always be valid. Experimental observations suggest a reduction in NLD for neutron-deficient nuclei compared to their neighboring stable isotopes, particularly in the mass regions around 60 and 120 [9–11]. Further investigations are needed to gain deeper insights into NLD trends in exotic nuclei.
Al-Quraishi et al. proposed two empirical relations for NLD parameters—one based on (N-Z) and another on (Z-Z_0), where Z_0 represents the atomic number of the nucleus at the bottom of the mass parabola for a given mass [12–13].
For excited nuclei with mass above 100, neutron emission is predominantly influenced by the large Coulomb barrier. Consequently, fast-neutron spectroscopy at backward angles provides a valuable tool for NLD measurements. In this talk, I will present recent experimental results on the fadeout of collectivity and the isospin dependence of NLD. Additionally, I will discuss future experimental plans under the IAEA-CRP project F41034 to further investigate these aspects. Plans for the compilation and evaluation of measured NLDs using the fusion evaporation reaction will also be outlined.

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