Level densities and gamma-ray strength functions in Sm isotopes

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The Oslo group has developed a technique\(^1,2\) to measure with high precision the level density from the ground state up to the neutron binding energy. The method provides simultaneously the level density and gamma-ray strength function in one and the same experiment. After establishing the level density as a function of excitation energy, the entropy is known by \(S(E) = k_B \ln \rho(E)\) and we can explore various thermodynamical parameters of the nucleus. The caloric curve \(T(E)\), derived within the framework of the micro-canonical ensemble, shows structures, which we associate with the break up of nucleon pairs. The nuclear heat capacity is deduced within the framework of the canonical ensemble and exhibits an S-shape as function of temperature, indicating a pairing transition.

Important applications of nuclear level densities are the determination of nuclear cross sections from Hauser-Feshbach type calculations. These cross sections are used as input parameters in large network calculations of stellar evolution, and in the simulation of accelerator-driven transmutation of nuclear waste. Unfortunately, the predictions of such calculations suffer from the lack of experimentally determined level densities. To day our knowledge is mainly based on the counting of discrete levels in the vicinity of the ground state and neutron resonance spacings at 6-8 MeV of excitation energy.

I will discuss the evolution of the level density and radiative strength function as one moves from the well deformed \(^{161,162}\)Dy, \(^{166,167}\)Er and \(^{171,172}\)Yb nuclei to the close to spherical \(^{148}\)Sm and \(^{149}\)Sm nuclei\(^3\). A pygmy resonance at around 3 MeV has been observed in several deformed rare earth nuclei and vanishes for the spherical nuclei. This is as expected for a scissors mode (M1 multipolarity) pygmy resonance. Results from Oslo combined with a thermal neutron capture experiment analysing two-step cascades finally establish the M1 multipolarity of this pygmy resonance\(^4\). Preliminary result for \(^{143,144,145,147}\)Sm will also be shown and a discussion of what happens to the level density and the radiative strength function of samarium isotopes as one approaches and crosses the N=82 closed shell. This work was supported by the Norwegian Research Council.

Figure 1: The level density is clearly lower for the spherical Sm isotopes as compared to the deformed Dy, Er and Yb isotopes.