Cumulative nuclear level density within a micro-macroscopic approach

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Many nuclear properties can be described in terms of the statistical level density. We have derived the nuclear level density in the micro-macroscopic approximation (MMA) beyond the saddle-point method (SPM), obtaining $\rho \propto I_\nu(S)/S^\nu$, where $I_\nu(S)$ is the modified Bessel function of the entropy S of order $\nu = (n+1)/2$, where n is the number of integrals of motion, taken n=3 in our case. This level density goes to the well-known *SPM* grand-canonical ensemble limit $\rho \propto \exp(S)$ for large entropy *S,* and to the finite micro-canonical limit at low excitation energy.

The MMA expressions for the one-parametric cumulative level density, $N = \int d\,W'\rho(W')$, where the integral is taken from 0 to the excitation energy W, provides a good fit, using a standard mean-least-square (MLS) code, to the experimental two-neutron-transfer reaction data for *N(W)* values shown (see the left panels of the Fig. 1) for different angular momenta $I^\pi = 0^+$, 2^+ and 4^+. The $N(W)$ is used for the unfolding procedure by transferring the spectrum W_i to the uniform states $w_i = \widetilde{N}(W_i)$,

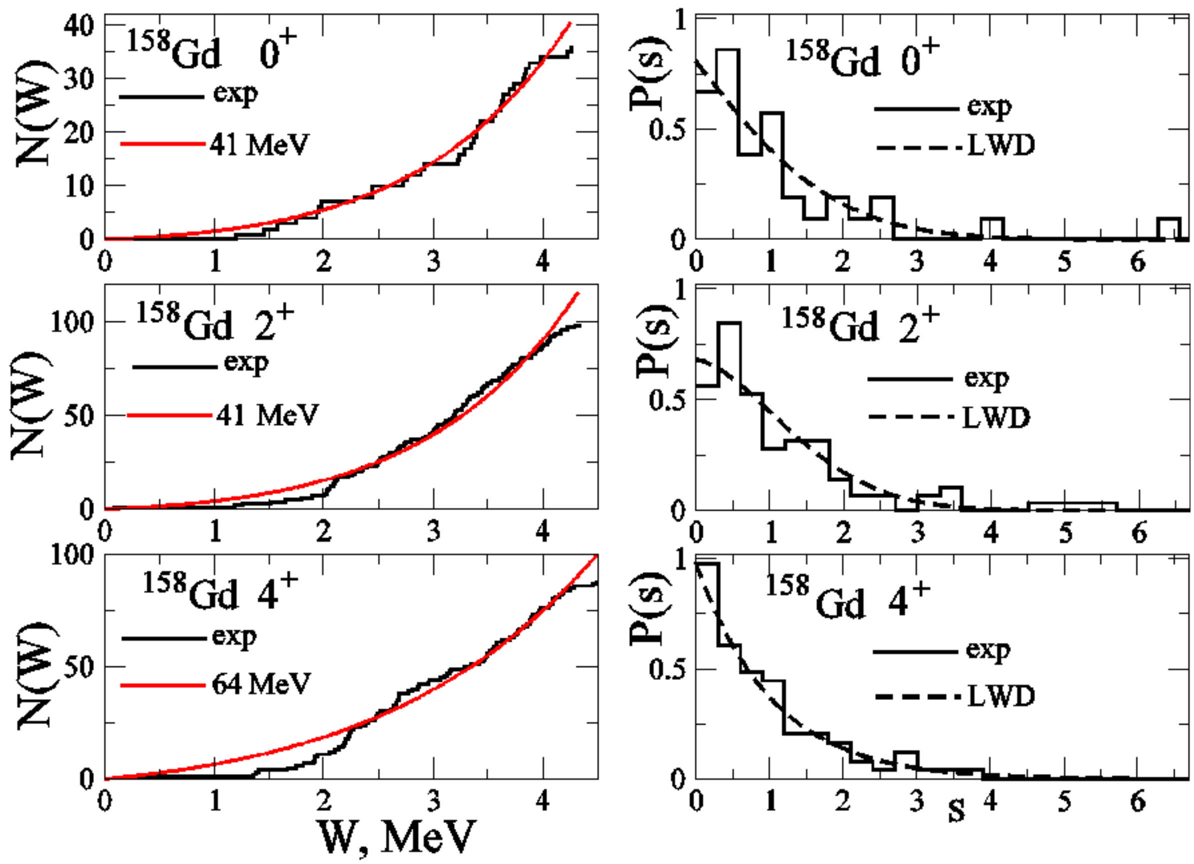

Fig. 1. Cumulative energy level density N(W) as function of the excitation energy W (left panels) and the nearest neighbor spacing distribution P(s) as a function of energy spacing s (right panels) for state with different angular momentum, 0^+, 2^+ and 4^+ in ^{158}Gd.

where the tilde means averaging over states i, and determining $s_i = w_{i+1} - w_i$. Using this result in the statistical analysis of the collective excitation states i in terms of the nearest neighbor spacing distribution (NNSD) $P(s)$ we obtained the experimental NNSD (see the right panels of the Fig. 1). From a good MLS fit to our one-parameter theoretical linear-repulsion-density NNSD within the Wigner-Dyson (LWD) theory for ^{158}Gd, as example, we finds the parameters of contributions of the Wigner chaos and Poisson order distributions for different angular momenta I^+. As seen from Fig. 1, with increasing I^+, there is an anomaly behavior of the NNSD $P(s)$ as a shift from the Poisson order with a sharp peak at zero spacing s to the side of the Wigner chaos distribution with the maximum at $s > 0$ for the angular momentum 2^+ and, then, again for 4^+ to the Poisson order, in contrast of a monotonical I^+ dependence found for the collective states in actinide nuclei. For perspectives, the moment of inertia for the collective rotational bands and K-symmetry breaking phenomenon is a challenge for study.

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