Signatures of nuclear phase transitions at finite excitation energies*

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The mean-field approximation predicts pairing and shape phase transitions in nuclei as a function of temperature or excitation energy. However, in the finite nucleus the singularities of these phase transitions are smoothed out by quantal and thermal fluctuations. An interesting question is whether signatures of these transitions survive despite the large fluctuations.

The shell model Monte Carlo (SMMC) approach provides a powerful method for calculating microscopically the statistical properties of nuclei at finite excitation energy beyond the mean-field approximation. This method has been implemented successfully in heavy nuclei [1, 2] using model spaces that are many orders of magnitude larger than spaces that can be treated with conventional diagonalization methods.

We have used the SMMC approach to study the crossover from vibrational (spherical) to rotational (deformed) nuclei in families of samarium and neodymium isotopes in a model space of dimension $\sim 10^{29}$ [3]. Such a crossover can be identified in the temperature dependence of $\langle \mathbf{J}^2 \rangle$ (where $\mathbf{J}$ is the total angular momentum). The latter is found to be in good agreement with experimental results.

We have calculated in the above families of rare-earth nuclei the collective enhancement factors of level densities versus excitation energy. We find that the decay of the vibrational and rotational enhancement factors is well correlated with the pairing and shape phase transitions, respectively.

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