Level densities in the shell model Monte Carlo approach: recent developments

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The shell model Monte Carlo (SMMC) approach provides a powerful technique for the microscopic calculation of level densities in model spaces that are many orders of magnitude larger than those that can be treated by conventional methods.

We discuss a number of recent major developments:

(i) *Heavy nuclei.* The SMMC approach was extended to heavy nuclei [1,2]. We have studied the crossover between vibrational and rotational collectivity in families of samarium and neodymium isotopes in model spaces of dimension $\sim 10^{29}$ [3]. We find good agreement with experimental results for both state densities and thermal observables that are sensitive to the type of collectivity.

(ii) *Collective enhancement factors.* We have calculated *microscopically* the vibrational and rotational enhancement factors of level densities versus excitation energy [3]. We find that the decay of these enhancement factors in heavy nuclei is correlated with the pairing and shape phase transitions.

(iii) *Odd-even and odd-odd nuclei.* The projection on an odd number of particles leads to a sign problem in SMMC (even for a good sign interaction). We discuss a novel method to calculate state densities in odd-even and odd-odd nuclei despite the sign problem and present first results for rare-earth nuclei [4].

(iv) *State densities versus level densities.* The SMMC approach has been used extensively to calculate *state* densities. However, experiments often measure *level* densities (where levels are counted without including their spin degeneracies.) A spin projection method [5] enables us to also calculate *level* densities in SMMC. We have calculated the SMMC *level* density of ^{162}Dy and found it to agree well with experiments [6].

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