Variational approach to exotic nuclear decays

Alexandrina Petrovici 1,2
1National Institute for Physics and Nuclear Engineering, R-077125 Bucharest, Romania
2Institut für Theoretische Physik, Universität Tübingen, D-72076 Tübingen, Germany

A self-consistent formalism for exotic decays of medium mass nuclei around the N=Z line based on the VAMPIR variational approaches will be presented. The properties of proton-rich nuclei in the A = 60-90 mass region are important to understand the rapid proton capture (rp) process, because their weak decay determines details of nucleosynthesis. Relevant for the Gamow-Teller beta decay of the waiting point nuclei could be the strength distributions for the low-lying excited states whose thermal population may result in a significant reduction of the effective lifetime at the high temperatures of X-ray bursts. Self-consistent microscopic approaches capable of describing the properties of the experimentally accessible nuclei are needed to predict the characteristics of nuclei beyond the experimental reach.

Apart from displaying interesting nuclear structure effects, the superallowed 0^+ → 0^+ Fermi β decays between 0^+ T=1 analog states of A≈80 nuclei provide tests of the validity of the conserved-vector-current hypothesis and the unitarity of the Cabibbo-Kobayashi-Maskawa matrix.

The description of the Gamow-Teller strength distributions for the beta decay of nuclei close to the proton-drip line, as well as the calculation of the effects of the isospin-symmetry breaking on the superallowed Fermi β decay of analogs meets the difficulty of treating self-consistently the shape coexistence and mixing that dominate the structure of both even-even and odd-odd involved nuclei. For the nuclei close to the N=Z line the problem is even more complicated by the competition between the neutron-proton and like-nucleon pairing correlations expected to influence the behaviour of these nuclei significantly.

We shall present a self-consistent calculation of the Gamow-Teller beta decay half-life of some waiting point nuclei on the rp-process path in the X-ray bursts environment. Results on the analog as well as nonanalog decays and the effects of the isospin-symmetry breaking on the superallowed Fermi beta decay of A-82 analogs within an improved formalism will be presented.

*We acknowledge the support from NASR (Romania) and DFG (Germany).