Nuclear Low-lying Spectrum and Quantum Phase Transition

Z. P. Li[1,2,3]
[1]School of Physical Science and Technology,
Southwest University, Chongqing 400715, China
[2]State Key Laboratory of Nuclear Physics and Technology,
School of Physics, Peking University, Beijing 100871, China and
[3]Physics Department, Faculty of Science, University of Zagreb, Croatia

The nuclear spectroscopic properties of low-lying states are important physics quantities that reveal rich structure information of atomic nuclei, including the nuclear quantum phase transition, evolution of the shell structure, isomeric states, shape coexistence, and so on. In particular, the nuclear quantum phase transition, characterized by the abrupt evolution between different ground-state shapes, is governed by the interactions of the valance nucleons. In recent years, it becomes to be one of the frontier areas of research in nuclear physics.

The Covariant Energy Density Functional (CDF) theory has achieved great success in the description of nuclear structure over almost the whole nuclide chart, In general, the framework based on the static nuclear mean field approximation can only describe ground-state properties. Excitation spectra and electromagnetic transition probabilities can only be calculated by including correlations beyond the static mean field through the restoration of broken symmetries and configuration mixing of symmetry-breaking product states. One effective approach is to construct a collective Bohr Hamiltonian with deformation dependent parameters determined from microscopic self-consistent mean-field calculations.

The developed model has been applied to the systematic investigation of the first order phase transition between spherical and prolate shapes in the $N \sim 90$ rare earth region and the second order phase transition between spherical and γ-soft shapes in Ba and Xe isotopes. It has reproduced not only the general features of nuclear quantum phase transitions, but also the singular critical-point symmetry and discontinuities of the order parameters.

[1] F. Iachello, Phys. Rev. Lett. **85**, 2580 (2000).
[2] F. Iachello, Phys. Rev. Lett. **87**, 052502 (2001).
[3] T. Nikšić, Z. P. Li, D. Vretenar, L. Próchniak, J. Meng, and P. Ring, Phys. Rev. C 79, 034303 (2009).
[4] Z. P. Li, T. Nikšić, D. Vretenar, J. Meng, G. A. Lalazissis, and P. Ring, Phys. Rev. C 79, 054301 (2009).
[5] Z. P. Li, T. Nikšić, D. Vretenar, and J. Meng, Phys. Rev. C 80, 061301(R) (2009).
[6] Z. P. Li, T. Nikšić, D. Vretenar, and J. Meng, Phys. Rev. C 81, 034316 (2010).

Collaborators: G. A. Lalazissis, J. Meng, T. Nikšić, L. Próchniak, P. Ring, and D. Vretenar.