Project Title:

Properties of finite systems including nuclei at high temperature and angular momentum (Properties of highly excited nuclei)

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(1) Quantum Hadron Physics

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1) The depletion of the nuclear density at its center, called the nuclear bubble, is studied within the Skyrme Hartree-Fock mean field consistently incorporating the superfluid pairing. The latter is obtained within the finite-temperature BCS theory and within the approach using the exact pairing. The numerical calculations are carried out for ^{22}O and ^{34}Si nuclei, whose bubble structures, caused by a very low occupancy of the $2s_{1/2}$ level, were previously predicted at T = 0. Among 24 Skyrme interactions under consideration, the MSk3 is the only one which reproduces the experimentally measured occupancy of the $2s_{1/2}$ proton level as well as the binding energy, and consequently produces the most pronounced bubble structure in ^{34}Si. As compared to the approaches employing the same BSk14 interaction, our approach with exact pairing predicts a pairing effect which is stronger in ^{22}O and weaker in ^{34}Si. The increase in temperature depletes the bubble structure and completely washes it out when the temperature reaches a critical value, at which the factor measuring the depletion of the nucleon density vanishes.

2) An exclusive systematic study of the giant dipole resonance (GDR) parameters has been performed in very light mass nucleus 31P in the temperature range of ~ 0.8–2.1 MeV and average angular momentum of ~11–16ħ. The high-energy γ rays from the decay of the GDR, evaporated neutrons and γ-ray multiplicities have been measured. The angular distribution of high-energy γ rays has also been measured at E_{beam} = 42 MeV. The GDR parameters, nuclear level density parameter and nuclear temperature were precisely determined by simultaneous statistical model analysis of high-energy γ ray and evaporated neutron spectra. It is observed that the measured width remains roughly constant up to a temperature of ~ 1.6 MeV. Moreover, the thermal pairing plays no role in describing the GDR width in this open-shell light nucleus at the above-mentioned temperatures and angular momenta. The present measurements provide an excellent platform to extend the applicability of the existing theoretical models down to the very light mass nuclei.

3) A fully self-consistent renormalized random-phase approximation is constructed based on the self-consistent Hartree-Fock mean field plus exact pairing solutions (EP). This approach exactly conserves the particle number and restores the energies-weighted sum rule, which is violated in the conventional renormalized particle-hole random-phase approximation for a given multipolarity. The calculations are carried out for several light, medium, and heavy-mass nuclei, such as ^{22}O, ^{60}Ni, and ^{90}Zr nuclei with MSk3 interaction. To study the study the pygmy dipole resonance (PDR),

^{12,14,22}C and ^{24,28}O are also employed. The results show that the inclusion of ground-state correlations beyond the RPA by means of the occupation numbers obtained in EP affects the RPA solutions within the whole mass range, although this effect decreases with increasing the mass number. The anti-pairing effect is also observed, including a significant reduction of pairing in neutron-rich nuclei. The enhancement of PDR is found in most of neutron-rich nuclei under consideration within our method.

4) With Prof. N. Quang Hung and Prof. L.G. Moretto, we have finished an invited review entitled “Pairing in excited nuclei” and submitted to Reports on Progress in Physics.

Future plan: We are planning to

I. complete and submit the paper on renormalized RPA using exact pairing (EP);
II. develop an approach based on the HF+EP+RPA to calculate the nuclear level density without the need of using the collective enhancement factors;
III. carrying out the theoretical calculations to support the experimental study of the Jacobi transition in nuclei.

Usage Report for Fiscal Year 2018

Fiscal Year 2018 List of Publications Resulting from the Use of the supercomputer

[Paper accepted by a journal]

1) Debasish Mondal, Deepak Pandit, S. Mukhopadhyay, Surajit Pal, Srijit Bhattacharya, A. De, N. Dinh Dang, N. Quang Hung, Soumik Bhattacharya, S. Bhattacharya, Balaram Dey, Pratap Roy, K. Banerjee, S.R. Banerjee, Study of giant dipole resonance in hot rotating light mass nucleus 31-P, Phys. Lett. B 784 (2018) 423.

2) L. Tan Phuc, N. Quang Hung, and N. Dinh Dang,
Bubble nuclei within the self-conistent Hartree-Fock mean field plus pairing approach
Phys. Rev. C 97 (2018) 024311.

3) Balaram Dey, N. Quang Hung, Deepak Pandit, Srijit Bhattacharya, N. Dinh Dang,
L.T. Quynh Huong, Debasish Mondal, S. Mukhopadhyay, Surajit Pal, A. De, S.R. Banerjee,
S-shaped heat capacity in an odd-odd deformed nucleus,
Phys. Lett. B 789 (2019) 634.

Accepted:
4) N. Quang Hung, N. Dinh Dang, L.G. Moretto, Pairing in excited nuclei, invited review, submitted to Reports on Progress in Physics.

[Conference Proceedings]

5) N. Dinh Dang, N. Quang Hung, and L.T. Quynh Huong, Role of exact pairing in the description of nuclear level density and radiative strength function, IOP Conf. Series: J. Phys.: Conf. Series 966 (2018) 012054.

[Oral presentation]

1) N. Dinh Dang, Pairing in excited nuclei, oral presentation at 6th International Conference on Collective Motion in Nuclei under Extreme Conditions (COMEX6), October 28 - November 2, 2018 , Cape Town, South Africa

2) N. Dinh Dang, Pairing in excited nuclei, invited talk at International Conference on Simplicity, Symmetry and Beauty of Atomic Nuclei, September 25 - 29, 2018 , Shanghai, China

[Others (Book, Press release, etc.)]

With Dr. Tetsuo Hatsuda, and Prof. Nguyen Quang Hung, organizing the 2nd International Workshop on Quantum Many-Body Problems in Particle, Nuclear, and Atomic Physics", which will be held in Nha Trang (Vietnam) on March 7 - 11, 2019.