Project Title:

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

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1) Extension of the phonon damping model (PDM) to non-zero angular momentum:

The PDM is extended to include the effect of angular momentum at finite temperature. The formalism is based on the description of the noncollective (single-particle) rotation of spherical systems.
This implies that the total angular momentum J can be aligned along the z axis, and therefore it is completely determined by its projection M on this axis alone.
The numerical calculations were carried out for two spherical nuclei ^{88}Mo and ^{106}Sn. The analysis of the numerical results shows that the GDR width increases with M at a given value of T for T ≤ 3 MeV. At higher T, the GDR width approaches a saturation at M ≥ 60ħ for ^{88}Mo and M≥80ħ for ^{106}Sn. However, the region of M ≥ 60ħ goes beyond the maximum value of M up to which the specific shear viscosity η/s has values not smaller than the KSS lower-bound conjecture for this quantity. This maximum value of M is found to be equal to 46ħ and 55ħ for ^{88}Mo and ^{106}Sn, respectively, if the value $\eta(0) = 0.6 \times 10^{-23}$ MeV s fm^{-3} for the shear viscosity at T = 0 is used.
A check by using the KSS lower-bound conjecture for the specific shear viscosity and the same η(0) also shows that the experimental data for the GDR line shape in ^{88}Mo at the the initial temperature T ≈ 4 MeV and J = 44ħ of the compound nucleus leads to a violation of the KSS conjecture. This calls for the need of reanalyzing the recent experimental data for the GDR in ^{88}Mo at these large values of temperature and angular momentum.

2) Description of the width of giant dipole resonance (GDR) in ^{201}Tl measured at low temperature:

We calculated the width and strength function of the GDR in ^{201}Tl at finite temperature within the framework of the quasiparticle representation of the PDM. Thermal pairing is taken into account by using the exact treatment of pairing within the canonical ensemble. This treatment allows us to calculate the exact equivalences to the pairing gaps for protons and neutrons in a nucleus neighboring a proton closed-shell one. Because of thermal fluctuations owing to the finiteness of the system, which are inherent in the canonical ensemble (CE), the exact CE thermal pairing gaps do not collapse at the critical temperature T_c of the superfluid-normal phase transition as in the case of infinite systems, but decrease monotonically as T increases and remain finite up to T as high as 5 MeV. The good agreement between the PDM predictions including thermal pairing and the recent experimental data is a clear demonstration of the manifestation of the effect owing to thermal pairing, which plays a vital role in reducing the GDR width at low T in open-shell nuclei. Under the influence of thermal pairing, the GDR width in ^{201}Tl becomes as low as around 3.7 MeV at T = 0.8 MeV, and the width Γ(0)$ of the GDR built on the ground state (T = 0) can be as small as 3 MeV, which is smaller than the GDR width in ^{208}Pb (4 MeV) at T = 0. The results obtained in the present work as well as the previous predictions for the GDR width in ^{120}Sn, where the important role of neutron thermal pairing has been shown to reduce the GDR width at T ≤ 1

MeV, confirm that, in order to have an adequate description of GDR damping at low T, a microscopic model needs to take into account thermal pairing at least up to T ≃ 1.5 MeV.

3) Specific shear viscosity in hot rotating systems of paired fermions:

The Green-Kubo relation is used to calculate the specific shear viscosity from the retarded Green's function that describes the propagation of quasiparticles within the quasiparticle mean field of a classically rotating system of nucleons that interact via a monopole interaction. Thermal fluctuations are included within the improved version of the finite-temperature BCS (called the FTBCS1), whereas coupling to monopole pair vibrations is taken into account within the self-consistent quasiparticle random-phase approximation (SCQRPA). The general feature of the specific viscosity η/s of this system can be summarized as follows. At a given temperature T, η/s increases with the angular momentum M, that is a rotating system of paired fermions is more viscous. In medium and heavy systems, η/s decreases with increasing T at T ≥ 2 MeV and this feature is not affected much by angular momentum. However, in light systems, it increases with T at the values of angular momentum M close to M_{max}, which is defined as the limiting angular momentum for each system. At T< 2 MeV, local minima and/or local maximum appear because of the significant change in the curvature of the temperature dependence of the thermal pairing gap. Thermal fluctuations and coupling to the quasiparticle pair vibrations within the SCQRPA significantly increases η/s for small N systems with N ≤ 10, whereas η/s decreases for large N>10 systems. All the results of η/s obtained within the schematic model as well as realistic nuclei are always larger than the universal lower bound of the specific shear viscosity up to T=5 MeV.

RICC Usage Report for Fiscal Year 2012

Fiscal Year 2012 List of Publications Resulting from the Use of RICC

[Publication]

1. N. Dinh Dang, Damping of giant dipole resonance in hot rotating nuclei, Phys. Rev. C 85 (2012) 064323.

2. N. Dinh Dang and N. Quang Hung, Giant dipole resonance in ^{201}Tl at low temperature, Phys. Rev. C 86 (2012) 044333.

3. N. Quang Hung and N. Dinh Dang, Specific shear viscosity in hot rotating systems of paired fermions, Phys. Rev. C 86 (2012) 024302.

4. N. Dinh Dang, Viscosity of hot nuclei, J. Phys.: Conference Series 366 (2012) 012035.

[Oral presentation at an international symposium]

N. Dinh Dang

Damping of giant dipole resonance in highly excited nuclei (Power Point presentation, 9 MB), invited talk at 47th Zakopane Conference on Nuclear Physics, August 27 - September 2, 2012, Zakopane, Poland