The rotational mode caused by the pair condensation in nuclei

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Spin-zero pairing correlation in finite produces a systematic difference between the ground-state energies of even-mass nuclei and those of odd-mass nuclei. We customarily use the odd-even mass staggering when discussing pairing correlation, but it is difficult to precisely calculate the energy of the odd-mass ground state, especially in the nuclear density functional theory (DFT). Another physical observable that avoids this problem, the moment of inertia of pairing rotation, has been suggested as a pairing indicator [1,2]. The pair-(boson) condensed state that is caused by the pairing correlation in the nucleus breaks the number-gauge symmetry and the shape of the potential changes (see left figure). Thus the pair-condensed nucleus has a specific direction in the number-gauge space. It can be viewed as a "deformation" of the nuclear wave function and rotates in the number-gauge space to restore the broken symmetry. Therefore the nucleus gets a pairing rotational energy and inertia which are obtained from the analogy of spatial rotation. Experimental data and nuclear DFT calculations in open-shell nuclei support the interpretation of binding energy systematics in terms of the pairing rotational bands [1].

In this presentation, we focus on revealing the fundamental properties of the pairing inertia. We adopt a pairing Hamiltonian and calculate the neutron pairing rotational bands and their moments of inertia within the BCS approximation and its extension for Ni, Sn, and Pb isotopes. We found that the pairing inertia increases with an increase in particle number as a general trend, and this trend is affected by the level density, subshell gap, and intruder orbits. Another important finding is that the pairing inertia decreases when increasing the deformation in gauge space (i.e., the order parameter of the pair condensation, see right figure) [3]. This relation between the moments of inertia and deformation in pairing rotation contradicts that in spatial rotation. We will discuss the similarities and differences in the spatial and pairing rotation. In addition, we will also show the results of the coupling of the pair-rotational and pair-vibrational modes to more accurately describe large amplitude paired nucleon dynamics.

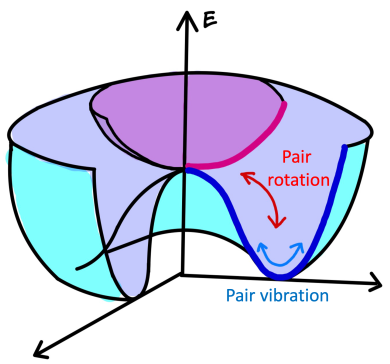

FIG. 1: Image of the pair-rotation and the pair-vibration occurring within the symmetry breaking

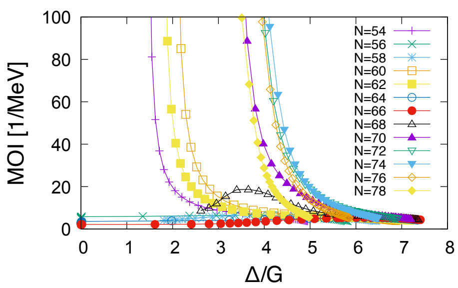

FIG. 2: The order parameter dependence of the pairing moments of inertia with Sn isotope

[1] N. Hinohara and W. Nazarewicz, Phys. Rev. Lett. **116**, 152502 (2016).
[2] N. Hinohara, J. Phys. G: Nucl. Part. Phys. **45**, 024004 (2018).
[3] C. Ruike, K. Wen, N. Hinohara, T. Nakatsukasa, arXiv:2405.04809.