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Collective Hamiltonian for chiral modes

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Since the occurrence of chirality was originally suggested in 1997 by Frauendorf and Meng [1] and the corresponding experimental signals, chiral doublet bands, were observed in 2001 [2], the study of chiral symmetry in atomic nuclei has become one of the intriguing topics in nuclear physics. More than thirty candidate chiral doublet bands have been reported in the A˜80, A˜100, A˜130, and A˜190 mass regions, see e.g. Refs. [3-5]. Theoretically, chiral doublet bands have been extensively studied in terms of tilted axis cranking (TAC) [6-8] approach and particle rotor model (PRM) [9-11]. However, it is imperative to search a unified microscopic method for studying both chiral rotation and vibration.

Recently, we develop a collective model to describe the chiral rotation and vibration and apply this model to investigate a system with one h11/2 proton particle and one h11/2 neutron hole coupled to a triaxial rigid rotor [12]. In this framework, it goes beyond the mean-field approximation, includes the quantum fluctuation in the chiral degree of freedom, and restores the chiral symmetry. The collective Hamiltonian is constructed from the potential energy and mass parameter obtained in the TAC approach. By diagonalizing the collective Hamiltonian with a box boundary condition, it is found that for the chiral rotation, the partner states become more degenerate with the increase of the cranking frequency, and for the chiral vibrations, their important roles for the collective excitation are revealed at the beginning of the chiral rotation region. Furthermore, the collective Hamiltonian reasonably reproduces the exact results calculated by PRM. The success of the collective Hamiltonian here guarantees its application for realistic TAC calculations.

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