MICROSCOPIC STUDY OF NUCLEAR QUADRUPOLE COLLCTIVE MOTIONS IN TERMS OF THE BOSON EXPANSION THEORY

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In studying dynamical aspects of a many-body system, one may first introduce fundamental modes of motion such as independent particle motions in an average field, collective vibrations about an equilibrium, and collective rotations of the system if the equilibrium configuration is anisotropic. In a nuclear system, however, couplings between them are often quite strong and they can even affect the fundamental modes themselves. Therefore, the construction of fundamental modes and the study of the coupling between them have been important subjects for microscopic theories of nuclear collective motions.

Among various types of nuclear collective motions, due to the characteristic nuclear shell structure, the quadrupole mode is most prominent and collective. Thus the microscopic description of anharmonicities in nuclear quadrupole collective motions becomes one of the essential topics in the field of nuclear structure theory. The anharmonicities can be caused by two factors in general terms. The vibrational quanta actually are made out of nucleon degrees of freedom, and therefore a simple superposition must be modified accordingly to the Pauli principle. Furthermore, there are residual interactions which are not taken into account when the normal modes are constructed, and they can produce interactions between the quanta.

Microscopic theories for nuclear collective motions become possible soon after both the BCS theory in the finite nuclear system and the random phase approximation (RPA) as a many-body system became available. The boson expansion theory (BET) emerged in 1960s as a microscopic method for the description of anharmonic vibrational motions [1,2]. The BET allows one to take into account higher-order terms neglected in the RPA, and the adiabatic condition for particle motions can be avoided.

To be useful for practical purposes, a linked-cluster expansion of the modified Marumori boson mapping [3] has been formulated by Kishimoto and Tamura [4]. In the formalism, the bosonized operators are allowed to be used in the ideal boson space. It is a promising method for the microscopic description of anharmonicities in nuclear quadrupole collective motions, if the couplings to non-collective states are faithfully included in the calculation. The BET, developed so far along the line of Kishimoto-Tamura, has been applied to study low-lying collective state of nuclei in various mass regions.

Recently, in Ref. [5], level structures and electromagnetic properties of low-lying collective states in ^{128}Ba were investigated by means of the BET with self-consistent effective interactions, where structures of collective wave functions were illustrated in some detail and the natures of the 0_2^+ and 0_3^+ state were discussed. In this work, recent results of further applications of the BET to the low-lying quadrupole collective states in various transitional nuclei will be presented and discussed.

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