Coupling of nuclear quadrupole and octupole degrees of freedom in an angular momentum dependent potential of two deformation variables

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Abstract

We propose a collective Hamiltonian for the rotation–vibration motion of nuclei in which the axial quadrupole and octupole degrees of freedom are coupled through the centrifugal interaction. The potential of the system depends on the two deformation variables β_2 and β_3. Its shape shows the contributions of both degrees of freedom which determine the softness of the system with respect to the quadrupole and octupole oscillations. The contribution of the octupole deformation is considered to be smaller compared to that of the quadrupole deformation. In the limit of a frozen β_2 the system oscillates between positive and negative octupole deformations by tunnelling through the barrier of the double-well potential in β_3. When β_2 is let to vary, the system oscillates between the positive and negative β_3-values by rounding the barrier in the $(\beta_2, \beta_3)-$ plane, instead of tunnelling. The effects of "rounding" in the two-dimensional space and the tunnelling in the one dimensional space are the respective physical manifestations of the octupole degrees of freedom in dependence on the quadrupole deformation properties of the system. We examine the consequence of the "rounding" in the cases when i) the potential possesses fixed β_2 and β_3 minima, and ii) the minima increase with the angular momentum. In the first case the spectrum of the system is characterized by a constant parity shift effect, while in the second one, the parity shift decreases with the increase of the angular momentum. This result demonstrates the evolution of quadrupole–octupole shapes in nuclear regions where octupole vibrations and octupole deformations are observed.