TRIUMF Advanced Rare Isotope Laboratory (ARIEL)

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The Refined Bohr-Mottelson Model for the Description of Collective Motion in Atomic Nuclei

The development of ARIEL and other new facilities which expand experimental capabilities to study atomic nuclei triggers the need to advance theories of nuclear structure and reactions. A strong theoretical framework addressing nuclear properties from first-principles is necessary to direct exploration, formulate informative experiments, and interpret the data that ARIEL will grant access to.

A nuclear system consisting of A nucleons is described in terms of $3A$ independent coordinates. Three coordinates are used in the transformation to the centre of mass frame, three Euler angles are used to set the nucleus in the body-fixed frame, and three variables ρ, β, and γ define the size, orientation, and shape of the nuclear inertial ellipsoid. The remaining $3A-9$ coordinates are generalized Euler angles characterizing the internal nucleon motion. A microscopic derivation of the kinetic energy of a nucleus is carried out from first principles resulting in expressions of the kinetic energy contributions from vibrations, rotations, intrinsic motion, and the Coriolis coupling (see also [1]). The derived rotational energy operator depends on the hydrodynamic moments of inertia and the angular momentum operators along the body-fixed axes, which arise naturally from the derivation procedure.

Additionally, the Refined Bohr-Mottelson (RBM) model is introduced, proposing an adjustment to the definition of the nuclear surface of the Bohr-Mottelson model. This redefinition takes into account the constant density of the incompressible nucleus and, by construction, conserves the volume of the nucleus with arbitrary deformation. The obtained collective Hamiltonian is a sum of the monopole and quadrupole Hamiltonians. For small deformations ($\beta \ll 1$) the latter coincides with the Bohr Hamiltonian. We established the relation of our refined deformation parameter β_r, which ensures constant nuclear volume at arbitrary deformation, with the conventional parameter β.

The derivations and results will be presented and discussed.

[1] A.Ya.Dzyublik, K.Starosta, Z.Yu, and T.Koike, Phys. Rev. C 110, 014325 (2024).

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