Problems with Derivations of Collective Hamiltonians*

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The Bohr idea of derivation of the nuclear collective Hamiltonian describing various kinds of nuclear collective motions consists of a few steps:

1. Choice of the appropriate colective variables in the laboratory frame.
2. Construction of required classical nuclear collective Hamiltonian.
3. Introducing a metric tensor in the collective manifold. Ususally, the metric tensor is chosen to be proportional to differential of the kinetic energy.
4. Transformation of the Hamiltonian and the metric tensor to an intrinsic frame.
5. Quantization of the classical collective Hamiltonian within the space of square integrable functions with the scalar product determined by the integral with the invariant volume element defined by square root of determinant of the metric tensor.

Following this recipe the choice of the intrinsic frame shouldn't have any influence on the physical content of the final classical Hamiltonian, though the transformation from the laboratory frame to chosen intrinsic frame is usually not unique. However, the quantization procedure is strongly dependent on the structure of chosen quantum state space. Different choices of intrinsic frames lead to the state spaces with different symmetrization groups – the physical state space consists of functions invariant in respect to the symmetrization group.

There is a question about uniqueness of quantum collective models which can be obtained in this way. In literature there is no discussion about this problem. In addition, it turnes out that even the Bohr collective Hamiltonian (five dimensional harmonic oscillator) do not fulfil the physical requirement to be invariant in respect to the octahedral group O which is, in this case, the symmetrization group of the collective quadrupole space. One needs to add that because of this fact there are two different possiblities of obtaining physical results from the unsymmetrized Bohr Hamiltonian. The first possibility is to project the Bohr Hamiltonian onto the space of O-symmetrized functions. The second one, which is, in fact the usual chosen procedure, is a selection of symmetrized states from the set of all solutions of unsymmetrized Bohr Hamiltonian. Both ways of solving the collective Hamiltonian are not equivalent.

The poster presents a preliminary discussion about these problems.

*POSTER presentation