Wigner Function Moments Method and RPA – Similarity and Difference

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The aim of this research is the systematic comparison of two methods to describe the collective motion: Wigner Function Moments (WFM) and RPA. The basis of both methods is the same: Time Dependent Hartree–Fock theory in its small amplitude approximation. Strictly speaking the small amplitude approximation is not compulsory in the WFM method – it allows one to study the large amplitude motion too [1]. So in this sense the WFM method is more general than the RPA.

As an example, their competition in the description of the nuclear scissors mode is considered. The full WFM analysis of this mode in the framework of a solvable model (harmonic oscillator with quadrupole-quadrupole residual interaction) is given in [2]. Formulae for excitation energies, magnetic and electric transition probabilities of the scissors mode, derived in the framework of WFM and RPA, turn out to be identical [3]. The closed analytical expressions for currents can be derived by the WFM method, whereas in RPA the currents can be constructed only numerically.

Instead of writing the equations of motion for microscopic amplitudes of particle hole excitations (RPA), one writes in WFM the dynamical equations for various multipole phase space moments of a nucleus: quadrupole and monopole moments, angular momentum, etc. This allows one to achieve a more direct physical interpretation of the studied phenomenon without going into its detailed microscopic structure. For example, it becomes obvious, that low lying M1 excitations must be interpreted as the scissors type motion [4].

References

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