Lublin, 4.12.2015

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"Hidden symmetries in nuclear models"

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(Summary of PhD thesis)

The purpose of this PhD thesis is to analyze the group structure of the symmetries which cannot be seen in a nuclear models in a direct way. The hidden symmetries are understood as symmetry groups which do not manifest explicitly in mathematical form of the Hamiltonian, but they have an influence on physical properties of the nuclear system. One can search such symmetries by transformation of the Hamiltonian to the so called intrinsic frame. Another way is a decomposition of the full Hamiltonian into a sum of orthogonal operators. Every element of this sum possess different symmetry group. This kind of decomposition is called partial symmetry decomposition.

The transformation from the laboratory frame to an intrinsic, rotating frame is the known procedure. My considerations are in fact general and allow for considering more general form of intrinsic frames. The analysis of a symmetry group of operators in the intrinsic frame, especially when the transformations from the laboratory frame to this intrinsic frame are not unique, has been an open question, so far. The partial symmetry decomposition is also a new idea. The motivation for working on this questions is lack of a method of searching and analyzing this kind of structure. As we expect existence of this structure can help in classification of energy spectra or can help to construct selection rules which complement the standard selection rules coming from the global symmetry of the quantum system. The main problem in my dissertation was to propose a systematic method of searching of hidden symmetry groups and to work out an influence of hidden symmetries on properties of the Hamiltonian and quantum transitions.

In the first chapter of his dissertation we discuss idea of intrinsic frame. In addition to review of the traditional definitions of intrinsic frames there is also new definition of intrinsic frame based on group theory. We describe also mathematical tools which are used for analysis of symmetry groups in intrinsic frame. There is also considered a fundamental property of transformation from laboratory to intrinsic frame: existence of so called symmetrization group. We describe the influence of the symmetrization group on symmetry group of intrinsic quantum states and intrinsic quantum observables. We also analyze the procedures of symmetrization of the intrinsic quantum operators.

The existence of symmetrization group have a great influence on symmetry structure of intrinsic Hamiltonian. Because of this fact it is important to consider an idea of "to be physical property". To solve this problem we had to formulate criteria of theoretical description in intrinsic frame which should guarantee the correct description in the laboratory frame - the other words to have true physical states in the intrinsic frame. The definition of "to be physical property" given in the chapter two leads us to procedure of separation the true physical symmetries from artificial symmetries which come from not unique transformations from the laboratory frame to the intrinsic frame. In this chapter we give also proof of equivalence of different intrinsic frames.

In chapter three we introduce the so called partial symmetries. We understand them as symmetry groups of some parts of the Hamiltonian which we call subhamiltonians. We also consider symmetries of the Hamiltonian in the space of parameters it depends on. The important result in this chapter is the method of partial symmetry decomposition of the full Hamiltonian which can be used as an algorithm in calculations. Searching of symmetry groups in an area of parameter space is a new idea.

The chapter four consists of two examples of realisation of theoretical analysis in practical calculations. The first example is a two dimensional model of collective Hamiltonian. The second example is a model of Hamiltonian which possess some partial symmetry structure. Both examples illustrate outcomes from previous chapters. In the chapter five we introduce the derivation of quantum multipole operators of electromagnetic transitions in space of collective variables by using the Generator Coordinate Method with the Gaussian Overlap Approximation. At the end of this dissertation one can find appendix which consists of descriptions of mathematical tools which are used in this work.

The main asset of the theoretical analysis described in this dissertation is its generality. The idea of intrinsic frame, analysis of symmetry in intrinsic frame or idea of partial symmetry can be used not only in nuclear models but also in case of every quantum system.

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