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**Report on the Habilitation thesis of Dr. František Knapp**

Theoretical description of nuclei, i.e. of the self-bound multi-nucleon systems, has to deal with two fundamental and related difficulties. The first one is the complexity of the nuclear interaction. It is, to some extent at least, resolved by using the chiral effective field theory that allows us to consistently derive an effective nucleon-nucleon interaction. The second fundamental difficulty is related to the dimensionality of the problem once more that few nucleon are involved. To solve the problem exactly means dealing with the number of states that grows like factorials, quickly exceeding the computational possibilities of even most advanced devices. However, it should be possible to describe accurately, at least the relatively low lying nuclear states, by appropriate choice of a restricted number of base states that can be handled with the present computers. The choice of such base states, without a loss of accuracy, is a formidable problem. The present thesis describes attempts to do just that.

The thesis represents (as it should) a coherent picture of results obtained in a number of papers by Dr. Knapp, published in reputable refereed journals. The most important ones are reprinted as appendices in the thesis. Most of these papers are well quoted, hence they have an appropriate impact. The quality of the work of Dr. Knapp must be judged by the quality of the published papers.

The thesis deals, as do the published papers, with two main topics. Chapter 1.3, representing the bulk of the thesis, describes the work on the Equation of motion phonon approach (EMPM) aiming at the description of the collective vibration-like states in spherical nuclei. Chapter 2 shows ways of truncation, without a loss of physical insight, of the shell model spaces making the numerical solutions easier or possible.

Low-lying nuclear spectra, in particular in magic or close to magic nuclei, are dominated by collective states. These states are characterized by the enhanced strength of certain operators, e.g. E1 for the dipole states or E2 for the quadrupole states. They also have some intuitive explanation, again e.g. quadrupole vibrations of the nuclear surface or vibration of neutrons again protons for the dipole states. There is a long tradition of theoretical approaches to describe such states in terms of the individual nucleon states. The EMPM approach is one of them. It has been developed and applied by Dr. Knapp and his collaborators in the original papers quoted in the thesis. They were able to derive a consistent approach to the problem, including issues like how to deal with the extra unphysical states or with the center of mass motion. The method has a number of nice features. It describes, at least to some degree, the anharmonicity of the phonons, the fragmentation of the giant dipole resonance, the features of the so-called "pygmy resonance", or the ground state correlations. However, as the authors are well aware, it is an approximation. There are some obvious issues that remain to be resolved. For example, while all two-phonon states can be consistently included, only some $n = 3$ states can be included. Is there a convergence? How important are the $n \geq 3$ states? Another problem is the dependence on the choice of the basis as shown in A2. I also would like to see a discussion of how the EMPM method deals with the corresponding sum rules. Also, the eternal problem whether and how the input nucleon-nucleon interaction should be modified when dealing with the incomplete set of states remains. Nevertheless and altogether, the development of the self-consistent EMPM approach is an important achievement. It is new, original, and clearly competitive with the other “beyond the TDA or RPA” approaches. It is an important step in the way to develop a solvable yet accurate description of nuclear collective states. The work described in the Chapter 1.3 of this thesis and in the corresponding publications obviously would be enough by itself to fulfill the requirements of a habilitation thesis.

Chapter 2 of the thesis is devoted to work of Dr. Knapp on the so-called importance truncation (IT) techniques for the nuclear shell model (NSM). The enormous dimensions are the main difficulty in applying the NSM to heavier nuclei. Yet the corresponding matrices that need to be diagonalized are rather sparse; many configurations do not play an important role to properties of low-lying states and thus could be skipped. Various ways of truncation have been proposed. Among them, the IT technique was developed by the Naples group before it was joined by Dr. Knapp. Therefore, unlike the EMPM method in Chapter 1.3, where Dr. Knapp participated from the beginning, here his contributions were on the improvement and applications of the method. Several well quoted papers on this topic have been published, some included with the thesis.

The procedure starts with a reference state $\Psi_{ref}$. The corresponding model space is small enough to be diagonalized. The other states are included or skipped if their relative energies (see eq. (2.1)) are smaller or larger than the input parameter $\kappa_{min}$. (By the way, there is a typo in the thesis just after (2.1). The criterion for acceptance should be $\kappa_\nu > \kappa_{min}$, not smaller as stated there.) By performing calculations for several values of the $\kappa_{min}$ one can see whether a convergence has been achieved. That is an attractive feature of the method. The application of the IT technique in nuclei near the magic neutron number $N = 82$ show that as far as the energies are concerned, only about 10% of the states are needed. However, for the transition probabilities the convergence is slower, and 30% of states need to be included.

Even though, at least in my judgement, the IT technique does not represent a major breakthrough in the application of the nuclear shell model, it allows to perform interesting calculations and reach better understanding of states in relatively heavy nuclei. As far as Dr.Knapp work on this topic is concerned, it shows the breath of his interest and a degree of versatility. A mature nuclear theorist should work on a variety of issues, some more fundamental, others perhaps less so.

From the text above it should be clear that I am positively impressed not just with the habilitation thesis but, more importantly, with total work of Dr. Knapp as represented by his numerous publications. I heartily recommend the positive outcome of his habilitation defense.

In conclusion, I was asked to comment on the Turnitin Analysis of the thesis. The analysis, as I expected, did not find any important signs of plagiarism. Altogether, for a habilitation thesis (or for PhD one for that matter) I do not see any usefulness of such analysis. I can, perhaps, understand if it is applied to a student essays or even a diploma, since these just test that a student studied and understood an existing material. But here the material should be in the publications, and be new and innovative. The Turnitin Analysis does not test any of those aspects. In my judgment it is a mistaken application of the ‘equality’ concept.

Sincerely

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