Nuclear Structure Calculations for Some Deformed Nuclei

THESIS

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Abstract

The nuclear pairing with all its types,including like- and unlike-particle pairing interactions,has a very important contribution to the nuclear binding energy. It is a fundamental quantity that enters all the nuclear structure calculations and low-energy nuclear structure properties strongly depend on the pairing interaction. Nuclear pairing affects significantly nuclear mass calculations, β-decay and double beta($\beta\beta$)-decay strength functions and other quantities. For these reasons, the present thesis is concerned withthe study of pairing interactionsin spherical and deformed nuclei using different models and different two-body residual interactions between nucleons.

In the first chapter we introduce description of the NN interaction between nucleons considering different types of realistic potentials such as Bonn-CD, Nijmegen I & II and Argonne V18. These potentials are classified as local and non-local potentials in the coordinate space. The definition and mathematical description of deformed nuclei is described using the deformedshell model (Nilsson model).

Chapter twointroduces the familiarBardeen-Cooper-Schrieffer (BCS)-model describing nucleonic pairing interaction. In this chapter we solve the BCS set of equations and calculate its different parameters such as pairing gap energies, pairing strengths, occupation probabilities and other quantities. A study of the effect of different types of realistic potentials on the BCS solutions is introduced. Like-particle pairing is only considered in this chapter.

In chapter three the proton-neutron pairing is includedin the normal BCS approach through the Bogoliubov-Valatin transformation and again we solve the new set of equations and study the effect of including the proton-neutron pairing on the calculations. Also in this chapter we compare theoccupation probabilities result from BCS approach with the experimental values. Calculations are performed using both realistic and schematic separable forces. It is the protons occupation probabilities of valence shells that are found to be far from fitting with experimental results. In addition, all types of pairing energy gaps are found to be dependent on the type of deformation, prolate or oblate, of the nucleus.

The second model used in the current thesis is the Lipkin-Nogami (LiNo) approach which is the topic of chapter four. In this chapter, a comparison is made between results of the two models,with the inclusion of proton-neutron pairing in each. It is found that the main difference between the two models is when one includes the proton-neutron pairing in the calculations.

In chapter five we calculate the two neutrino double beta decay matrix element through the Quasi-particle Random Phase Approximation(QRPA) formalism. The occupation probabilities and quasiparticle energies are calculated using the BCS and LiNo approaches with comparison between the two cases. The inclusion of proton-neutron pairing in the calculationsis found to affect significantly the calculated matrix elements. The calculations are performed for spherical and deformed nuclei, where we considered only the two-neutrino double-beta $(2\nu\beta\beta)$-decay of ${}^{76}_{32}\mathrm{Ge} \rightarrow {}^{76}_{34}\mathrm{Se}$.