The work has been carried out by the author in the following two main areas:

(1) The use of the Hartree-Fock (HF) theory in
   a) examining the pairing and deformation - producing parts of the effective two-body nuclear interaction and b) in carrying out structure calculations for some even-even nuclei in the upper p-f shell region.

(2) The development of a schematic model for studying the collective features of the low-lying states of even-even, even-odd as well as odd-odd nuclei.

An emphasis is usually placed on the pairing nature of the T=1 component of the effective interaction while at the same time considering the T=0 component to play an important role in producing deformation. Contrary to this, the author has shown that the T=1 component of the effective interaction in the 2p-1f shell has a multipole character almost similar to that of the T=0 component. It is pointed out that the single-particle energies and Pauli principle play a very significant role in determining the magnitude of the deformation that the two-body interaction can produce for a given nucleus.
Further, considering the instability of the Hartree-Fock state as a measure of the pairing tendency of an interaction, it has been shown that the $T=1$ interaction does not possess substantially more pairing tendency as compared to the $T=0$ interaction. It is seen that there is a large difference in both the structure and the stability of the HF states generated by the full $T=1$ interaction and by only the $J=0$ part of it. This clearly showed how misleading it is to regard only the $J=0$ matrix elements as representing the essential property of the $T=1$ interaction.

It has been suggested that the effective interactions in the 2p-1f shell should satisfy certain constraints imposed by the observed $\Delta E2$ systematics in the shell. An analysis of the various parts of the effective interaction as described in the preceding paragraph helps in knowing its deficiencies in the light of experimental information. The Hartree-Fock theory has been used in a novel way to extract information about the effective interaction and in making it satisfy the constraints that the observed trend of $\Delta E2$ systematics can impose. Based on this, certain simple modifications of the Kuo-Brown (KB) effective interaction have been suggested. The modified KB interaction yields only 18 per cent admixture of the two-particle two-hole core-excited configurations to the $(f_{7/2})^{16}$ core for the nucleus $\text{Ni}^{56}$. The $f_{7/2}$
sub-shell closure for Ni^{56} has thus been found to be quite good.

An interplay of the deformation and pairing, with respect to the HF state, has been studied for some even-even isotopes of the nuclei Germanium and Selenium in the self-consistent framework of the Hartree-Fock-Bogoliubov method. An important feature of the calculation has been the inclusion of the g_{9/2} orbital in the valence space in addition to the 2p-1f shell orbits. Contrary to the results obtained in some earlier calculations in which only the 2p-1f shell was taken as the valence space and which had led to spherical shapes for nuclei with neutron number 40, a large deformation has been found for these nuclei. Structural information about these nuclei such as the spectroscopic factors etc. has been obtained and compared with the experimental results.

The approximate description of the collective states of nuclei provided by the wave functions with definite angular momenta obtained by carrying out HF or HFB calculations is usually found to be quite good. However, the many-particle, multi-configurational wave functions resulting from HF or HFB projection procedure have a large number of components and appear quite complicated. A schematic model has been developed which helps very much in understanding the essential structure of these wave functions. The model also helps
in examining systematically the development of rotational and to some extent vibrational spectra in nuclei.

The simplicity of our schematic model makes it possible to carry out a comparative study of the "Variation After Projection (VAP)" and the "Projection After Variation (PAV)" approaches. A rather surprising result that emerged out of this study was that a well defined intrinsic state may exist which provides a good description of all the low-lying states of a nucleus but it may not be possible to determine such a state by a Hartree-Fock procedure.

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