CHAPTER VI

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In this thesis the nuclear structure and matter properties of $^{40}$Ca and $^{16}$O are investigated for various nuclear temperatures. For analyzing the structural properties under the extreme conditions of temperature and deformation the Fermi Dirac distribution function in the statistical theory along with the usual thermodynamic concepts is used. A new formalism incorporating the realistic bound state potentials and wave functions is suggested to have an insight in understanding the matter properties of these nuclei.

The basic input for the statistical theory to understand the structural properties is the single-particle level scheme chosen to reproduce the shell correction to ground state masses over a wide range of nuclei. The single-particle levels and the single-particle spins needed for our calculations are generated by diagonalizing the triaxially deformed Nilsson harmonic oscillator potential in the cylindrical representation. The occurrence of shape changes in these nuclei with spin and temperature is studied. The nuclear structural properties such as Fermi energy, nuclear level density, single-particle level density parameter, spin cutoff parameter, backbending effects, yrast traps etc., are extracted as functions of angular momentum, temperature and deformation. The Schrutinsky prescription is used for
obtaining the variation of shell correction with angular momentum for these nuclei.

The matter properties of $^{40}$Ca and $^{16}$O are studied using the new formalism suggested in this work. It involves the solution of the Schroedinger equation for the bound state energies and wave functions using a realistic description of the nuclear potential with the parameters in the Saxon-Woods form fitted to experimental elastic scattering data by Elton-Swift. The surface tension constant, the finite nuclear compressibility coefficient and the giant monopole resonance energy are obtained for these nuclei using the proposed formalism involving Hellmann-Feynman theorem. The effect of the leptodermous nature or the surface diffuseness of the nuclear potential on the above properties is studied. The dependence of these matter properties on temperature is also investigated.

The main results of this work are as follows:

Shape changes with temperature and angular momentum are found to occur for $^{40}$Ca and $^{16}$O. However these nuclei are found to be oblate at all temperatures and spins. These shape changes give rise to the phenomena of backbending and yrast traps. The shift in the yrast minima towards higher angular momenta with increase in entropy and excitation energy is observed for both $^{40}$Ca and $^{16}$O. The shell structure of the nuclei is found to have a dominant role on the structural properties of the nuclei.
The formalism suggested here for determining the nuclear matter properties is found to give results fairly in good agreement with the experimental observations. The diffuseness of the nuclear surface due to its thin skinned nature has the effect of reducing the nuclear compressibility coefficient to a considerable extent. The increase of temperature is also found to have a similar effect.

In conclusion the utility and versatility of the statistical theory in the investigation of the nuclear structural properties is highlighted in the present work. The applicability of the phenomenological nuclear potential form in understanding the matter properties is illustrated. The motivation for exploring many complex nuclear properties has been partially fulfilled in this work.