Present thesis is concerned with the calculation of nuclear matter optical potential, binding energy, incompressibility and the construction of nucleon-nucleus optical potential starting from realistic two-nucleon interaction in the lowest order Brueckner theory. Previous calculations have used four internucleon potentials, i.e. the Hamada-Johnston potential, the Reid potential, the Paris potential and the Urbana V14 potential. All these potentials are designed to reproduce the available, empirically determined, internucleon phase shifts for nucleon laboratory energies less than roughly 300 MeV. Additionally they reproduce the known deuteron binding energy. The Hamada-Johnston potential has a hard core at small internucleon separation while the remainder are strongly repulsive in this region but not infinitely so. The Hamada-Johnston and Reid potentials are now quite old potentials fitting essentially the same empirical phase shifts while the V14 and Paris potentials are the results from modern data and analyses. For this reason we have used Urbana V14 soft core potential throughout the present thesis and the results obtained using V14 potential are compared with those using the older Hamada-Johnston hard core potential.

In chapter I we give the general motivation of our work.
In chapter II we first describe in detail the calculational technique to obtain nuclear matter optical potential, nuclear matter binding energy and nuclear matter incompressibility in the first order Brueckner theory using Urbana V14 soft core and Hamada-Johnston (HJ) hard core interactions. We find that the lowest order Brueckner theory using Urbana V14 realistic interaction predicts a large saturation density and an overbinding of the infinite nuclear matter. Whereas HJ interaction predicts a saturation density quite close to the empirical one, however the predicted binding energy is too low as compared with the empirical value. Thus the saturation density is correct but the system is underbound. Our calculation using Urbana V14 interaction gives rise to nuclear matter binding energy and nuclear matter incompressibility which are in fair agreement with the results using variational approach using the same (V14) two-body interaction. This is quite satisfying and it strengthens our confidence in the calculational procedure.

Chapter III is concerned with the construction of nucleon-nucleus optical potential for finite nuclei from the effective t-matrices calculated in the lowest order Brueckner theory of infinite nuclear matter starting from realistic interaction following the folding procedure of Brieva and Rook. We do not use the approximate generalized reference spectrum method but solve the integral equation using matrix
inversion technique. In this chapter we first describe in detail the method of calculation of different components, direct central, exchange central, direct spin-orbit and exchange spin-orbit parts of the nucleon-nucleus optical potential. We also present a new formulation of obtaining the effective mass correction to the optical potential, which slightly differs from others. The new feature is not only the modification of the central imaginary part but also a feedback term in the real central part and a modification of the real spin-orbit and imaginary spin-orbit parts of the calculated optical potential. We have performed calculations for obtaining nucleon-nucleus optical potential using both, Urbana V14 soft core and HJ hard core realistic interactions. The results show that the calculated potentials are in reasonable agreement with the ones required to fit the scattering data. In particular we find that the real part of our calculated optical potential resembles in shape with the wine-bottle bottom type of potential in the intermediate energy region. The radial shape of real optical potential changes substantially with increasing energy. At low incident energy the calculated optical potential contains a mild surface enhancement in the imaginary part. At high incident energies the imaginary potential has no surface peaking in the calculated potential. Further, at low incident energies the central optical potential using V14 interaction in the
interior region is more attractive (by about 8 MeV in case of real part and by about 2–4 MeV in case of imaginary part) as compared with that using HJ interaction. Further, at low incident energies HJ interaction gives a pronounced surface enhancement whereas V14 interaction gives a milder surface enhancement in the imaginary central potential.

In chapter IV we investigate the approximations used to calculate the central exchange part of the potential where we show that this part of the potential can be written as a series whose first term corresponds to that used by all previous authors. We have calculated the first three terms of the series which seems to converge fairly rapidly. Our calculations show that the additional two terms of the series contribute significantly only to the imaginary part of the central potential. The effect of these additional terms on the real part of central potential is only marginal. In particular, we show that as a result of these additional terms the surface peaking in the imaginary potential is enhanced to some extent at low incident nucleon energies. This surface peaking at low incident nucleon energies has often been suggested by empirical analyses. Its absence in all microscopic calculations starting from basic nucleon interaction has been a problem. The size of the imaginary part of the central potential, particularly in the nuclear interior is not substantially reduced by the inclusion of the two
additional terms of the series as required by the low energy scattering data. Thus the calculated imaginary potential remains about 40% larger than the one required for obtaining good agreement with the scattering data.

In chapter V we investigate the calculation of spin-orbit part of the nucleon-nucleus potential. Our investigations lead us to the following conclusions. First we consider the direct part of the spin-orbit potential. Previous calculations used series expansions and made use of various approximations to sum the series. In particular, we show that the series of Greenlees et al. and that of Scheerbaum are formally equivalent. Further, we show that the convergence of the series is doubtful, that is, the second term of the series is almost as large as the first term. We show that one can easily calculate the direct part of the spin-orbit potential exactly without making any of the approximations mentioned above. Our calculations show that the approximation of using just the first term of the series underestimates the direct part of the spin-orbit potential at short distances and overestimates it at large distances. However, the volume integrals calculated from the first order term of the series and that from the exact expression are very similar. For the exchange part of the spin-orbit potential, our calculations show that the approximations made earlier are more severe. We have presented, in this chapter, a method of calculating the
exchange part without making any approximation. In particular, we find that the calculations following the approximate method of Brieva and Rook overestimate the exchange part of the spin orbit potential by about 30%. Thus the total spin-orbit potential at peak is reduced by 15% as a result of our exact calculations.

We have made analyses of the differential cross sections and polarization data of elastic scattering of protons from $^{40}\text{Ca}$ at several energies in low and intermediate energy regions using the new potentials of chapter IV and chapter V. The agreement obtained using the calculated potential is reasonable. However, the calculated central imaginary part is still appreciably large as in earlier calculations. Calculations of the central imaginary part of the potential using three nucleon correlation terms in the Brueckner theory shows a promise of substantially affecting the strength of the central imaginary potential. The results indicate that the inclusion of such higher order terms reduces the calculated potential by about 10-15% and further enhances the surface peaking. Further, the use of off-shell prescription for calculating the energies of the intermediate state nucleons also reduces the strength of the imaginary potential at low energies. However, in the present thesis, we have not investigated these effects. Further, from this analysis the calculated spin-orbit part is too small (about 30%). We think
that this feature and the size of the imaginary central part are the present major discrepancies at lower energies in calculations of the type described here.

In conclusion we feel satisfied that we have been able to make substantial improvement in the calculational procedure for obtaining both the central and spin-orbit parts of the microscopic optical potential for spherical spin zero nuclei.