Chapter 8

SUMMARY, AND OUTLOOK
The work reported in this thesis is mainly concerned with a theoretical study of nucleus-nucleus elastic scattering at medium and high energies within the framework of Glauber multiple scattering model. The study has two main objectives. First, to analyze some $^4\text{He} - ^4\text{He}$ elastic scattering experiments using realistic descriptions for $^4\text{He}$ by evaluating the full Glauber amplitude without recourse to any approximation with a view to examine working of Glauber model for nucleus-nucleus scattering which has not been subjected to as much rigorous study as for N-nucleus scattering. Second, to examine in detail two approximation schemes namely the rigid projectile model and the effective profile expansion method for evaluating Glauber amplitude for nucleus-nucleus scattering to estimate some corrections in the first case and study convergence of the effective profile expansion over a given momentum transfer region in the second case. The importance of undertaking these studies lies in the fact that evaluation of full Glauber amplitude with realistic densities is, in general, prohibitively tedious and hence there is a need for some thoroughly studied approximation method for nucleus-nucleus scattering calculation.

The thesis begins with the introduction of the subject of present study and the definition of the main objectives. A brief description of Glauber multiple scattering theory and
its generalization to nucleus-nucleus scattering is given next. This is followed by a brief review of various approximation methods for nucleus-nucleus scattering and a brief discussion on their merits and demerits. This provides the necessary background for the theoretical study reported here.

Monte Carlo technique for evaluating multidimensional integrals is adopted and developed for evaluating the full Glauber amplitude for nucleus-nucleus scattering without recourse to any approximation. Using this technique elastic scattering differential cross sections have been calculated for $^4\text{He}-^4\text{He}$ scattering at the incident particle momenta of 4.32, 5.07 and 7.0 GeV/c. The calculation have been performed with the generally used single Gaussian density and with the realistic double Gaussian density for $^4\text{He}$. Two acceptable sets of NN amplitude parameters available in the literature have been used. The results show that calculated cross sections are fairly sensitive to the form of the densities of the colliding nuclei. In particular a fairly good description of the data is obtained at the incident momenta of 4.32 GeV/c and 5.07 GeV/c over the momentum transfer region covered in experiments with the double Gaussian density for $^4\text{He}$. The theoretical prediction at the incident momentum of 7.0 GeV/c which extends upto $q \approx 4$ GeV/c is improved with the double Gaussian model only upto $q \approx 1$ GeV/c. At larger
momentum transfers there are noticeable discrepancies which may be removed by introducing a phase variation in the NN scattering amplitude.

The Monte Carlo technique is also applied to calculate $^4\text{He} - ^4\text{He}$ elastic scattering at the incident particle momentum of 4.32 GeV/c with the correlated variational wavefunction of generalized Jastrow form. The wavefunction gives a good account of electron scattering experiments and has not been used to study nuclear scattering problem earlier. It is found that the variational wavefunction gives a fairly good account of the data up to moderate momentum transfers. The some discrepancies at large momentum transfers may be attributed to the deficiencies of the wavefunction in the interior region.

Over full Glauber model calculations amply demonstrate validity of the Glauber model for nucleus-nucleus scattering at intermediate energies.

The remaining part of the thesis is devoted to some studies of approximation schemes for evaluating the Glauber amplitude for nucleus-nucleus scattering calculations. The importance of examining some potentially good approximation methods lies in the fact that full Glauber series calculation is not only highly time consuming but also impractical for larger values of mass numbers of the two colliding nuclei. Of
the various approximate methods employed in the literature, two seem to be promising enough to form the basis of the present study. They are: the rigid projectile model and the effective profile expansion of the S-matrix. In an attempt to have an improvement over the rigid projectile model (RPM), S-matrix is expanded such that the leading term gives the RPM result and the next term gives corrections to the RPM arising from the c.m. pair correlation in the target and excitations of the projectile in intermediate collisions. Calculation show that the corrections coming from the afore mentioned considerations are small in \(^4\)He-\(^{40}\)Ca and \(^4\)He-\(^{12}\)C elastic scatterings at 1.37 GeV. An expression for the monopole inelastic N\(\times\)N amplitude is also derived in this work.

Lastly, a finite series expansion of the S-matrix in terms of Bell's polynomials is proposed and it is adopted to study the convergence of the effective profile expansion. We find that the first four terms of the expansion are almost sufficient to retain the full series character up to momentum transfers equal to .4 GeV/c. This may be contrasted with the usual expansions in terms of the free NN profile functions in which case the first ten terms are needed to achieve the same result.

To conclude this part corrections to the RPM arising from intermediate excitations of the projectile during the passage in the target nucleus as well as from the target
two-body correlation are generally small and their inclusion does not provide any significant improvement over the RPM result. The expansion of the S-matrix in terms of Bell's polynomials involving the effective profile function seems to provide a relatively good approximation scheme for evaluating nucleus-nucleus scattering amplitude over the momentum transfer region generally covered in present experiments.