We present a systematic study of multifragmentation and associated phenomena such as finite size effects, role of momentum dependent potentials in heavy-ion (HI) collisions, thermalization and entropy production at intermediate energies. These aspects are studied within the framework of quantum molecular dynamics (QMD) model as primary transport theory.

In the first part of thesis, we study the beam energy and system size dependence of fragment production in central symmetric reactions. The fragment production at central geometries is still an unclear phenomenon which is significantly affected by the radial flow and squeeze out of nuclear matter. The collective transverse expansion tends to enhance the process of clusterization. Recently, the production of intermediate mass fragments (IMFs) was studied as a function of beam energy in the center-of-mass frame ($E_{c.m.}$) on MSU 4π-Array set-up. The peak $E_{c.m.}$ (at which maximal IMF emission occurs) reveals a clear system mass dependence. We shall show that our model calculations for the unfiltered events reproduce the linear dependence of peak $E_{c.m.}$ on system mass as is observed experimentally. We shall further show that multiplicities of various fragment species also reflect similar mass scaling behavior at peak $E_{c.m.}$ indicating the role of surface to volume ratio in clusterization process.

In the next part, we shall address the problem of spectator fragmentation at relativistic bombarding energies using advanced clusterization algorithm namely simulated annealing clusterization algorithm (SACA). For the first time, our calculations based on the SACA method explain successfully the universality behavior in the production of intermediate mass fragments over entire energy range between 400-1000 AMeV, as observed on ALADiN set-up. We shall also propose an improved version of SACA method where constant binding energy check of -4 MeV/nucleon will be replaced by realistic binding energy check leading to most bound fragment structure.

The application of SACA method will be made in describing the spectator fragmentation in ultra low-energy HI reactions. We shall simulate the peripheral collisions of Au+Au at 35 AMeV using SACA and conventional minimum spanning tree (MST) clusterization subroutines. The SACA method allows early recognition of fragment pattern. We shall demonstrate that our model calculations for charge yields and charge of the heaviest frag-
ment using SAC A approach are in closer agreement with experimental data reported by Multics-Miniball Collaboration. Conventional MST procedure, however, completely fails to predict the dynamics of spectator fragmentation at such low incident energies.

The phenomenon of multi-fragment emission in low-density regime is least exploited to probe the nature of nuclear matter equation of state. The heavy-ion reactions at low incident energies are particularly suitable to extract the information on the nuclear EoS, as the role of different nucleon-nucleon scattering cross sections is minimal at these energies. To achieve this goal, we shall simulate the reaction of $^{197}$Au + $^{197}$Au at an incident energy of 35 AMeV and at different peripheral geometries. We shall show that fragment charge distributions obtained from spectator matter decay are highly sensitive towards the stiffness of nuclear EoS. The comparison of fragment charge multiplicities calculated at different peripheral geometries indicates preference for soft compressibility modulus of the nuclear matter.

We shall further extend our analysis by studying the consequences of implementing momentum dependent interactions on the stability of nuclei, stopping and fragment emission characteristics. The evolution of cold QMD nuclei using momentum dependent interactions depict no artificial emission of heavier clusters and nuclei remain stable for the characteristic reaction times. The IMF multiplicity calculated using soft momentum dependent EoS for the Au+Au reactions as a function of impact parameter will be shown to reproduce the experimental trends very nicely.

As the last piece of research work discussed here, we aim to understand the thermal properties of hot & dense nuclear matter formed in HI reactions. For central symmetric reactions at relativistic energies, the fireball formed at midrapidity is expected to be equilibrated. This aspect is implemented to extract the baryonic entropy from the yield ratio of deuteron-like to proton-like clusters using Siemens and Kapusta’s formalism. For this analysis, we shall simulate central symmetric reactions of $^{40}$Ca+$^{40}$Ca, $^{93}$Nb+$^{93}$Nb and $^{197}$Au+$^{197}$Au at different incident energies. Our model calculations predict ‘universality characteristics’ for baryonic entropy produced i.e. it depends upon the participant proton multiplicity irrespective of the system mass chosen. Nearly no effect of beam energy is visible on the magnitude of baryonic entropy.