# Theoretical study of nuclear multifragmentation reactions around the VECC superconducting cyclotron energies

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The study of nuclear multifragmentation is an important area of research in intermediate energy heavy-ion collisions [1, 2]. In India, superconducting cyclotron facility for studying intermediate energy heavy-ion reactions [3] is now operational at VECC, Kolkata. This paper focuses on theoretical studies of nuclear multifragmentation reactions around the VECC K=500 superconducting cyclotron energies.

The theoretical studies are performed in the framework of recently developed isospin dependent hybrid model of nuclear multifragmentation reactions [4]. This model calculation consists of three different stages: (i) initial stage of the reaction is studied by isospin dependent transport model (BUU@VECC-McGill) [5] based on Boltzmann-Uehling-Uhlenbeck equation [1, 6]. BUU@VECC-McGill model calculation is initiated when two nuclei in their respective ground states approach each other with specified velocities in centre of mass frame. Each nucleon is represented by 100 test particles. The test particles move in a mean-field and occasionally suffer two-body collisions, with probability determined by the nucleon-nucleon scattering cross section. By checking the isotropy of the momentum distribution, the time evolution is stopped at $t$=150 $fm/c$. Excitation and isospin asymmetry of compound nuclear system is determined by selecting the test particles which create 90% of the total mass (remaining part is considered as pre-equilibrium emission) from the most central dense region. (ii) Fragmentation of the compound nuclear system into different clusters and free nucleons is examined by canonical thermodynamical model (CTM) [7] at a temperature and freeze-out volume (which produces similar excitation determined in the previous stage). (iii) Decay of excited fragments produced in the fragmentation stage is studied by the evaporation model based on Weisskopf formalism [8].

For studying charge and isotopic distri-

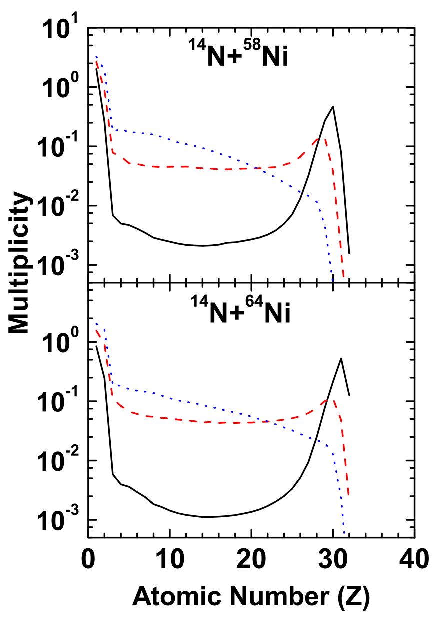


FIG. 1: Charge distribution for $^{14}$N+$^{58}$Ni (upper panel) and $^{14}$N+$^{64}$Ni (lower panel) reaction at 18 (black solid lines), 32 (red dashed lines) and 46 (blue dotted lines) MeV/nucleon.

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bution at intermediate energies, $^{14}N+^{58}Ni$ and $^{14}N+^{64}Ni$ reactions are simulated. Three different projectile beam energies 18, 32 and 46 MeV/nucleon are considered. Fig. 1 shows the charge distributions. At lowest projectile beam energy (18 MeV/nucleon) the charge distributions are "U" shaped, i.e. mainly occurring of particle evaporation. But with the increase of projectile beam energies significant production of intermediate mass fragments are observed which is an important signature of nuclear multifragmentation. Hence, from the study of charge distributions for $^{14}N$ on $^{58,64}Ni$ reactions it can be concluded that nuclear multifragmentation dominates over evaporation near the Fermi energy domain. Similarly, for heavy mass target and/or projectile combination (i.e. for a heavy compound system with lower value of Coulomb barrier) nuclear multifragmentation will dominate over nuclear fission around the Fermi energy domain.

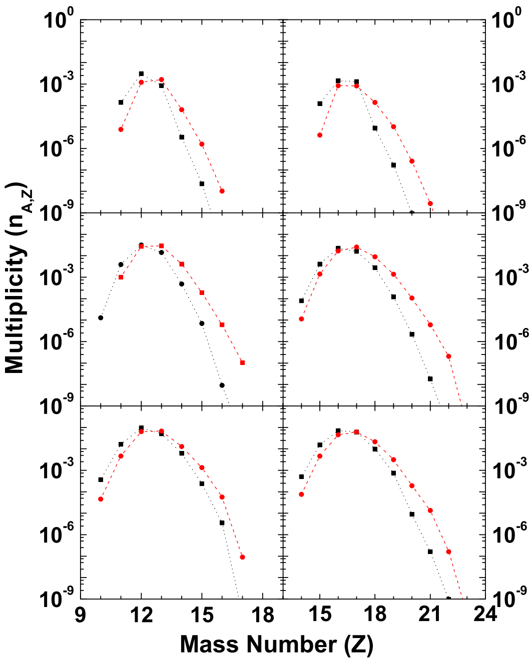


FIG. 2: Isotopic distribution of different carbon (left panels) and oxygen (right panels) fragments produced from $^{14}N+^{58}Ni$ (black squares) and $^{14}N+^{64}Ni$ (red circles) reactions at 18 (upper panels), 32 (middle panels) and 46 (bottom panels) MeV/nucleon. Lines are drawn to guide the eyes.

Fig. 2 represents the isotopic distributions of Carbon and Oxygen fragments produced in the $^{14}N+^{58}Ni$ and $^{14}N+^{64}Ni$ central collision reactions at three different projectile beam energies mentioned above. With the increase of projectile beam energies, multiplicities of these intermediate mass isotopes gradually increases and the isotopic distributions become wider. From the isotopic distributions it is clear that the production of neutron rich fragments is more in $^{14}N+^{64}Ni$ compared to the other other reaction $^{14}N+^{58}Ni$.

Hence, from this isospin dependent hybrid model calculation it can be concluded that nuclear multifragmentation dominates over particle evaporation and/or fission near the Fermi energy domain. Significant amount of very neutron rich isotopes will be produced in the upcoming experiments around the Fermi energy domain at VECC K=500 superconducting cyclotron facility.

## References


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