Light Particle Probes of Expansion and Temperature Evolution: Coalescence Model Analyses of Heavy Ion Collisions at 47A MeV

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Our study of the reactions ^{12}C+^{116}Sn, ^{22}Ne+Ag, ^{40}Ar+^{100}Mo and ^{64}Zn+^{89}Y at 47A MeV projectile energy were completed in the past year. A short publication on this work has appeared [1]. A longer and more detailed paper has been submitted [2]. The light ejectile spectra for the different systems exhibit strong similarities even though the deposited excitation energies differ greatly. Comparisons of the multiplicities and spectra of light charged particles emitted in the reactions with the four different projectiles indicate a common emission mechanism for those ejectiles associated with an intermediate velocity source even though the deposited excitation energies differ greatly. The ^{3}He spectra, in particular, appear to result predominately from this mechanism.

Self-consistent coalescence model analyses applied to the light cluster yields exploited correlations between ejectile energy and emission time, suggested by both CMD and QMD calculations. These analyses provided evidence for increasing expansion of the emitting system with increasing projectile mass. At freeze-out, densities of the systems studied here range from just below normal density to ~1/3 of normal density. Masses of the expanded nuclei range from 102 to 116 amu and excitation energies range from 2.6 to 6.9 MeV/u. A caloric curve for expanded A~110 nuclei exhibits a plateau at temperatures near 7 MeV. The plateau extends from ~3.5 to 6.9 MeV/u excitation energy.

In the coalescence framework, measured values of the t/^{3}He ratio as a function of V_{surf} indicate "free nucleon density" ratios significantly higher than the N/Z ratios in the composite systems.

This work indicates that information on the space-time evolution of a system, complementary to that contained in HBT measurements, can be obtained in a relatively simple manner. It would clearly be interesting to make a direct comparison of the two techniques for some well-chosen cases. It would also be interesting to extend the application of the present coalescence techniques to the study of IMF emission in detailed experiments including both Z and A identification of the IMF which provide a sensitive probe of the degree of transparency and equilibration in the collision. By clearly establishing the relative importance of different mechanisms of IMF formation it should be possible to explore the degree to which thermal and/or chemical equilibrium is achieved, the degree to which pre-existing correlations are preserved, implying some transparency in the collisions. More detailed investigations along the lines pursued here would allow a clearer picture of the degree to which the different species can be said to originate from either gaseous or liquid phases which might be present. Applying the techniques to systems of varying N/Z could provide a much clearer picture of isospin effects and the isospin dependence of symmetry energy.

References

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