Experimental study of liquid-gas phase transition in Xe+Sn at 50A MeV

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The experimental liquid-gas phase transition is studied for A~120 Quasi-Projectile(QP) system, using GANIL data of $^{129}Xe+^{nat}Sn$ at 50 MeV/nucleon, taken with a 4π detector array INDRA. The experimental details and data analysis are given in Refs.[1-4]. The methods used for characterizing the QP and constructing the caloric curve for this liquid-gas phase transition study are essentially same as those of the previous study, where the QP is reconstructed from the reactions of $^{40}Ar+^{27}Al$, ^{48}Ti, ^{58}Ni at 47 MeV/nucleon, taken with NIMROD [5].

In order to characterize the QP source, a moving source analysis is used. In this study, the event centrality classification is made according to the mass of the projectile-like fragments, which has Z ≥ 3 with $v_z \geq 0.75\ v_{Beam}$, where v_z is the velocity of the fragment at the beam direction. All events are classified by ZBin=Z_{PLF}/10 from ZBin=0 to 4. Those with Z_{PLF}>=50 are included in ZBin4. In order to select out the QP particles, the velocity distribution of light charged particles are examined, which is shown in Fig.1 for p, d, α for ZBin=0, 2, 4. As one can see in the case of α particles, a well developed

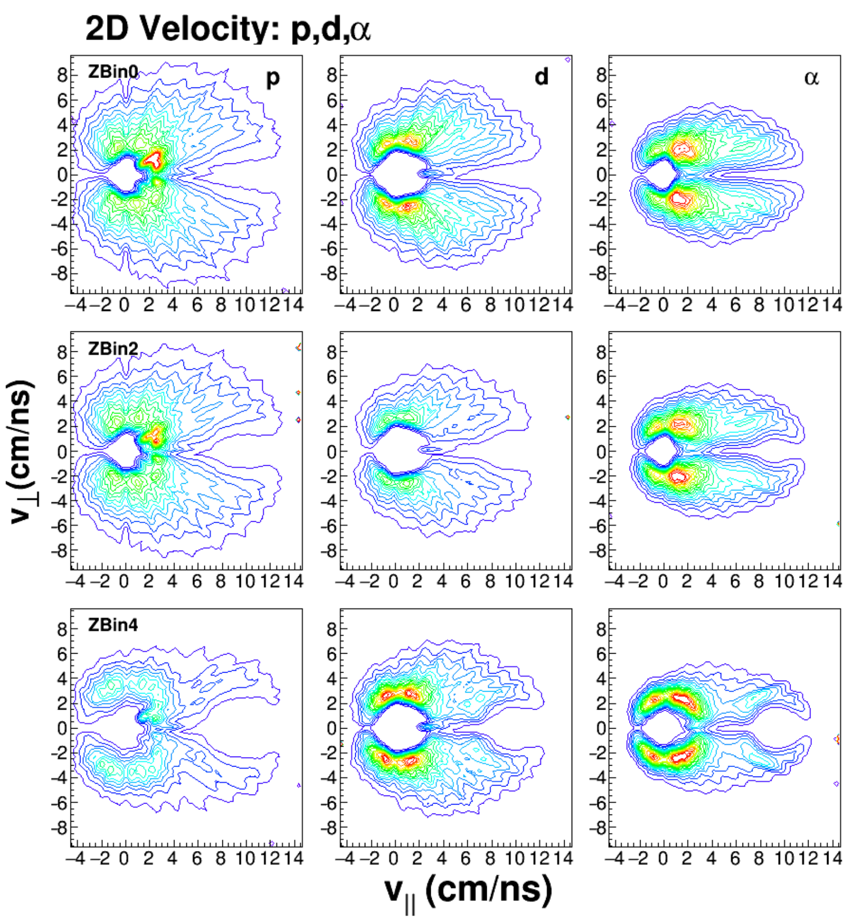

Fig. 1. Galilean invariant velocity distribution for p,d, α (from left to right) for ZBin 0,2,4 (from top to bottom, as indicated. Z axis is an arbitrary unit in logarithmic scale.

Coulomb ring is observed for ZBin 4, in which an observed large projectile-like fragment (PLF) characterizes the QP events. On the other hand for ZBin 0 no such a Coulomb ring is observed, though many particles from a PLF source are observed. The Coulomb ring is less prominent for the lighter LCPs. For protons for all ZBins show a large Coulomb-like ring around the beam velocity, but this is caused by the fact that the most forward ring, Ring 1, in the INDRA array is not capable to identify p,d,t and all these particles are assigned as protons and therefore the yield of protons enhanced at the most forward angle and causing like a ring when the contour is smoothed between the neighboring rings. In order to reproduce these features, all particles are fit with four sources, a target-like source (TLF) with a very small velocity, an intermediate velocity source (IV) and two PLF sources. One of PLF sources represents a binary sequential decay source (PLFB) which shows a clear Coulomb ring and the other is to represent a multifragmented PLF source and therefore a Coulomb ring is significantly reduced or is not seen.

Typical results of the four source fits are shown in Fig.2 for p, α, and ^{12}C at selected angles from left to right for ZBin3, where differential multiplicity of a given particle is plotted as a function of kinetic

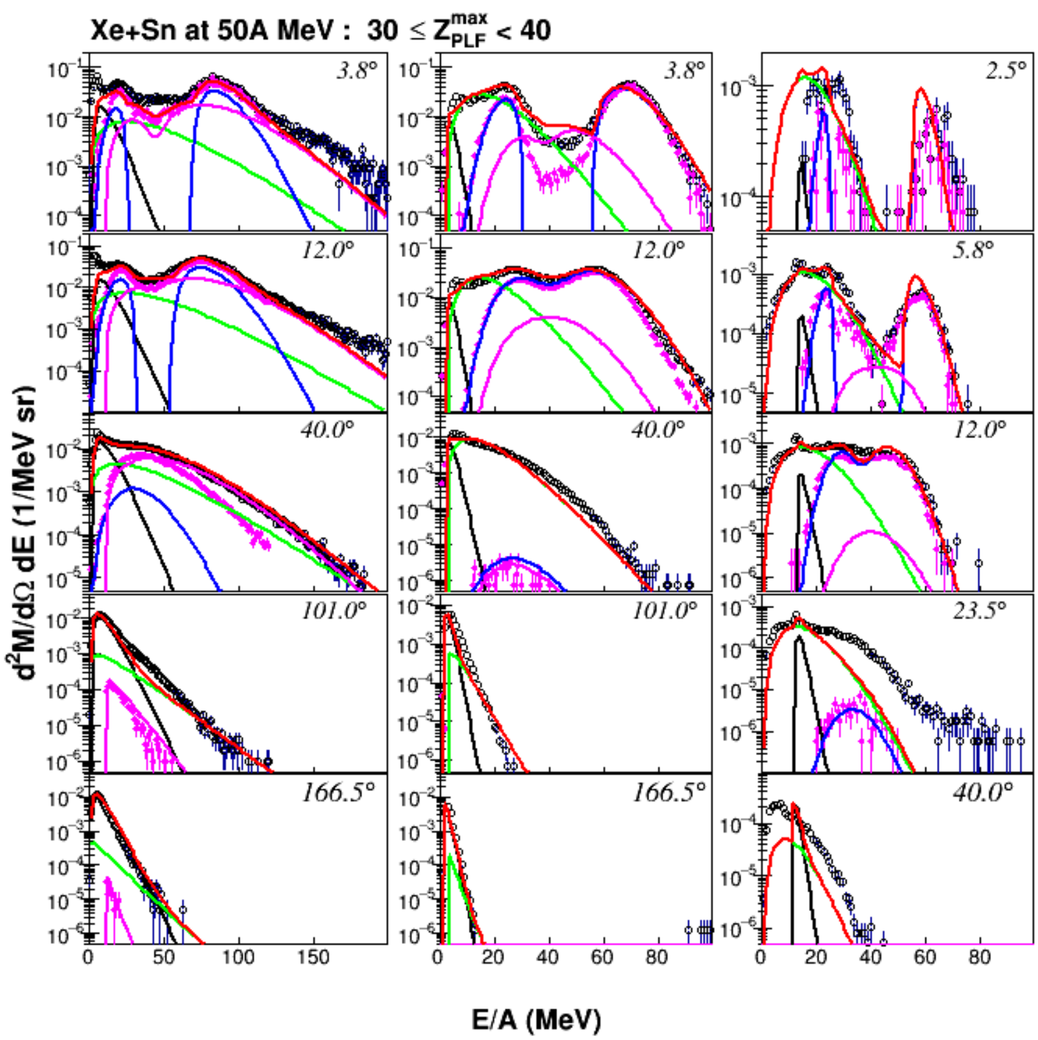

Fig. 2. Typical MS fits for p, α, and ^{12}C at the selective angles. See details in the text.

energy per nucleon (E/A) in the Laboratory frame. The experimental data are shown by black open circles. The curves are; TLF (black curves), IV (green), PLFB (blue), PLFM (magenta), sum of all four (Red). Generally, the PLF sources are dominated at forward angles of the energy spectra near the beam velocity. The binary PLFB dominates in ZBin4 events and multi-fragment PLFM dominates at ZBin0-2 as expected. For LCPs, the PLFB multiplicity becomes comparable to that of PLFM in ZBin3. The trends are similar for IMFs, but the multiplicity values change more drastically as ZBin changes, because in ZBin3-4, many of IMFs in PLFB are from a partner of the fission-like binary decay of the parent PLF and therefore accompanies with another large PLF.

In a similar manner in Ref.[5], the extracted moving source parameters are used to select out the QP particles, in which the MS fits are assumed to represent the probability of each component of each particle at a given angle. Using this probability selection method, the QP particles are selected as the PLFM+PLFB components from all particles in the entire energy and the entire angulaer range in each ZBin. The dots with magenta in Fig. 2 represent those QP particles.

The next step is to evaluate the excitation energy of the extracted QP source and their temperature will be evaluated, using the fluctuation thermometer to examine the caloric curves. The study is underway as a collaboration work of GANIL-TAMU-IMP.

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