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

R. Wada, Guoyu Tian, Xueying Liu, Weiping Lin, Xingquan Liu, K. Hagel, and A. Chbihi

The experimental liquid-gas phase transition is studied for Quasi-Projectile(QP) system with A~ 120, using the 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 the liquid-gas phase transition study are essentially same as those of the previous study, in which 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 construct QPs, a moving source analysis is employed, as described in the 2019 annual report. Among those, complete events are selected, requiring the 80 <= A_{QP} <= 129. These QP events are further classified into three, multi-fragmentation like (M_{LF}=0), evaporation residue like (M_{LF}=1) and fission-like (M_{LF}=2) events, in which M_{LF} is the multiplicity of "large fragment" with Z>=15 in each event.

In Fig.1 caloric curves are made, using the fluctuation thermometer with p, d, t, h and α. From the probed particle to particle, the caloric curves behave quite differently, which was not expected. The differences among different M_{LF} classes are noticeable and some are quite different. The caloric curve for deuteron worked well for lighter QP system in the previous analysis [5], but it is not the case here.

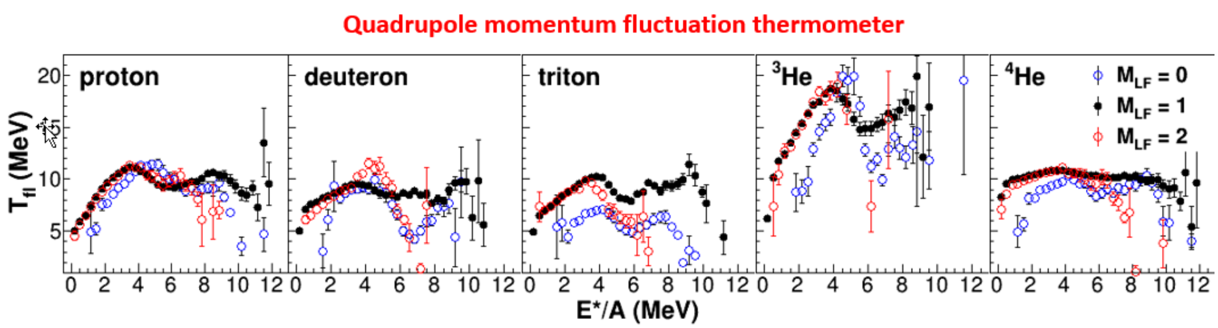

Fig. 1. Caloric curves, using the momentum fluctuation thermometer with p, d, t, h, α from the left to right for M_{LF}=1 (black) and 2 (red) events.

In Fig.2 caloric curves with Albergo thermometer, utilized the ratios of {Y(d)/Y(t)}/{Y(h)/Y(α)} for the different M_{LF} triggers. The caloric curve for MLF=0 shows a smooth increase as E*/A increases. That with M_{LF}=1 on the middle shows a peak at E*/A ~ 4 MeV with T ~ 5.5 MeV and become flat at T ~ 5 MeV for the higher excitation energies. For events with M_{FL}=2, the peak occurs at E*/A ~ 3 MeV, but the temperature is similar (~ 5.5 MeV) and also shows a peak structure. At E*/A > 5 MeV, statistics is getting poor.

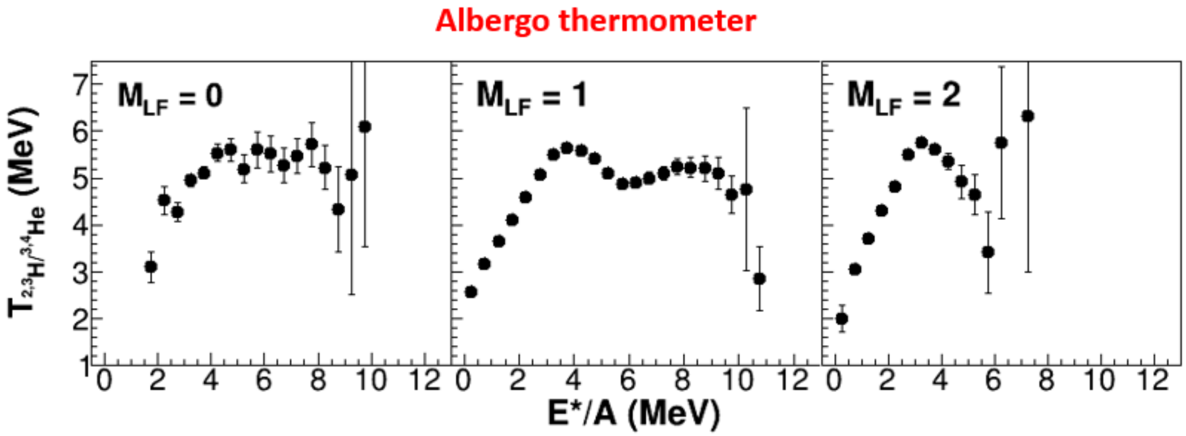

Fig. 2. Caloric cur ves are plotted, using Albergo thermometer for the events with MLF= on the left and 2 on the right.

In Fig.3, the multiplicity of all QP charged particles, M_{CP}, is plotted as a function of E*/A. In Ref.[6] it has been demonstrated that M_{CP} is also a sensitive measure for the liquid-gas phase transition. The shape is very similar to those of protons in Fig.1. These inconsistencies among different measures for different M_{LF} classes are under investigation, using AMD simulations.

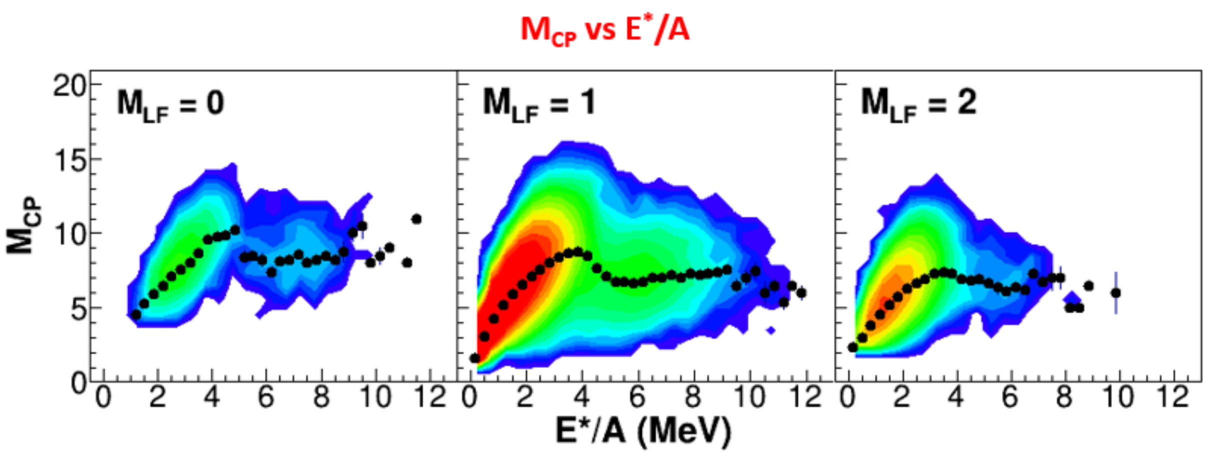

Fig. 3. Charge particle multiplicity in QP events, M, vs the excitation energy for the events with MFF=1 on the left and 2 on the right.

[1] J. Pauithas *et al.*, Nucl. Instrum. Methods Phys. Res. **A357**, 418 (1995).

[2] J. Łukasik *et al.*, Phys. Rev. C **55**, 1906 (1995).

[3] N. Marie *et al.*, Phys. Lett. B **391**, 15 (1997).

[4] E. Plagnol *et al.*, Phys. Rev. C **61**, 014606, (1997).

[5] R. Wada, W. Lin, P. Ren, H. Zheng, X.Liu, M. Huang, K. Yang, and K. Hagel, Phys. Rev. C **99**, 024616 (2019).