A statistical interpretation of the correlation between IMF multiplicity and E_t

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Recent evidence has been put forth for the lack of statistical competition between intermediate mass fragment (IMF) emission and light charged particle (LCP) emission. It has been shown that for the reaction ^{136}Xe+^{209}Bi at 28 AMeV: a) LCP emission saturates with increasing number of emitted IMFs ($N_{\rm IMF}$) [1]; b) with increasing transverse energy (E_t), the contribution of LCPs to E_t saturates while that for IMFs becomes dominant [2]; c) there is a strong anti-correlation of the leading fragment kinetic energy with increasing $N_{\rm IMF}$ [1]. This evidence seems to suggest that beyond a certain deposited energy most, if not all, of the energy goes into IMF production rather than into LCP emission in a manner inconsistent with statistical competition.

Given the importance of these results in showing a potential failure of the statistical picture and a possible novel dynamical mechanism of IMF production, we have applied the same analysis to a set of systematic measurements of ^{129}Xe+^{197}Au at several bombarding energies.

Observation a) was discussed in [3]. In short, the observation of saturated LCP multiplicities as a function of IMF multiplicity is predicted by statistical models.

Observation b) is an instrumental effect as discussed in [4]. In essence, the measurements in [2] were made with very thin detectors – so thin that the full LCP energies were not measured. The saturation of $\langle E_t^{\rm LCP}\rangle$ as a function of E_t observed in ref. [2] is due to the incomplete measurement of the LCP energies. We can account for this saturation [4] by filtering the present measurements of ^{129}Xe+^{197}Au with the experimental thresholds present in refs. [1,2]. The resulting distortions to the data are large and induce qualitative changes in the trends of the data, causing an unphysical saturation of $\langle E_t^{\rm LCP}\rangle$.

Lastly, observation c) is addressed in Fig. 1. The average kinetic energy of the projectile-like fragment ($\langle E/A\rangle_{\rm PLF}$, defined as the heaviest forward-moving particle in an event, with $Z_{\rm PLF} \geq 10$ and $\theta \leq 23°$) has been determined as a function of $N_{\rm IMF}$, an example of which is given in Fig. 1. Here, we confirm the observation in [1]. For increasing $N_{\rm IMF}$, the energy per nucleon of the leading fragment decreases continuously.

From the decrease of $\langle E/A\rangle_{\rm PLF}$ with $N_{\rm IMF}$, it was concluded that kinetic energy of the PLF is expended for the production of IMFs [1]. It was also argued that for increasing $N_{\rm IMF}$, the saturation of $\langle N_{\rm LCP}\rangle$ represents a critical excitation energy value beyond which no further amount of relative kinetic energy between the PLF and TLF is converted into heat. The IMFs no longer compete with the LCPs for the available energy – they get it all.

One can test the consistency of this explanation by

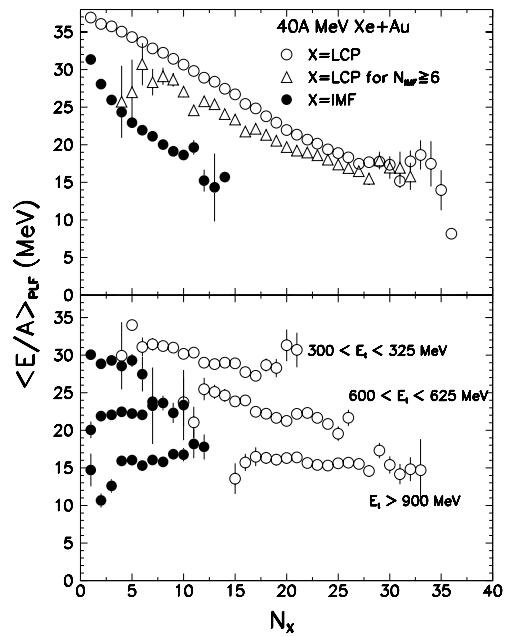

FIG. 1. Top panel: the average kinetic energy per nucleon of the projectile-like fragment is plotted as a function of $N_{\rm IMF}$ (solid circles) and $N_{\rm LCP}$ (open symbols). Bottom panel: Same as top panel but selected from events within the indicated range of E_t.

studying the same observable, $\langle E/A\rangle_{\rm PLF}$, but as a function of $N_{\rm LCP}$ (open symbols, top panel of Fig. 1). We observe the same dependence as that of the IMFs – a monotonic decrease of $\langle E/A\rangle_{\rm PLF}$ with increasing $N_{\rm LCP}$ which reaches a value of ~17 MeV at the largest multiplicities. This behavior persists whether we restrict ourselves to the saturation region ($N_{\rm IMF}\geq$ 6, triangles) or not (open circles). The similar behavior of $\langle E/A\rangle_{\rm PLF}$ with respect to $N_{\rm IMF}$ and $N_{\rm LCP}$ indicates that the LCPs compete with the IMFs for the available energy.

This can be seen more clearly by pre-selecting events with a better global observable, E_t, as done in the bottom panel of Fig. 1. Once a window of E_t is selected, a corresponding value of $\langle E/A\rangle_{\rm PLF}$ is also determined, and there is no longer any strong dependence of $\langle E/A\rangle_{\rm PLF}$ on $N_{\rm IMF}$ or $N_{\rm LCP}$. In fact, the resulting $N_{\rm IMF}$ and $N_{\rm LCP}$ selections both give the *same* value of $\langle E/A\rangle_{\rm PLF}$, consistent with a scenario where both species compete for the same available energy.

[1] J. Toke *et al.*, Phys. Rev. Lett. **77**, 3514 (1996).
[2] J. Toke, *et al.*, Phys. Rev. C **56**, R1683 (1997).
[3] L. Phair, *et al.*, Phys. Rev. Lett. **81**, 4021 (1998).
[4] L. Phair, *et al.*, submitted to Phys. Rev. C, LBNL-41893.