Comment on “Phase Coexistence in Multifragmentation”

In their letter Moretto et al. [1] propose the fragment charge distribution function in nuclear multifragmentation to give a signal for the coexistence of nuclear liquid and vapor phase. To our opinion this signal is not useful and misleading as fluctuations of different origin spoil it.

Phase transitions in macro-physics are usually indicated by a peak in the specific heat e.g. $c_v(T)$ or by an anomaly of the caloric equation of state (CES) $T(E)$ e.g. at constant pressure or volume. In closed finite systems, as e.g. highly excited nuclei, phase transitions are well indicated by the shape of the CES c.f. [2]. Inherent to phase transitions are large fluctuations at the transition which do not allow a clear phase separation in space or any other observable in small finite systems because of the nonvanishing coherence length of the phase fluctuations c.f. [3] and which differ at const.$E$ and at const.$T$. E.g. even though the backbending of the CES is clearly seen for a 10-state Potts model at a lattice size of $100 \times 100$ and the area under the oscillation of $T^{-1}(E)$ is close to the asymptotic value of the surface entropy no phase separation can be seen in the configurations. Therefore, the interpretation by ref. [1] is too na"ive and suffers from several further difficulties:

Equations like formulas (1-3) of ref. [1] notice charge conservation only via the mean value but leave its fluctuation unrestricted. These fluctuations are usually substantial especially near to phase transitions. Moreover, in nuclear fragmentation one has to take care of the indistinguishability of identical fragments and the partition problem is not the Euler problem as is suggested in [1].

The correct formula for the quantum partition of an integer $Z_0$ is given in [1].

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We guess that at low transverse energy the experimental data of ref. [1] are overshadowed by deep inelastic collisions where some of the small fragments are likely from projectile break-up which as such have small transverse energies. Consequently, low total transverse energies do not really characterize the limitation to low excitation energies as indicated by the large width in $\epsilon^\ast(E_t)$ [4]. This is probably the reason for the vanishing quantity $c$ found in ref. [1] at low transverse energies.

Conclusion: From all experience of microcanonical first order phase transitions in small systems one knows that it is normally rather difficult to see a clear phase separation even though the caloric equation of state gives an unambiguous signal, phase fluctuations are usually too large. Within the arguments of ref. [1] there are at least two important conservation laws to be observed by the reaction: Conservation of charge and energy. The latter forces the “chemical potential” $c$ to rise again at low excitation energy. The observation of an anomaly in the caloric equation of state [4] is still the best signal for a phase transition as was predicted in [4-3]. Since long this is one of the classical signals for phase-transitions.

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