Comment on “Negative heat · · ·” by Moretto et al.

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Backbending of the caloric curve $T(E)$ is experimentally found in nuclear multifragmentation e.g. [1,2]. In their recent paper (arXiv:nucl-th/0012037) Moretto et al. claim that the first order transition and the backbending of the caloric curve in small systems like fragmenting nuclei is trivial. Of course well understood physics is always trivial, but in this case they miss some essential facts which make phase transitions in such small systems interesting by generic reasons.

- Nuclear multifragmentation is not the story of a single nuclear drop embedded in its vapor at some given temperature and pressure. In nuclear fragmentation experiments there is a constant energy but neither a heat bath (temperature) nor a vapor pressure. I.e. the realistic scenario is not as trivial as Moretto et al. claim.

- Multifragmentation is first of all a fast, nearly simultaneous but statistical breaking of a hot nucleus into several intermediate nuclei with several surfaces. As was discussed in [3] and earlier papers, the intruder in $S(E)$ at the beginning of the transition is caused by the increase of the number $N_{fr}$ of intermediate fragments and thus of the total surface area including a partition entropy $S_{part}$ connected to various partitions into several fragments with a fluctuating number. With no $S_{part}$ there would be no multifragmentation. This aspect is lost in Moretto’s scenario.

- The Rayleigh (curvature-) pressure of a liquid drop invoked by Moretto has of course its microscopic origin in the surface tension which is a cooperation of surface energy and the entropy of the surface. Without surface tension there is no Rayleigh pressure.

- Their example of a nucleus with 20 nucleons is far away from a macroscopic liquid drop with a surface. There is nearly no volume part in such nuclei.

- If $T$ and $P$ are fixed as one may interprete their fig.3 they are in the $\{T,P,N\}$-ensemble. Then neither the overall-volume nor the enthalpy are fixed. In the stationary approximation of the Laplace-transform $\{H,V\} \rightarrow \{T,P\}$ (and this corresponds to standard thermodynamics) there are two stationary points: one on the left branch of their fig.3 and one on the right branch. The middle downwards going branch is unstable. I.e. the system should jump along a horizontal line ($\sim$ Maxwell construction) from the left branch to the right one and the backward (interesting) branch remains invisible. If, however, their figure means that they fix the enthalpy and determine the temperature implicitly by $T = (dS/dH)^{-1}$ then they are in the micro-canonical ensemble with respect $H$ which is not standard thermodynamics for a small system. In full consistency with my general statements then the backbending can be observed. Thus the backbending is indeed a specific feature of microcanonicity in sharp contrast to their concluding point 3.

- On a much more fundamental level: Nearly all textbooks of statistical thermodynamics claim that phase transitions exist in the thermodynamic limit only. It is an important, anything else but trivial, and for thermodynamics in general quite fundamental question whether one can define phase transitions of any order and (multi-)critical phenomena unambiguously in such small, non-extensive systems as hot nuclei. A question addressing the majority of systems in nature like also atomic clusters, biological and astrophysical systems. This is discussed in [4].

The contribution of Moretto et al. is a nice exercise in macroscopic liquid drop theory but misses the crucial features of nuclear multifragmentation. It is too trivial and moreover wrong.
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