Extensivity of thermodynamic bodies, weak nonlocality of continua and long-range interactions

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Extensivity is defined as first-order Euler homogeneity of the thermodynamic entropy. Therefore it is the key concept that connects bodies with continua, more properly thermodynamic bodies with thermodynamic continua. Nonextensivity and nonadditivity are body concepts and are often connected to long-range forces and to nonlocal interactions. Nonrelativistic gravity and heat conduction are nonlocal in the sense, that the speed of propagation of a perturbation is infinite. However, their field equations, the Poisson and Fourier ones, are local nonrelativistic evolution equations.

In the presentation, it is shown that nonextensive thermodynamic bodies may be modelled as extensive ones. My primary example will be the thermodynamics of a Schwarzschild black hole, where the thermodynamic volume coincides with the Christodoulou-Rovelli volume and the body entropy can be transformed to and extensive one, with nonnegative heat capacity [1].

Moreover, I demonstrate that weakly nonlocal gradient extensions of well-known continuum equations result in nonextensive homogenous thermodynamic bodies because body quantities become shape and boundary dependent. The simplest example is the thermodynamics of elasticity [2], but there are many gradient theories in fluid mechanics, too, both in nonrelativistic and relativistic ones. Therefore, our fluid-based intuition in thermodynamics and thermostatistics should be generalised and properly analysed when applied in weakly nonlocal continua. Also, the natural starting point of theory building is the continuum part.

Finally, I argue that a meaningful body-continuum transition in mechanics requires the classical holographic property: in ideal continua without dissipation, body forces can be represented by surface tractions [3,4]. Classical holographic property is the consequence of thermodynamic principles of second law compatibility. The transition from body to continua, from mass point representation to field theory is the general aspect of extensivity and nonextensivity in thermodynamics.

References

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