Group entropies and statistical physics: Equilibrium condition, first thermodynamics law within the micro canonical ensemble and pointers towards macroscopic thermodynamics

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We discuss equilibrium condition (zeroth's law) and the first law (energy conservation) within the micro canonical ensemble in the framework of the group entropies introduced by Piergiulio Tempesta [1], see Tempesta's talk for a review. Repeating the usual counting of states and assuming that equilibrium corresponds to the macro-state with the maximum number of micro-states, the first law can be cast in the usual form involving work, changes in internal energy and changes in (group) entropy with temperature given by the derivative of the group entropy with respect to energy, i.e. the fundamental thermodynamic temperature[2].

The equilibrium between two systems described by the same universality class of group entropies is not given by equality of the fundamental temperature, but instead one needs to consider an empirical temperature. This temperature is given by the derivative of the group entropy with respect to energy times a prefactor given by the state space growth rate W(N), the number of allowed microstates of the system consisting of N constituents. This suggests that for group entropies, the thermodynamic fundamental temperature cannot be equal to the empirical temperature.

We briefly mention that fully consistent macroscopic thermodynamics can be established.

References:

[1] P. Tempesta, Group entropies, correlation laws, and zeta functions. Phys. Rev. E 84, 021121 (2011).

[2] H.J. Jensen, Pert Jizba, and P. Tempesta, Universality classes, Thermodynamics of Group Entropies, and Black Holes. arXiv:2603.02385