Extensive nonadditive entropies for black holes and cosmology

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No empirical indication exists that classical thermodynamics needs to be violated for any system, including cosmological ones, either quantum or not. Consistently, the Legendre structure of thermodynamics remains valid for all macroscopic systems. This implies that -- in contrast with the total energy, which typically is either extensive or superextensive -- the total thermodynamical entropy S must -- like the volume, magnetization and similar quantities -- always be, extensive, i.e., asymptotically proportional to the number of particles. This requirement severely constrains the admissible entropic functionals to be used for the statistical-mechanical approach to the system. The appropriate entropic functional to be used definitively depends on the particular occupancy of the corresponding phase space or Hilbert space, as determined by its dynamics. These issues will be illustrated in concrete systems where the nonadditive entropic functional $S_{q,\delta}$ introduced in Tsallis and Cirto, Black hole thermodynamical entropy, Eur. Phys. J. C 73, 2487 (2013) and similar entropies [Zamora and Tsallis, Thermodynamically consistent entropic-force cosmology, Phys. Lett. B 827, 136967 (2022); Zamora and Tsallis, Thermodynamically consistent entropic late-time cosmological acceleration, Eur. Phys. J. C 82, 689 (2022); Jizba and Lambiase, Tsallis cosmology and its applications in dark matter physics with focus on IceCube high-energy neutrino data, Eur. Phys. J. C 82, 1123 (2022)] have been successfully used with regard to the available observational data.