

Non-extremal Black Holes, Thermodynamics of Inner Horizons and Holography

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We address the thermodynamic properties of the outer and inner horizons of non-extremal asymptotically flat black holes in four and five dimensions, focusing on so-called STU black holes. We show that if one regards the Christodoulou and Ruffini formula for the total energy or enthalpy as defining the Gibbs surface, then the rules of Gibbsian thermodynamics imply that negative temperatures arise inevitably on inner horizons, as does the conventional form of the first law. We also give a discussion of left-moving and right-moving temperatures and entropies, and show that both the left-moving and right-moving temperatures are non-negative. The left-moving sector contributes half the total energy of the system, and the right-moving one contributes the other half. Microscopic interpretation of these results within so-called subtracted geometry is also addressed.