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On the local thermodynamic relations in relativistic spin hydrodynamics

In this talk, I will present our latest research building upon the findings of PLB 850 (2024) 138533, which demonstrated that the entropy current can be derived from first principles using the quantum statistical method, bypassing the need for assumed traditional local thermodynamic forms. Our study uncovers that the local thermodynamic relations, which have been conventionally used as educated guesses in relativistic hydrodynamics with spin based on global thermodynamic equilibrium, are generally inadequate. We will present two specific examples to illustrate this: a system of massless and massive free fermions under rotation and acceleration at global thermodynamic equilibrium. Our findings reveal that the traditional local thermodynamic relations are incomplete when the spin tensor is considered. Notably, we show that the derivative of the pressure function with respect to the spin potential deviates from the spin density, acquiring corrections due to acceleration and rotation. These results suggest that for an accurate derivation of constitutive relations in relativistic spin hydrodynamics, the traditional thermodynamic relations must be extended.

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