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“Internal Energy, Fundamental Thermodynamic Relation, and Gibbs’ Ensemble Theory as Laws of Statistical Counting”

Counting ad infinitum is the holographic observable to a statistical dynamics with finite states under independent repeated sampling. Entropy provides the infinitesimal probability for an observed frequency $n$ w.r.t. a probability prior $p$. Following Callen’s thermodynamic postulate and through Legendre-Fenchel transform, without help from mechanics, we show an internal energy $u$ emerges; it provides a linear representation of real-valued observables with full or partial information. Gibbs’ fundamental thermodynamic relation and theory of ensembles follow mathematically. $u$ is to $n$ what omega is to $t$ in Fourier analysis.

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