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A Principled Basis for Nonequilibrium Dynamics

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Abstract: The laws of material equilibria follow a well-known logic: a First Law (conservation); a Second Law (entropic tendency); and Legendre Transforms that give: (i) forces (T, P, μ) from observables (U, V, N), (ii) the conjugate phase-space coordinates they constitute, and (ii) the fluctuation-response and Maxwell Relations they obey. There has been no equivalent logic for non-equilibria such as energetic or material flows in biology. I will describe such a logic, which we call Caliber Force Theory (CFT). It requires replacing (U, V, N) with dynamic observables (node probabilities, edge traffics, and cycle fluxes) and state entropies with path entropies. I will describe some of the new concepts and relations it gives, and how it synthesizes Stochastic Thermodynamics, Large Deviation Theory, and Maximum Caliber Principle.