Pure fluids to black holes: thermodynamics probes microstructures

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What can the thermodynamic entropy tell us about the microstructures in a thermodynamic system? As I argue in this talk, the answer is a surprising amount. Simple fluctuation theory provides a thermodynamic metric based on information geometry. This metric carries with it a curvature function R, which plays a special role as the only thermodynamic invariant. The magnitude of R is the correlation length, and its sign is positive/negative for systems with interparticle interactions repulsive/attractive. I discuss a number of basic examples of pure fluids and magnetic systems. Another essential scenario consists of black holes, where there is no currently accepted microscopic theory. But there is a well-established black hole thermodynamic structure, and I will discuss the considerable work that has been done exploring what R has to tell us about black hole microstructures.