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Enhancing the understanding of entropy through computation

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We devise a hierarchy of computational algorithms to enumerate the microstates of a system comprising N independent, distinguishable particles. An important challenge is to cope with integers that increase exponentially with system size, and which very quickly become too large to be addressed by the computer. A related problem is that the computational time for the most obvious brute-force method scales exponentially with the system size which makes it difficult to study the system in the large N limit. Our methods address these issues in a systematic and hierarchical manner. Our methods are very general and applicable to a wide class of problems such as harmonic oscillators, free particles, spin J particles, etc. and a range of other models for which there are no analytical solutions, for example, a system with single particle energy spectrum given by {\epsilon}(p,q) = {\epsilon}0 (p^2 + q^4), where p and q are non-negative integers and so on. Working within the microcanonical ensemble, our methods enable one to directly monitor the approach to the thermodynamic limit (N \rightarrow \infty), and in so doing, the equivalence with the canonical ensemble is made more manifest. Various thermodynamic quantities as a function of N may be computed using our methods; in this paper, we focus on the entropy, the chemical potential and the temperature.

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