How small does your rice pudding need to get when stirring jam into it?

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Have you ever tried turning the spoon back after stirring jam into a rice pudding? It never brings the jam back into the spoon. This ever-increasing disorder is linked to a notion called entropy. Entropy is of interest to physicists studying the evolution of systems made up of multiple identical elements, like gas. Yet, how the states in such systems should be counted is a bone of contention. The traditional view developed by one of the fathers of statistical mechanics, Ludwig Boltzmann - who worked on a very large number of elements - is opposed to the seemingly disjointed theoretical perspective of another founding scientists of the discipline, Willard Gibbs, who describes systems with a very small number of elements.

In a new study published in *EPJ Plus*, Loris Ferrari from the University of Bologna, Italy, demystifies this clash between theories by analysing the practical consequences of Gibbs' definition in two systems of a well-defined size. Ferrari speculates about the possibility that, for certain quantities, the differences resulting from Boltzmann's and Gibbs' approach can be measured experimentally.

This debate centres around the notion of negative absolute temperature (NAT), seen as a misleading consequence of Boltzmann's definition of entropy. In contrast, Gibbs' theory prohibits NAT and makes the energy equipartition rigorous in systems of arbitrary size. The two approaches, however, converge when the systems have a very large number of elements. So the issue here is to define the minimum size system for which both theories agree.

To test the two approaches against each other, the author examines two models; namely a gas of N atoms which do not interact chemically and another system with N interacting spins. His numerical simulations show that it is possible to assess which of the two models is the most accurate using experimental proof.

More information: Loris Ferrari, Comparing Boltzmann and Gibbs definitions of entropy in small systems, *The European Physical Journal Plus* (2017). DOI: 10.1140/epjp/i2017-11756-5

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