ABSTRACTS

Typicality in Statistical Mechanics: An Epistemological Approach
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In recent years, the concept of typicality has been the center of a lively debate on the foundations of statistical mechanics. Briefly said, the idea behind this notion is that the size of the set of microstates leading to equilibrium is so overwhelmingly larger than any other set, that the system will "typically" reach the equilibrium during a very short time. According to its upholders, the concept elucidates the emergence of thermal equilibrium by, at the same time, eschewing dubious dynamical assumptions such as ergodicity. Its critics, however, counter that this approach to equilibrium statistical mechanics is not immune from the problems that have traditionally beset ergodic theory or the information-theoretical approach. In spite of the cogency of the philosophical arguments, physicists supporting typicality are far from impressed. Even philosophically-minded physicists do not engage these objections and sometimes even debunk them as misunderstandings. They usually claim that typicality is not a form of probability and therefore much of the probability-based philosophical objections are mere misconceptions. As a result, a potentially fruitful debate on the explanatory value of typicality has now stalled.

In this paper, I argue that part of the problem lies in the fact that philosophers use accounts of explanation too distant from actual scientific practice. My proposal is to consider explanations as epistemic stories that combine a cognitive and a socio-historical dimension. From this perspective, it becomes understandable why many physicists find themselves at ease with the typicality language.

On the probabilistic approach to renormalization
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This paper is about the probabilistic approach to renormalization in statistical mechanics, pioneered by authors such as Sinai and Jona Lasinio. Recall that the central limit theorem (CLT) states that successive standardised averages of independent and identically distributed random variables with a finite variance have the Gaussian N(0,1) as limit. One naturally asks: What about: other ways of taking the average? Or averages of subsequences? Or dependent random variables? Or random variables with infinite variance? Much is known about such questions; and the probabilistic approach to renormalization connects such results to understanding the critical point at the thermodynamic limit.

The key idea of this connection is clearest for the paradigm case of the classical Ising lattice, which associates a random variable with each site of a lattice (or chain). Thus Gibbsian statistical mechanics assigns to each block of the lattice, a probability distribution over configurations (random fields). Critical phenomena involve the large-scale behaviour of such a system. So to understand them, one wants to study the induced probability distributions for successive averages over appropriately chosen larger and larger blocks, i.e. the results of successive block-spin transformations. But due to the interaction between neighbouring sites, the random variables are dependent; and so one seeks appropriate generalizations of the CLT.

The probabilistic results, above, gives such generalizations: some in which the limiting distribution is again Gaussian, and some in which it is not—allowing one to classify critical points. Physics apart: the main philosophical pay-off is that this approach’s results: (i) teach us to think of universality and emergence in terms of domains of attraction of a limiting probability distribution, and (ii) strengthen Khinchin’s program in the foundations of statistical mechanics (by weakening his main premise to allow for dependence of random variables, and so generalizations of the CLT).

On How to Approach the Approach to Equilibrium
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A great deal of philosophical literature on statistical mechanics is concerned with recovering aspects of thermodynamics. These works typically aim at recovering something like the following qualitative fact: (T1) isolated macroscopic systems that begin away from equilibrium approach equilibrium and then remain in equilibrium for incredibly long periods of time. The most popular attempts to account for (T1) appeal to typicality. This paper ignores the usual concerns with these accounts and instead highlights their limitations. These accounts do not underpin the kinds of facts we usually care about most. They also do not have the resources to answer the questions we are most interested in concerning the behaviour of systems away from equilibrium. While they may underpin facts like (T1), they do not underpin facts about the rates in which systems approach equilibrium, about the kinds of states they pass through on their way to equilibrium, or about fluctuation phenomena.
I suggest that the limitations of these accounts are a symptom of what they are aiming at. By focusing on recovering aspects of thermodynamics, those contributing to the literature have merely been in the business of recovering a few qualitative facts. To remedy this situation, I suggest moving the discussion away from these accounts and onto understanding why the techniques physicists actually use to model the behaviour of nonequilibrium systems are effective. By understanding the success of these techniques, we will not only be able to underpin qualitative facts like (T1) but we will also be able to underpin many of the important quantitative facts that typicality accounts cannot. I also take some of the first steps in this direction by outlining and attempting to rationalise a technique commonly used by physicists. The approach takes its cue from the theory of Brownian motion.