Open questions in statistical mechanics [draft]

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Some unanswered questions in the foundations of statistical mechanics

1   Questions

1.1   Meaning and use of "average" in the canonical ensemble. Implications for the theory of fluctuations

In speaking of the canonical ensemble we say that the energy value U is only an "average". Do we mean an average over time while we observe such a system? Or an average over identical preparations of such a system?

The difference is important because in the second case the system, after preparation, may have an energy U^*, with $U^* \approx U$, that is perfectly constant in time. It also means that such a system may be perfectly closed: we can use the canonical ensemble also for a perfectly closed system, but created with a protocol that does not always lead to the same energy.

From the second point of view the fluctuations of the system are not fluctuations in time while we observe it: they are differences among identical preparations of the system.

This also mean that the fluctuations that we observe in time in a system described by the canonical ensemble may be different from the fluctuations obtained across preparations, and may be absent altogether.

The Gaussian ensemble[1] allows for the exact specification of fluctuations across identical preparations.

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[1] **johaletal2003; hetherington1987**.