Physics 127a: Class Notes

Lecture 1: The Fundamental Postulate

After a general discussion of the scope of Statistical Mechanics I introduced the **Fundamental Postulate** of equal *a priori* probabilities:

> **An isolated system in equilibrium is equally likely to be found in any of the microstates accessible to it.**

This phrase introduces a number of ideas that will be developed further in future lectures:

System: part of the universe we are interested in, only weakly coupled to the rest of the universe so that the dynamics is dominated by the internal interactions.

Isolated: idealization — eliminate all external influences, in particular no forces, energy flux, particle flux etc. so that quantities conserved by the internal dynamics are strictly constant for the isolated system.

Equilibrium: wait long enough so that all transient behavior dies out, and measurements of macroscopic quantities become time independent.

Microstate: a complete microscopic specification of the particles so that the dynamics of the whole system could be followed in principle. Basically where particles are, and their velocities, for a classical system, and the quantum state (wave function) for a quantum system.

Likely: we are dealing with probabilities! To make this idea precise for a single system, we introduce the notion of an **ensemble** — a huge number of essential repetitions of the system (i.e. macroscopically the same, but maybe differing in microscopic properties such as initial conditions of the particles). The probability of a microstate is then the fraction of the members of the ensemble in which the microstate is represented. We usually assume that the average done in a typical experiment, which is usually a time average on a single system, are well predicted by ensemble averages. This relies on an idea known as **ergodicity**.

Accessible: consistent with the macroscopic constraints, usually the values of the conserved quantities e.g. fixed energy, number of particles etc., but may also include others, e.g. an "order parameter" defining the state below a phase transition, or the separation of the ends of a long polymer.

The fundamental assumption reduces the probability of finding a macroscopic configuration in an isolated system to **counting** the number of microstates consistent with the macroscopic configuration.