1.5: Classical microscopic states or microstates and ensembles

A *microscopic state* or *microstate* of a classical system is a specification of the complete set of positions and momenta of the system at any given time. In the language of phase space vectors, it is a specification of the complete phase space vector of a system at any instant in time. For a conservative system, any valid microstate must lie on the constant energy hypersurface, $H(x) = E$. Hence, specifying a microstate of a classical system is equivalent to specifying a point on the constant energy hypersurface.

The concept of classical microstates now allows us to give a more formal definition of an ensemble. An ensemble is a collection of systems sharing one or more macroscopic characteristics but each being in a unique microstate. The complete ensemble is specified by giving *all* systems or microstates consistent with the common macroscopic characteristics of the ensemble.

The idea of ensemble averaging can also be expressed in terms of an average over all such microstates (which comprise the ensemble). A given macroscopic property, A, and its microscopic function $a = a(x)$, which is a function of the positions and momenta of a system, i.e. the phase space vector, are related by

$$A = \langle a \rangle_{ensemble} = \frac{1}{N} \sum_{\lambda=1}^{N} a(x_\lambda)$$

where x_λ is the microstate of the λ th member of the ensemble.