3.10 Introduction to LTE Model Atmospheres

3.10.1 Definition of LTE (Local Thermodynamic Equilibrium)

LTE is a valid assumption if thermodynamic equilibrium holds at the local value of the temperature $T(r)$ and density $\rho(r)$.

The Source Function S_ν is then given by $B_\nu(T)$, the excitation and ionization state of the gas are given by the Boltzmann and Saha equations, and the velocity distribution of the particles follows a Maxwellian distribution.

Microscopically, LTE holds if all atomic processes are in detailed balance i.e. the number of any given process is exactly balanced by the same number of opposite processes.

LTE is valid if:

1. The density is high. Collisions then dominate and drive the excitation, de-excitation and ionization to the Boltzmann, Saha values. This is because the electrons have a Maxwellian velocity distribution and collisions will distribute the temperature information among the atomic levels and so local equilibrium will be maintained.
2. The optical depth is large and thus the photons will have a small mean free path. If radiative processes dominate over collisions, then the local conditions will still have a dominating effect because of the small photon mean free path.

In stars, LTE is valid in the interior if the density is high and the mean free path is low.

LTE will break down in the upper layers of a star since the optical depth is small and the photons can escape. The number of photo-excitations will then drop below spontaneous de-excitations and the detailed balance requirements will not be met.

Departures from LTE are most likely to occur in hot stars which have a strong radiation field and in stars with low density atmospheres (supergiants).