4. OPACITIES

The equations of hydrostatic equilibrium, radiative transfer and radiative equilibrium together with the complications of convection (Section 5) describe the stellar material from the *macroscopic* point of view.

Within this framework, we also have the interaction of radiation with the atoms/ions/molecules with a detailed frequency dependence, which depends on the detailed properties of the gas on the *microscopic* level (level populations, ionization state).

These interaction processes determine the opacity χ_ν which with the equation of radiative transfer determines how the frequency distribution of the radiation field is modified, as radiation flows from the interior to the surface of the star to be emitted (and observed) as the emergent spectrum.

The monochromatic opacity χ_ν quantifies the property of a material to remove energy of frequency ν from a radiation field. The removal of energy from a beam of photons as it passes through matter (i.e. stellar interior or atmosphere) is governed by:

1. spectral line absorption (bound-bound absorption)
2. bound-free absorption (photo-ionization)
3. free-free absorption (absorption of a photon by an electron that briefly interacts with an ion)
4. Rayleigh (photon) scattering / electron scattering

Items 2–4 are continuum processes. The total opacity is the the sum of the individual processes plus bound-bound absorption at a given frequency. Most of the continuous opacity is due to hydrogen in some form since it is by far the most abundant element. The continuous opacity is therefore dominated by the properties of the H atom.

For example, a photon will interact with a hydrogen atom, it will absorbed and have sufficient energy to remove the electron i.e. ionize the H atom. The photon will be lost from the radiation field and this will cause an absorption in the spectrum corresponding to the frequency of the photon. The depth of the absorption is determined by the atomic absorption coefficient a_{bf} and the number of H atoms.