

7 - ATOMIC PROCESSES

Atomic processes can be:

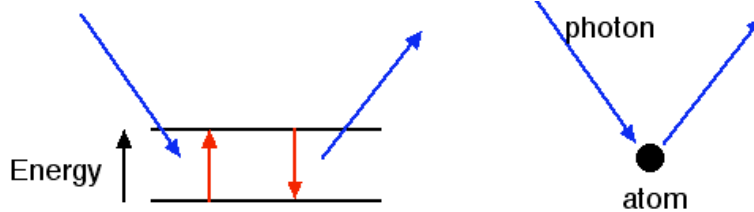
1. Scattering
2. Absorption/Thermal Emission

They may also be:

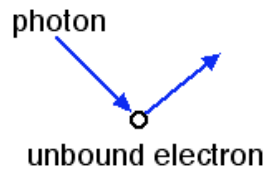
- A. Line processes
- B. Continuum processes

Scattering

Line (bound-bound) Scattering



Continuum Scattering



During the scattering process, the frequencies may change a little:

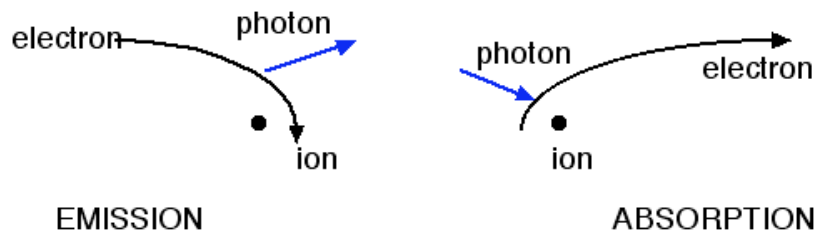
Lines \Rightarrow widths of energy levels

Continuum \Rightarrow Thomson scattering (recoil of electron)

Generally, we will assume isotropic scattering, although the results won't change much when this condition is relaxed.

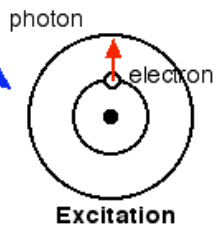
Absorption/Thermal Emission

Free-free (continuum) ("Bremsstrahlung") Emission/Absorption

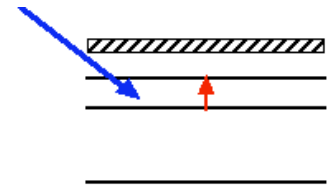


Bound-Bound & Bound-Free Processes

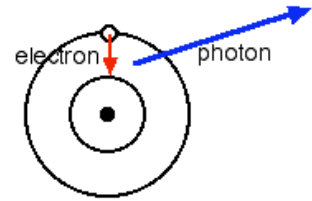
Bound-Bound



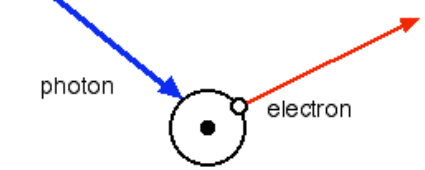
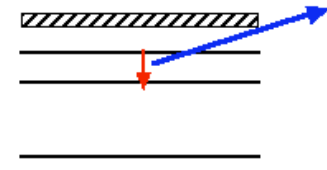
Excitation



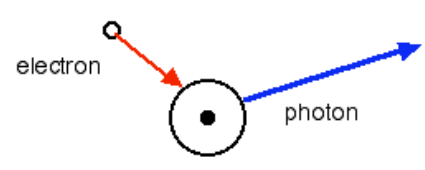
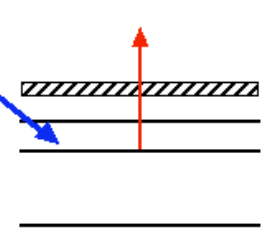
Bound-Free



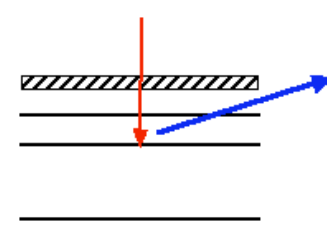
Deexcitation



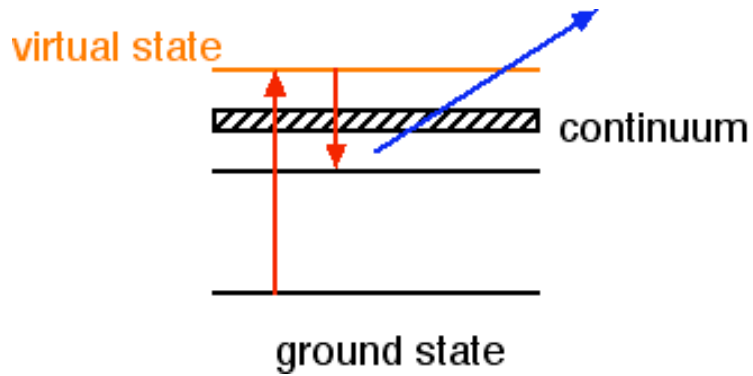
Ionization



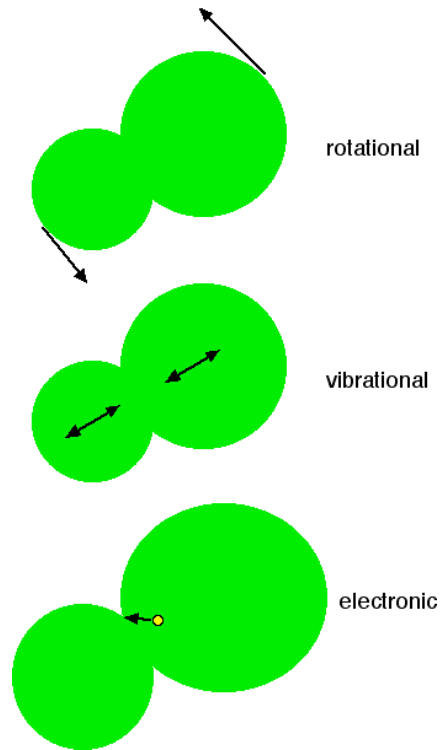
Recombination



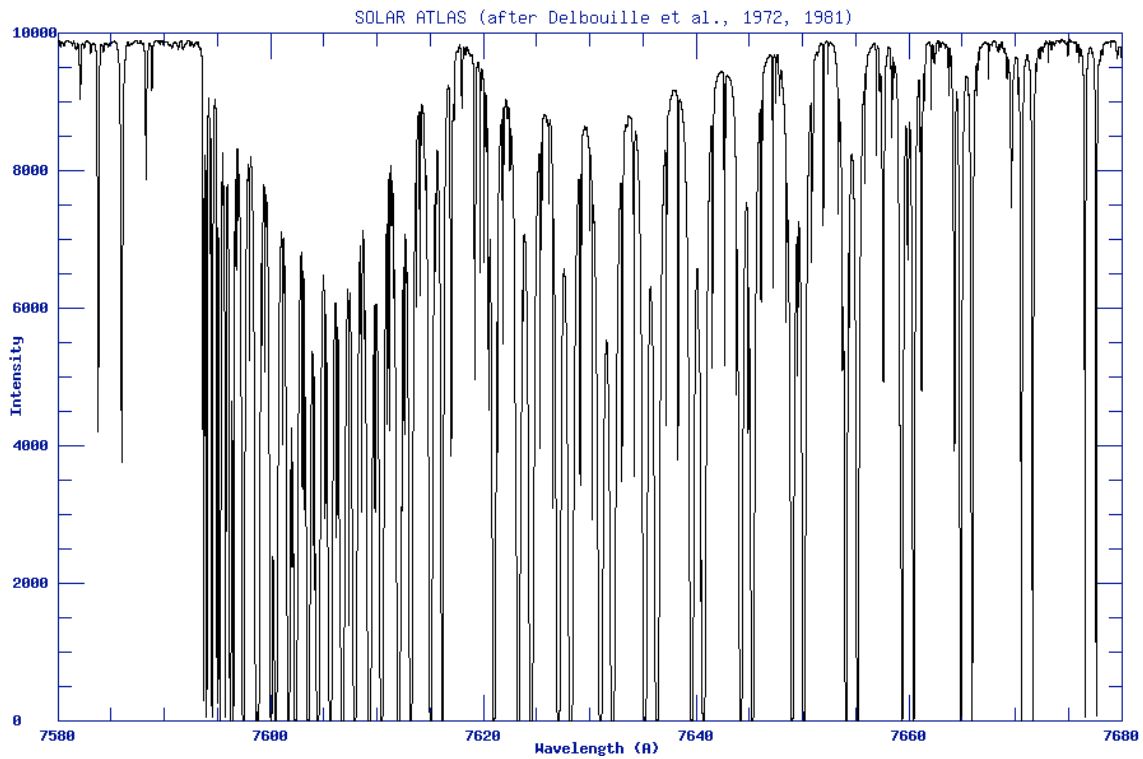
Auger Transitions, Autoionization & Dielectric Recombination



Molecular Processes: rotational, vibrational, electronic



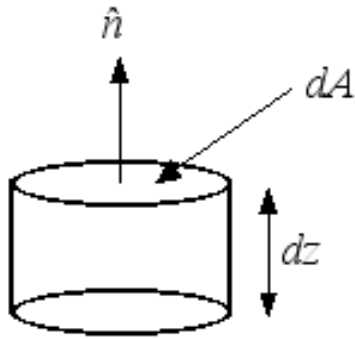
These can produce very complex emission and absorption bands



The solar spectrum, showing the effects of telluric O₂ absorption.

Emission Coefficient (j_λ, j_ν, j)

j_ν - Energy (erg) at frequency ν per gram per second per Hz per ster



$$dE_\nu = j_\nu dmdt d\nu d\omega$$

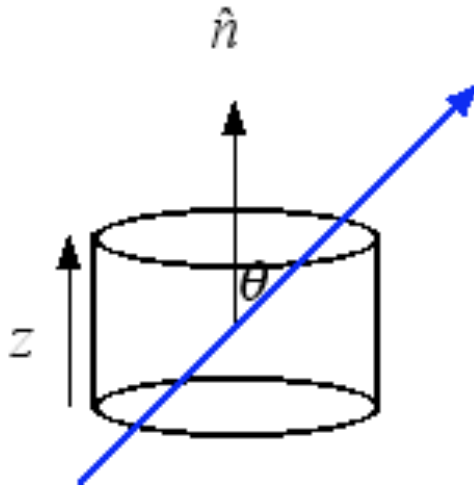
$$= j_\nu (\rho dA dz) dt d\nu d\omega$$

$$j_\nu = j_\nu^{sc} + j_\nu^{th} \quad \text{scattering + thermal}$$

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energy scattered into the beam from another direction

Extinction Coefficient



$$dE_\nu \propto E_\nu(\text{incident}) \cdot (\text{path length}) \cdot \rho$$

$$dE_\nu = k_\nu (I_\nu dA \cos \theta d\omega dt d\nu) \cdot (dz \sec \theta) \rho$$

$$= k_\nu I_\nu \rho dA dz d\omega dt d\nu$$

(units of k_ν are $\text{m}^2/(\text{kg Hz})$)

$$\text{and } dE = \rho dA dz d\omega dt \int_0^\infty k_\nu I_\nu d\nu$$

(units of k are m^2/kg)

$$k_\nu = \sigma_\nu + \kappa_\nu \quad \text{scattering + thermal}$$