# Atomic Physics

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## 1 NLTE Equation of state

## 2 NLTE opacities

There are multiple processes that control the physics of photons:

- Absorption or destruction of photons
  - Bound-bound excitation (**stimulated absorption**)
  - Bound-free ionization (**photoionization**)
  - Free-free photo-absorption (**inverse breemstrahlung**)
  - Pair production: Beta-Heitler ($\gamma \rightarrow e^- + e^+$), linear Breit-Wheeler ($\gamma + \gamma' \rightarrow e^- + e^+$), non-linear Breit-Wheeler ($\gamma + n\gamma' \rightarrow e^- + e^+$).
- Emission or creation of photons
  - Bound-bound de-excitation (**stimulated emission**, **spontaneous emission**)
  - Free-bound recombination
  - Free-free photo-emission (**breemstrahlung from Coulomb collisions**)
  - Cyclotron, Synchrotron, and Betatron radiation
  - Pair annihilation
- Scattering of photons
  - **Rayleigh scattering**: elastic scattering of a photon from an atom or molecule whose size is less than that of the wavelength of the photon.
  - **Mie scattering**: same as Rayleigh scattering but for cases where the sizes of the atoms or molecules are comparable to the wavelength of the incoming photon.
  - **Raman scattering**: inelastic scattering of a photon from a molecule. The interaction changes the molecule's vibrational, rotational, or electron energy.
  - **Brillouin scattering**: inelastic scattering of a photon caused by its interaction with material waves in a medium (i.e. mass oscillation modes, charge displacement modes, magnetic spin oscillation modes).

  - **Compton scattering**: inelastic scattering of a photon from a charged particle.
  - **Thomson scattering**: low-energy limit of Compton scattering. The photon energy and the particle's kinetic energy do not change as a result of the scattering. Can be explained with classical electrodynamics.

- Reflection???
- **Pair production/annihilation**