Blackbody

Requires:
- Object of high opacity
- Plus standard "thermal" conditions

Visual:
- Basic Emission from thermal motions.

Spectrum:
- Common sources: Cosmic microwave background, stars, planets, etc.

Free-free / Thermal Bremsstrahlung

Requires:
- Ionized medium
- Plus standard "thermal" conditions.

Visual:
- Free- is accelerated due to Coulomb force from proton

Spectrum:
- Opt. thick regime
- Opt. thin regime

Common sources: HII regions, solar wind, etc.

These are both "thermal" mechanisms, which requires:
- All e- have same characteristic temperature (LTE).
- Brightness depends on temperature: \( I_v(T_e) \)
- Thermal velocity distribution \( \langle v^2 \rangle = \frac{3kT}{m} \)

→ see ERA B.8
Synchrotron/Magneto Bremsstrahlung

**Relativistic**

- Relativistic protons or e⁻'s ("cosmic rays")
- Diffuse magnetic field

**Visual:**

- \( \vec{B} \) \hspace{1cm} \text{Relativistic } e^- \hspace{1cm} \text{constantly accelerated by magnetic field } \vec{B} \\

**Spectrum:**

- "opt thick" (synchrotron self-absorption)
- Defined by energy distribution of e⁻'s
- \( n(E) \propto E^{-\alpha} \) \hspace{1cm} \text{usually } \alpha = 2 - 0.7
- Down-turn from e⁻ energy losses (high E lose energy fast)
- Usually \( \frac{(1+z)^{-2}}{\nu} \) \hspace{1cm} \text{above this break}

Common sources: active galactic nucleus cores & jets, diffuse Galactic structure, supernova remnants, shocks in galaxies, etc.

Compton & Inverse Compton Scattering

**Compton Requires:**

- Low-energy \( e^- \)
- Incident high-energy photon

**Visual:**

- \( e^- \) gains energy
- Photon loses energy

**Invert Compton Requires:**

- High-energy (relativistic) \( e^- \)
- Low-energy photon

**Visual:**

- \( e^- \) loses energy
- Radio wave (gains energy)

Inverse Compton most relevant for us because requires:

- Relativistic e⁻'s (synchrotron source)
- External radiatron field
- Own radio waves (self-Compton)

**Spectrum:**

- Shifts radio waves to higher energy

Commonly seen: CMB as external rad. field, synchrotron source (AGN or cluster halo) in foreground.