Outline

- Go over problem 5-3
- Interstellar medium
- Molecules
- Atomic hydrogen
- Dust
- Reddening
- Dynamics

Colloquium on Monday:
“The Path to Magnetic Fusion Energy”
by Professor Stewart Prager, Princeton Plasma Physics Laboratory
Interstellar Medium

- Interstellar medium (ISM) contains:
  - ionized gas
  - neutral gas
  - molecular gas
  - dust
  - cosmic rays

- How do we see these components?
Interstellar Medium

- Ionized gas – optical, UV, IR emission lines

- Neutral gas
  - absorption lines
  - Spin-flip or hyperfine transition of HI makes 21 cm radio line emission

- Molecular gas
  - $\text{H}_2$ is inefficient radiator – too symmetric
  - CO often dominant coolant
  - OH, NH$_3$, complex molecules
  - stimulated emission from masers
Dust

- Grains containing Fe, Si, C, H₂O, CO₂ (ice)
- Sizes typically 1-250 nm
- Produced in evolved stars and supernovae

- Usually seen in absorption = reddening
- Dust produces infrared emission
  - blackbody at dust temperature, 20-100 K
  - lines from dust components, notable polycyclic aromatic hydrocarbons (PAHs)
Reddening / Extinction

- Dust absorbs more strongly at short wavelengths.
- Curve of absorption versus wavelength is a “reddening curve” or “extinction law”. Depends on dust properties (distribution of grain sizes).
- Need to correct for reddening when measuring fluxes or spectra.
- Usually use “Balmer decrement”. In most nebulae, emitted ratio \( \text{H}\alpha: \text{H}\beta: \text{H}\gamma = 2.8:1.0:0.47 \).
- Use observed \( \text{H}\alpha: \text{H}\beta: \text{H}\gamma \) and find extinction that best fits the data (with assumed reddening curve).
Dynamics of ISM

- Newly formed stars ionize the ISM.
- Winds from evolved stars, novae, and supernova circulate products of nuclear burning into the ISM.
- Galaxy-galaxy interactions disturb the ISM, often enhancing star formation.
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- Galaxy-galaxy interactions disturb the ISM, often enhancing star formation.
Homework

• For next class: problem 5-4