Spectroscopy
**Light: a Form of Energy**

- Light - electromagnetic transverse (up-down) waves traveling at $3 \times 10^8$ m/s.
- Wavelength - the distance between wave peaks.

| Wavelength | Energy | Color   |
|------------|--------|---------|
| shorter    | higher | “bluer” |
| longer     | lower  | “redder” |
Blackbody: Temperature Dependence

- All objects emit their own light, whose wavelength depends on temperature.
- As temperature increases molecules vibrate more → shorter wavelengths!

![ Spectrum Diagram ]
Blackbody: High Density

- Imagine an object so dense that it absorbs all light that hits it (no radiation passes through), and it re-emits all of the light that hit it (none is lost).

- **Blackbodies therefore emit a continuous spectrum** with a peak wavelength that is dependent on their temperature (how?).

- Do perfect blackbodies exist?

   ![Continuous Spectrum](image)

   **Wien’s Law:** \( \lambda_{\text{peak}} T = \text{constant} \)
Blackbody Emission: Cool Objects

Things near room temperature emit in the infrared!

\[ \lambda_{peak} T = (\sim 400 \ K) \ \lambda_{peak} = C \ [m \cdot K] \]

\[ \lambda_{peak} = 7.25 \ \mu m \ (IR) \]
Blackbody Emission: Hotter Objects

As $T$ increases to $\sim 3500 K$ peak emission is RED light.

$$\lambda_{peak} T = (\sim 3500 \, K) \quad \lambda_{peak} = C \, [m \cdot K]$$

$$\lambda_{peak} = 828 \, nm \quad \text{(visible - red)}$$
Blackbody Emission: Even Hotter Objects

As \( T \) increases to \( \sim 5500 \text{K} \) peak emission is \textbf{WHITE} light.

\[
\lambda_{\text{peak}} T = (\sim 5500 \text{ K}) \quad \lambda_{\text{peak}} = C \left[ m \cdot K \right]
\]

\[
\lambda_{\text{peak}} = 523 \text{ nm} \quad \text{(visible)}
\]
Blackbody Emission: Very Hot Objects

As $T$ increases to $\sim 9000 K$ peak emission is **BLUE** light.

$$\lambda_{peak}T = (\sim 9000 \, K) \quad \lambda_{peak} = C \, [m \cdot K]$$

$$\lambda_{peak} = 322 \, nm \quad \text{(visible - blue)}$$
Blackbody Emission: Visualization

10.6: Quantitative Behavior of Blackbody Radiation (follow along 1-3)

The Bohr Atom

\[ n \rightarrow \text{energy levels} \]

\[ \bullet \rightarrow \text{electrons} \]

\[ \text{gray} \rightarrow \text{nucleus} \]

*IMPORTANT*

Energy levels are discrete, or "quantized". Electrons can only be at particular energies, and no where in between!
Emission Line Spectrum

- Produced by \textit{low-density gas}.
- Lines come from downward electron energy jumps (remember, the electrons must “jump” energies because levels are \textit{discrete}, or “quantized”).
- Different elements have different lines because they have different electron configurations.
Absorption Line Spectrum

- Produced by cold, low-density gas in front of a blackbody.
- Lines come from \textit{upward} electron energy jumps due to the cloud atoms \textit{absorbing} photons.
- Lines still exist, but they are subtracted from the continuous spectrum of the background source.
- Again, different elements have different lines because they have different electron configurations.
very tiny scale

c cloud of molecules

spectrum
Which Spectrum is Which?
Matching
Helpful Hints

• Spectroscopes: DO NOT TOUCH SLIT OR DIFFRACTION GRATING!
• Spectroscope units are in hundreds of nm (so 4 means 400nm, etc.)*
• Come to me when you are ready to do 10.5. I will demonstrate it for you.
• Do not move the large spectroscope in front of the mystery element.
• Problem #4 in 10.6 is tricky for some. You know $T$ and $\lambda$ for 4 different points (Table 1), and since $C$ does not vary, you can use any of the points to solve for $C$. Please give your answer in units of $m \cdot K$ (weird, I know).
• Table 10.1 will not match 10.2 exactly; just do your best. You should still find that the trend matches a particular element.
• 10.8 is worth a large fraction of the points for this lab, so do not rush through the Questions section. If you don’t understand something, please ask!