The Physics of Spectrum Formation, Kirchoff’s Laws and Wien’s Law

• Hot opaque solid or liquid produces a continuous spectrum
• Hot, tenuous gas observed against dark background produces emission line spectrum
• Cold, tenuous gas observed against bright background produces absorption spectrum
Kirchoff’s Laws of Radiation

Source: A hot solid, liquid, or dense gas

Thin cloud of cool gas

Continuous spectrum

Dark line (absorption) spectrum

Bright line (emission) spectrum
Kirchoff’s First Law + Wien’s Law

- Hot, opaque objects produce *continuous spectrum*
- The hotter the object, the bluer it is
- Wien’s Law $w_{\text{max}} = 2.9\text{E}-03/T$
- The hotter an object, the brighter it is
- demo
Why does Wien’s Law look like that?

A physicist is bothered when he or she sees an equation like:

\[ w_{max} = \frac{2.90 \times 10^{-3}}{T} \text{ meters} \]

The form which emerges from fundamental equations of physics is:

\[ w_{max} = \frac{0.201hc}{k_B T} \]
The Planck Function...how radiation is distributed by a hot, radiating object.
Kirchoff’s Third Law: Absorption Spectra
The Maxwell-Boltzmann distribution of atomic speeds

$V_t = 2.00$
Absorption lines in planetary atmospheres

Cloud layer

atmosphere
The final class of binary stars: spectroscopic binaries

Wavelength is shorter; frequency is higher.

Wavelength is longer; frequency is lower.

demo
Spectroscopic binaries (3rd class of binaries); known to be binaries only because of periodic variations in the spectrum