Quick notes on

Blackbody Radiation

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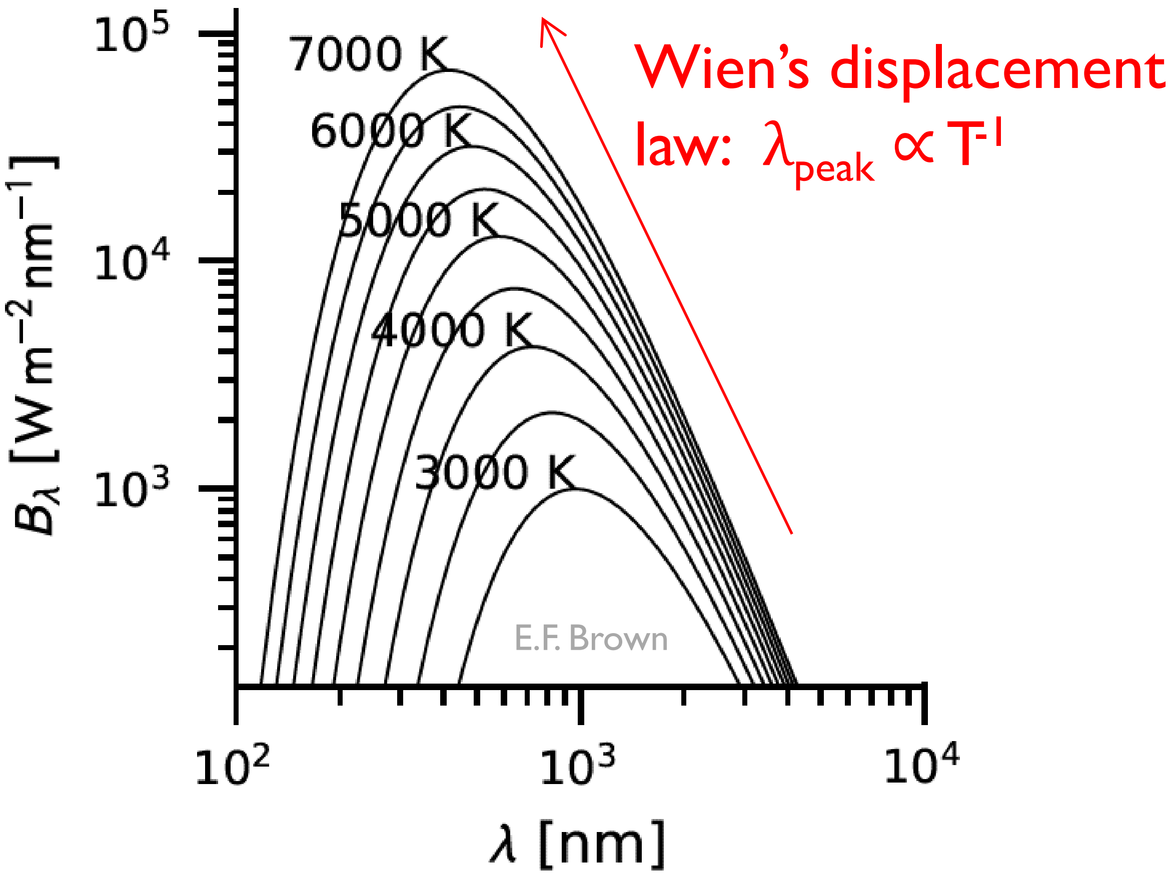
Blackbody Spectrum

- The Planck spectrum (a.k.a. blackbody)
- Intensity = $B(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{\exp\left(\frac{hc}{\lambda k_B T}\right) - 1}$ [Wsr $^{-1}$m^{-2}nm^{-1}]
- To express in frequency, perform substitution from c=λν
- By integrating over all λ and all outward angles (half of a sphere), the **outward flux** from a blackbody is $F_{bb} = \frac{2\pi^5 k_B^4}{15h^2 c} T^4 \equiv \sigma_{SB} T^4$

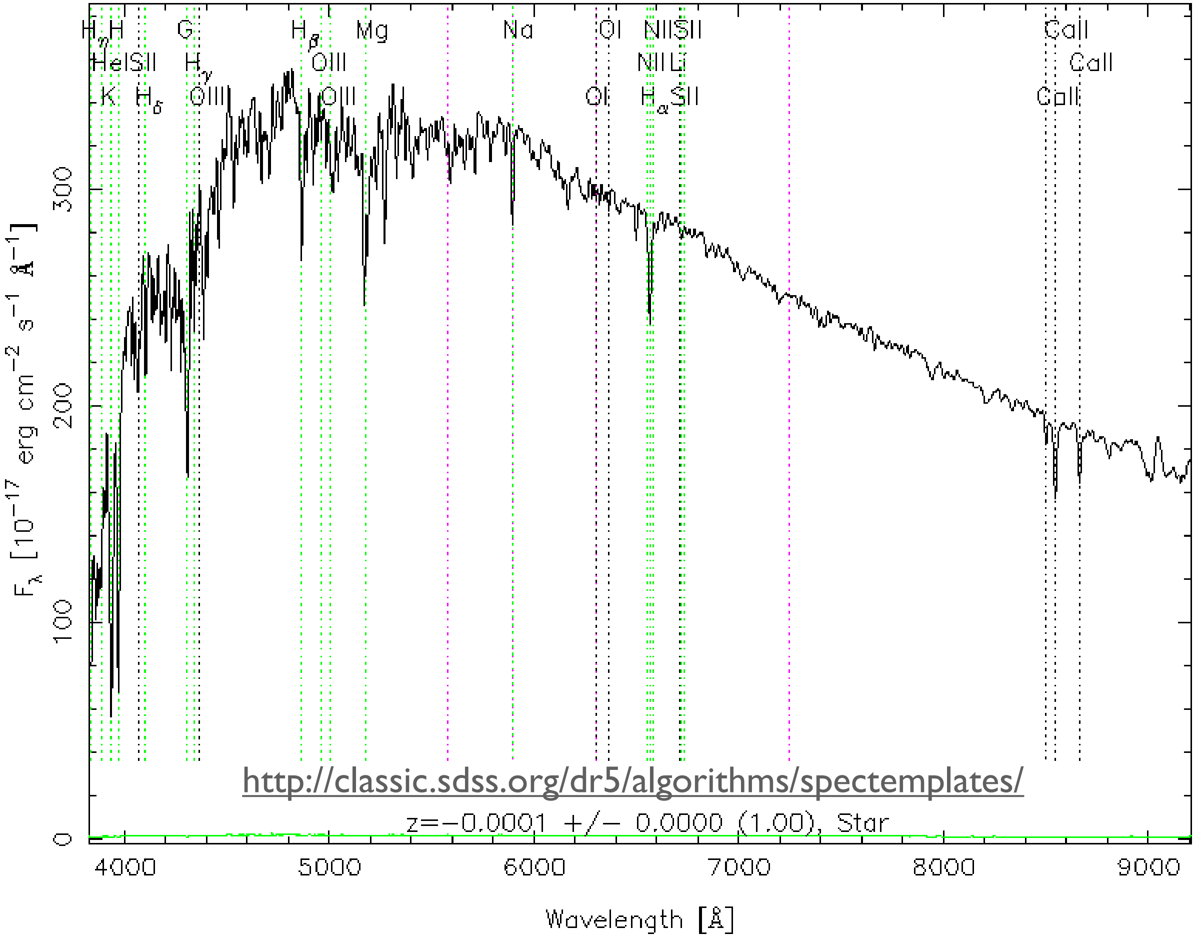


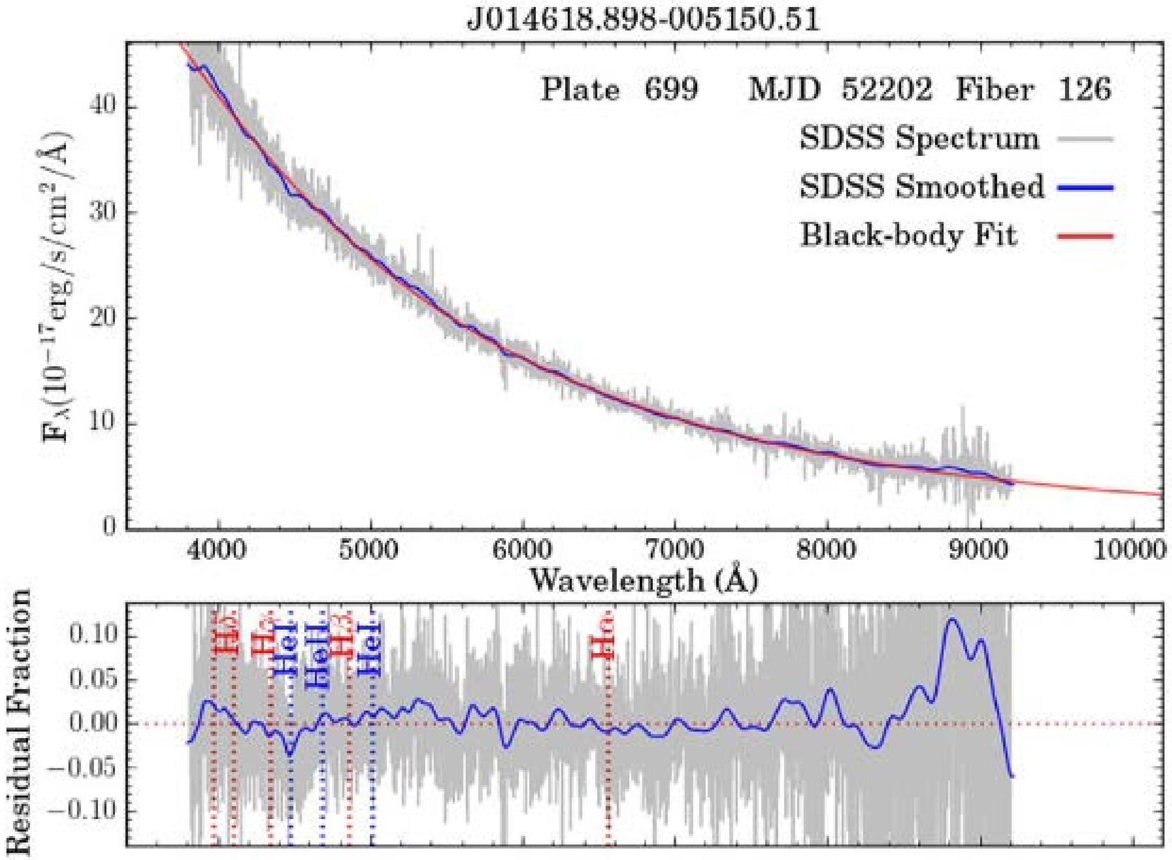
How good is "blackbody" for a star?

Often ok, but not so great…

…sometimes outstanding

Example G-Type Star from the Sloan Digital Sky Survey





Suzuki & Fukujita *AJ* 2019 found 17 out of 798,593 were "near black body"

Effective Temperature

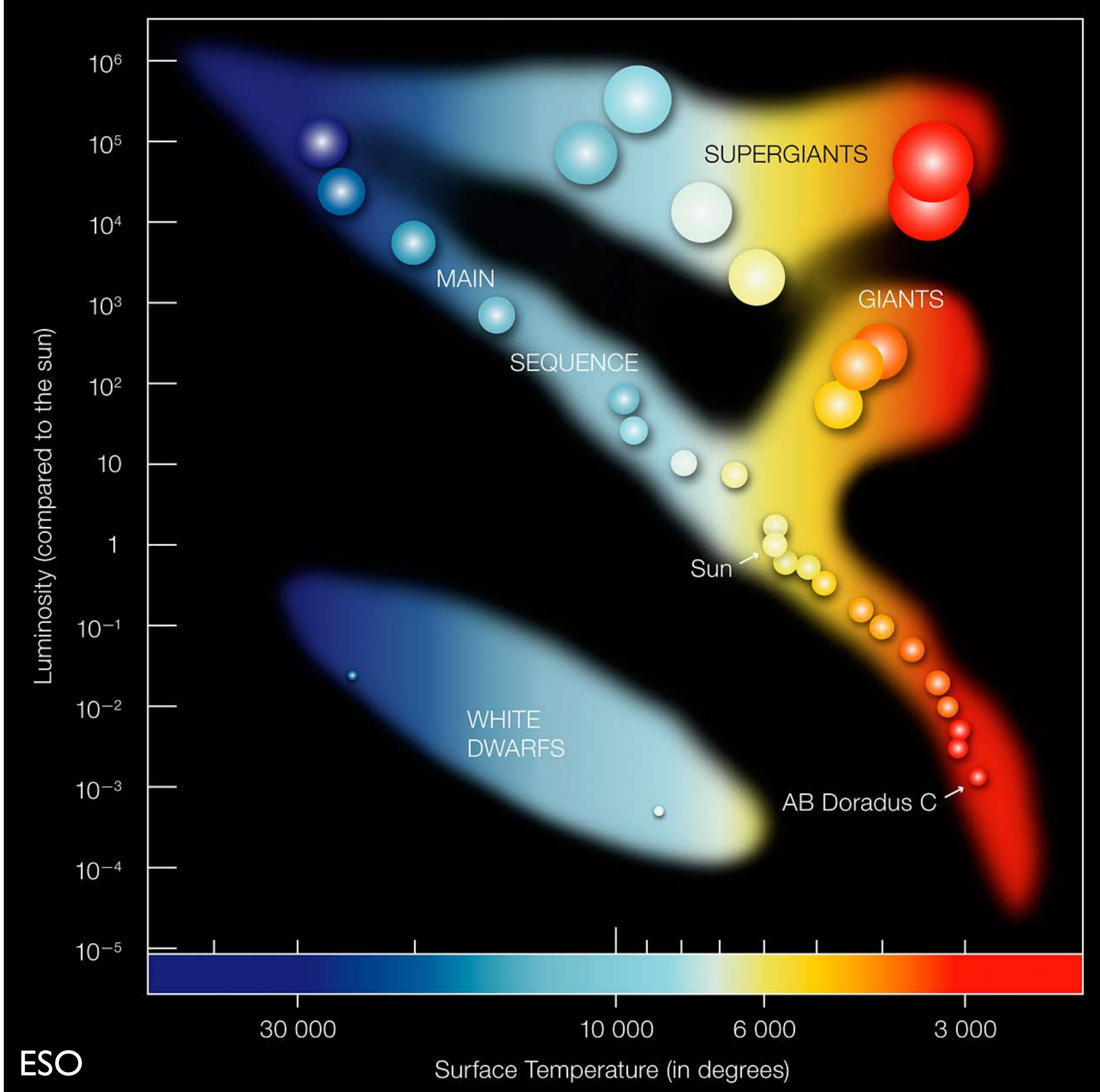
- By approximating a star as a blackbody, determine the **effective temperature**:

$$T_{\text{eff}} = \left(\frac{F}{\sigma_{SB}}\right)^{1/4}$$

- Meaning

$$L = 4\pi R^2 \sigma_{SB} T_{\text{eff}}^4$$

- A greater L for the same λ_{peak} means a larger R



Radiation Pressure

- Radiation pressure is one component of pressure propping a star up against gravitational collapse
- Pressure = Force/Area = (Rate of Change of Momentum)/Area
- For photons, momentum $p = \frac{E}{c}$
- Intensity, $I_\lambda = \frac{\Delta E}{\cos\theta dA d\Omega dt d\lambda}$.   …integrate over all angles and λ results in F/A
- Pressure from one wavelength, $P_\lambda = \frac{4\pi}{3c} B_\lambda$

really strong temperature dependence!

- Integrate over λ for **Total radiation pressure**, $P_{\text{rad}} = \frac{4}{3c}\sigma_{SB} T^4 \equiv \frac{1}{3} a T^4$
- The **radiation energy density** per wavelength $U_\lambda = \frac{dE}{dV d\lambda} = \frac{1}{c}\int I_\lambda d\Omega = \frac{4\pi}{c} B_\lambda$
- So, the total radiation energy density is $U = 3P_{\text{rad}}$.
  This is the photon equation of state.