Class Exercise

The high latitude spot lags the equatorial spot by 3 days or 1/10th of its orbit.

Therefore 10 orbits are needed before the overtake.

This takes 300 days.

A more accurate, formal mathematical solution is overleaf.

For the equatorial latitude spot

$$\theta_e = \omega_e t = \frac{2\pi t}{P_e}$$

and for the high latitude spot

$$\theta_h = \omega_h t = \frac{2\pi t}{P_h}$$

The overtake occurs when

$$\theta_e - \theta_h = 2\pi$$

$$\frac{2\pi t}{P_e} - \frac{2\pi t}{P_h} = 2\pi$$

$$t\left(\frac{1}{P_e} - \frac{1}{P_h}\right) = 1$$

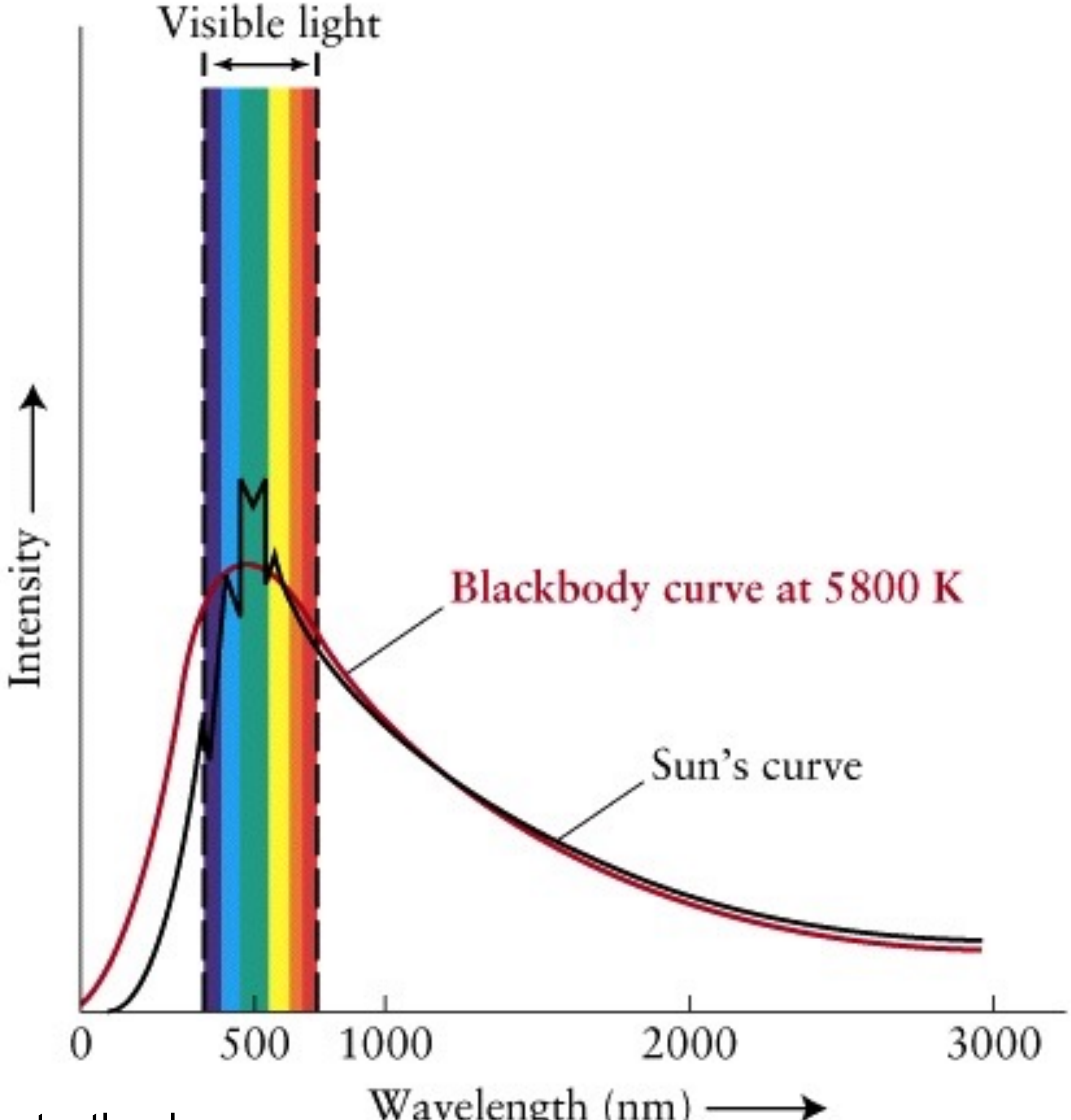
$$t = \frac{1}{\left(\frac{1}{P_e} - \frac{1}{P_h}\right)} = \frac{1}{\left(\frac{1}{27} - \frac{1}{30}\right)} = 270 \text{ days}$$

Starlight

- Continuum spectrum
- Blackbody radiation
- Wien’s Displacement Law
- Luminosity and Flux

Continuum Spectrum

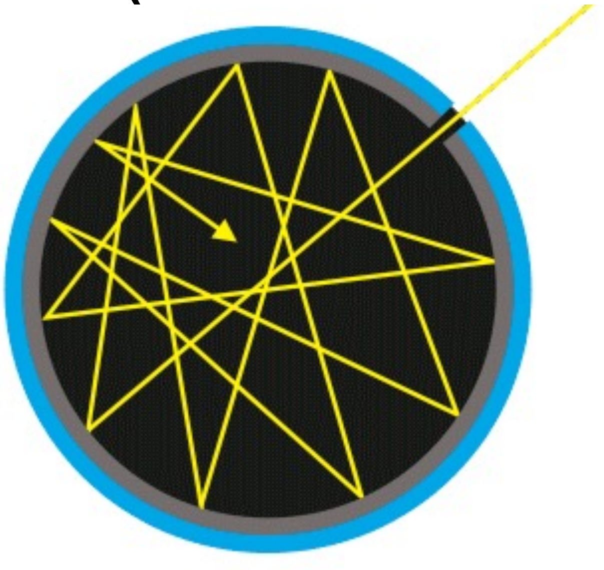
- The intensity of light from the Sun peaks at a wavelength λ=500nm
- Continuum spectrum is approximately that of a perfect blackbody with T=5800 K



From Universe textbook

Blackbody Radiation

- A perfect absorber and emitter of radiation is called a blackbody
- Intensity of radiation is described by the Planck function (see handout)



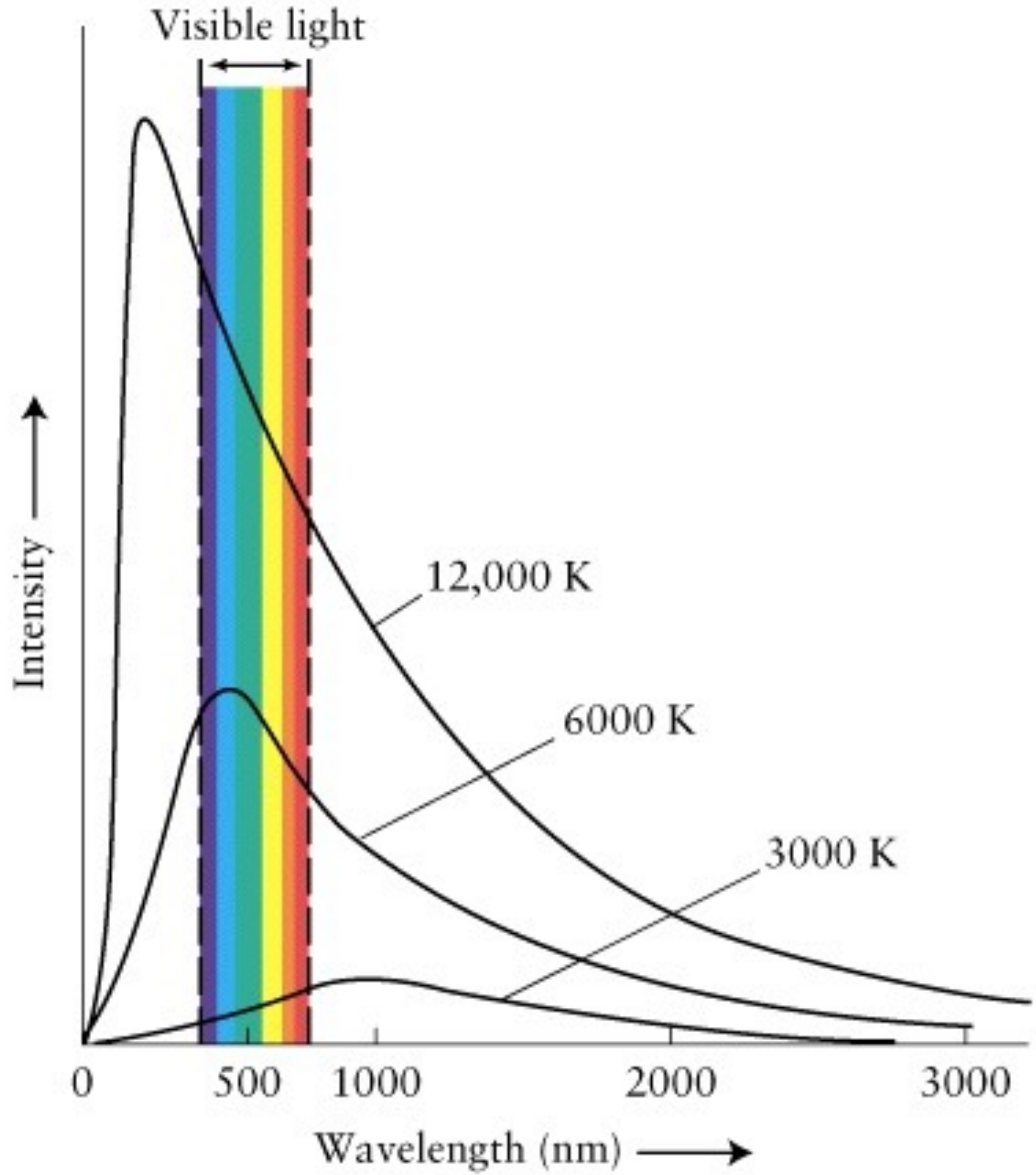
Conceptual Black Body

Wien Displacement Law

- The wavelength of the peak of the emission from a blackbody of temperature *T* is given by

$$\lambda_{\max} = \frac{3.10^{-3}}{T}$$

- The hotter the blackbody the shorter the wavelength of the peak emission



From Universe textbook

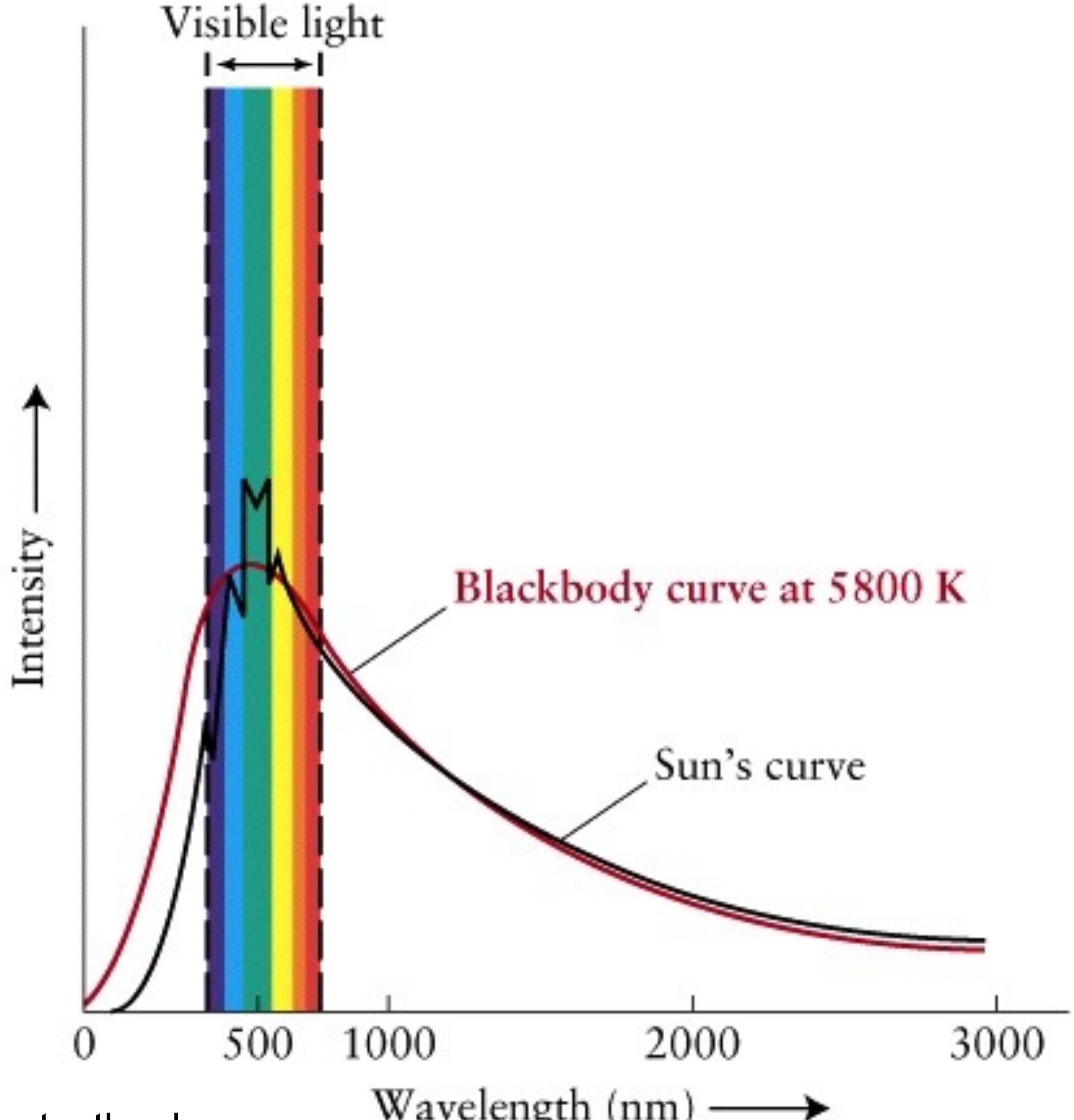
Example of the Sun

$$\lambda_{\mathrm{max}} = \frac{3.10^{-3}}{T}$$

$$= \frac{3.10^{-3}}{5800}$$

$$= 5.2 \times 10^{-7}\,\mathrm{m}$$

$$=520\ \mathrm{nm}$$



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Luminosity of a Blackbody

- The total power in the radiation from a sphere of radius *R* emitting blackbody radiation with temperature *T* is

$$L = 4\pi R^2 \sigma T^4$$

where σ is the Stefan-Boltzmann constant

Effective Temperature

- The *effective* temperature of a star is the surface temperature that a spherical blackbody with the star's radius would have to provide the star's luminosity. i.e.

$$L = 4\pi R^2 \sigma T_{eff}^4$$

Class Exercise

Calculate the effective temperature of the Sun given that it has a radius, $R=7 \times 10^8$ m and luminosity, $L=4 \times 10^{26}$ W

Class Exercise

$$L = 4\pi R^2 \sigma T_{eff}^4$$

$$T_{eff} = \left(\frac{L}{4\pi R^2 \sigma} \right)^{\frac{1}{4}}$$

$$= \left(\frac{4.10^{26}}{4\pi (7.10^8)^2 5.7.10^{-8}} \right)^{\frac{1}{4}}$$

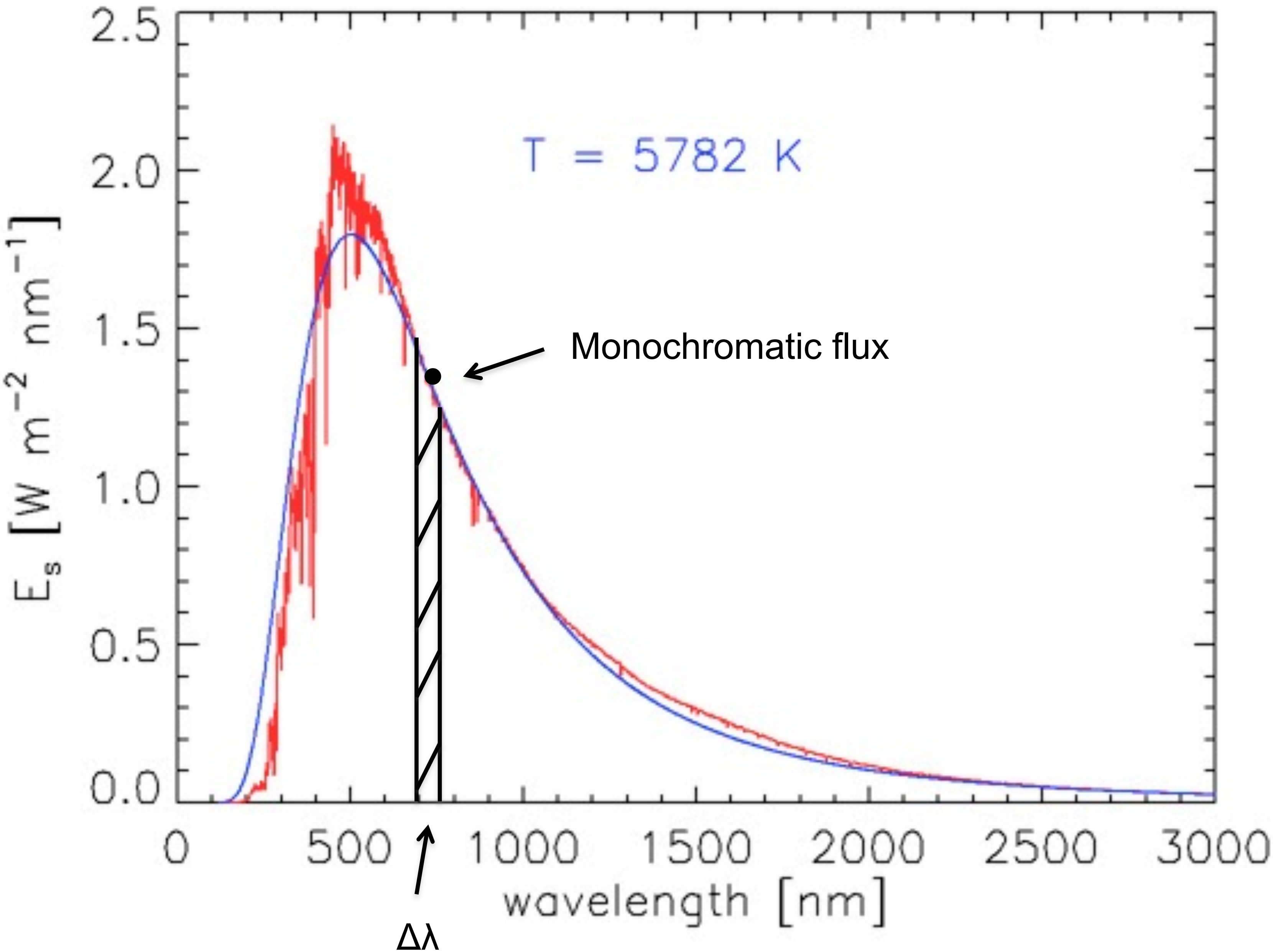
$$= 5\ 800\ \text{K}$$

Luminosity and Flux

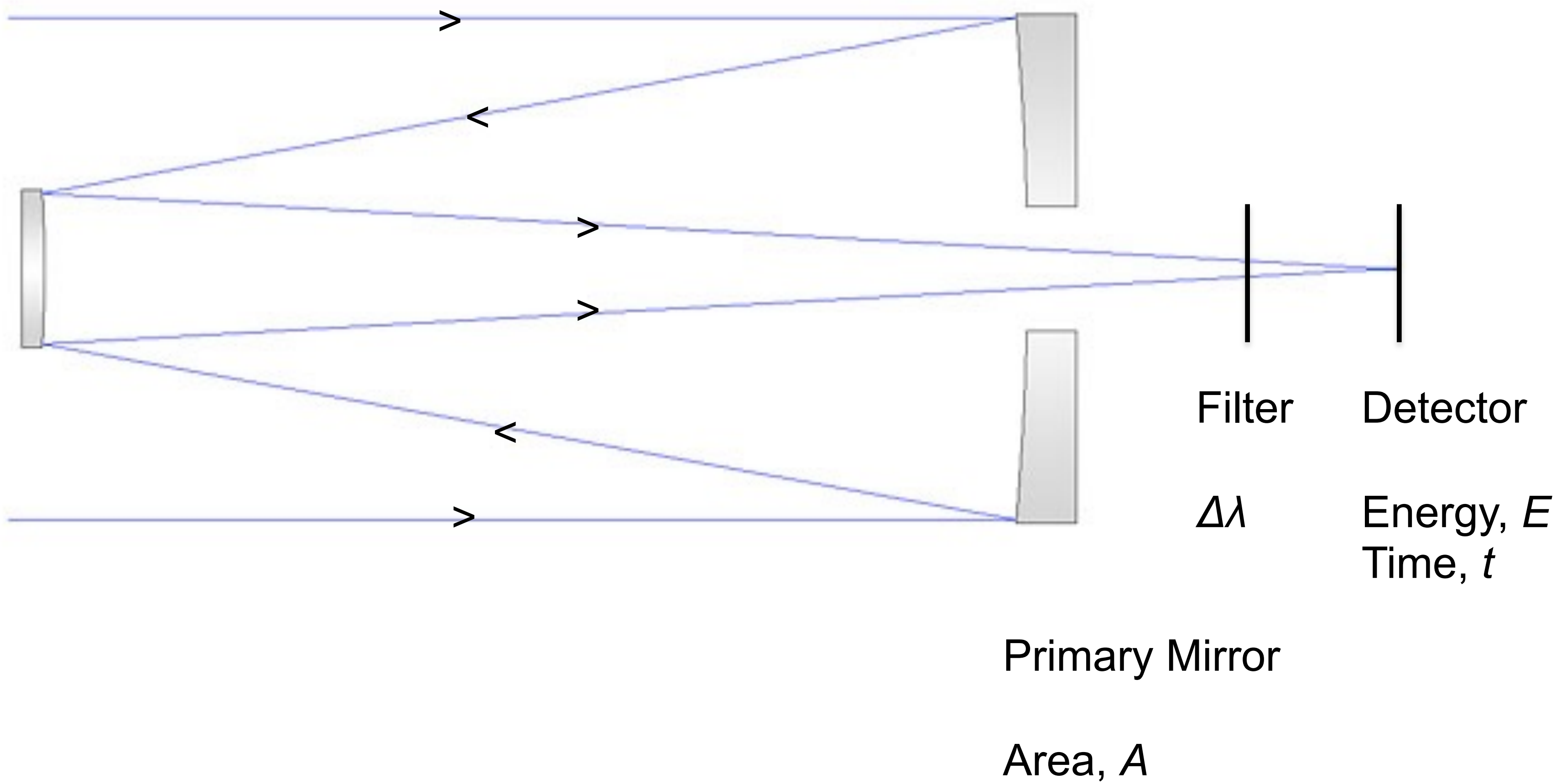
- We can also determine the luminosity of the Sun (or any star) by finding the total flux of radiation reaching Earth as long as we also know the distance
- When we observe the spectrum of a star we are measuring the flux of radiation as a function of wavelength

Monochromatic Flux

- monochromatic flux of radiation f_λ is defined as the amount of energy crossing a unit area per unit time per unit wavelength interval ($Js^{-1}m^{-2}m^{-1}$ or e.g. $Wm^{-2}nm^{-1}$)


T = 5782 K
Monochromatic flux
Δλ
E_s [W m^{-2} nm^{-1}]
wavelength [nm]
0.0
0.5
1.0
1.5
2.0
2.5
0
500
1000
1500
2000
2500
3000

Telescopes Measure Flux

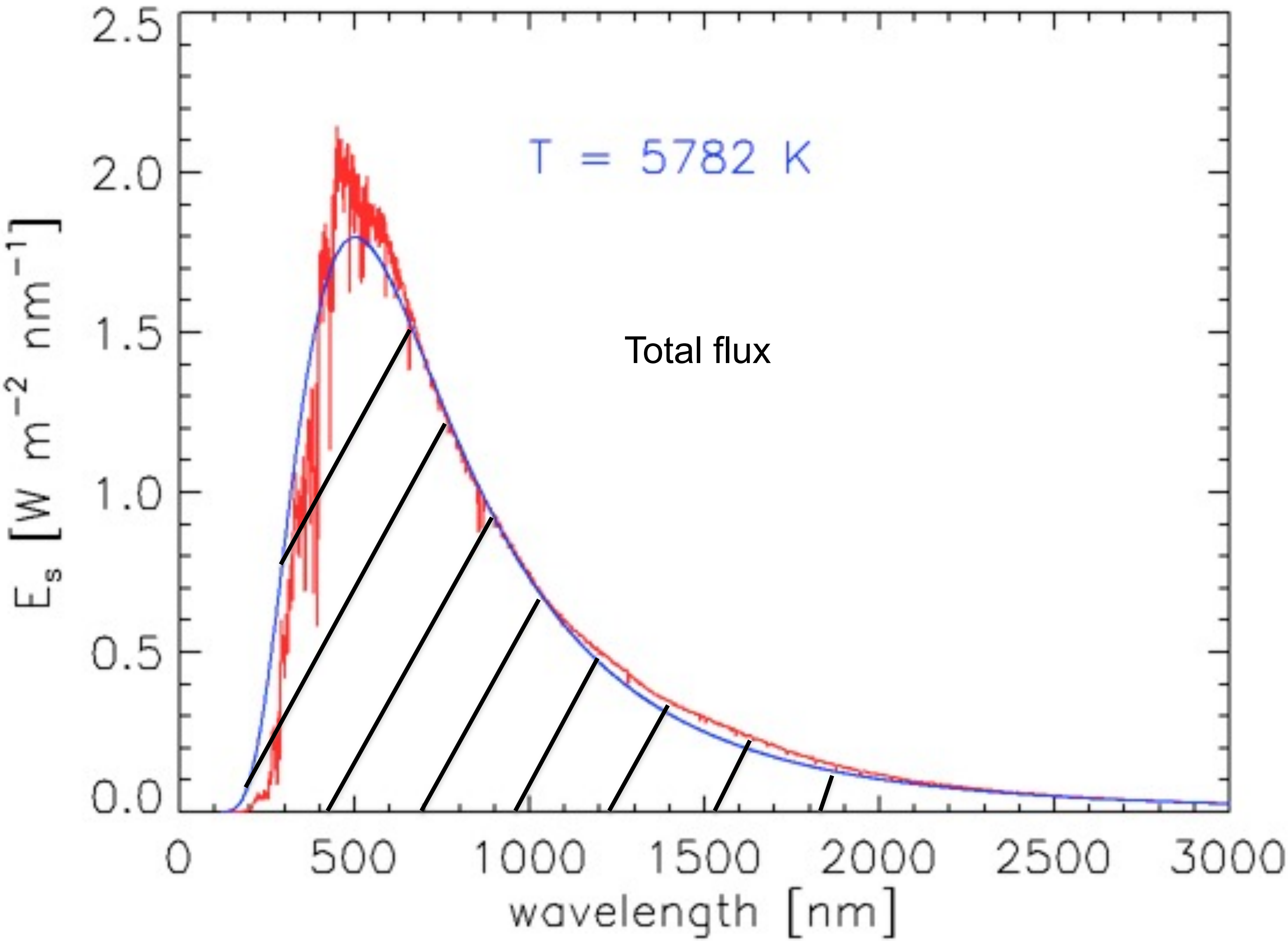


From starizona.com

Total Flux

- The flux of radiation, *f*, is defined as the amount of energy crossing a unit area per unit time ($Js^{-1}m^{-2}$ or Wm^{-2})
- It is the sum of the monochromatic fluxes over all wavelengths

$$f = \int_0^\infty f_\lambda d\lambda$$

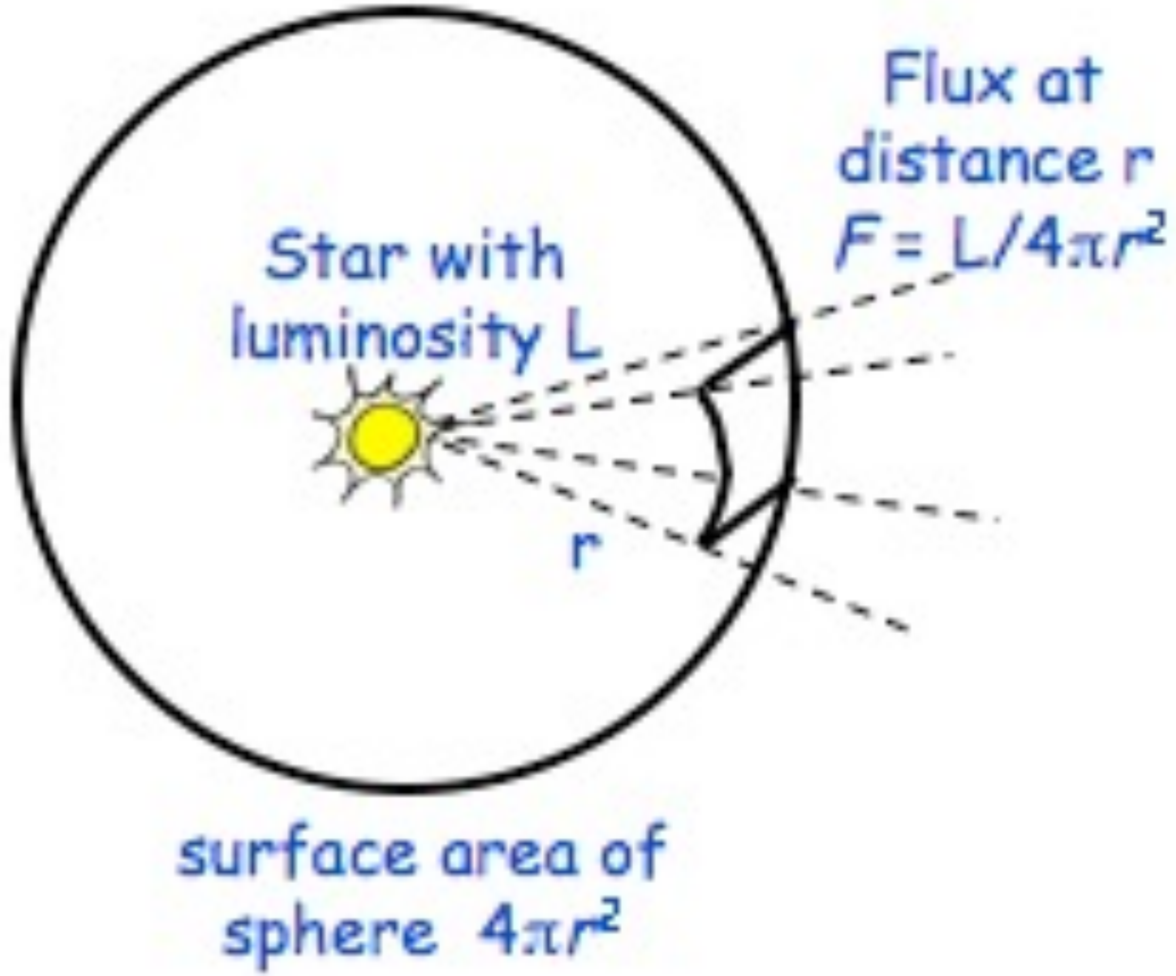

T = 5782 K
Total flux
2.5
2.0
1.5
1.0
0.5
0.0
E_s [W m^{-2} nm^{-1}]
0
500
1000
1500
2000
2500
3000
wavelength [nm]

- At a distance, *d*, from the Sun it is given by

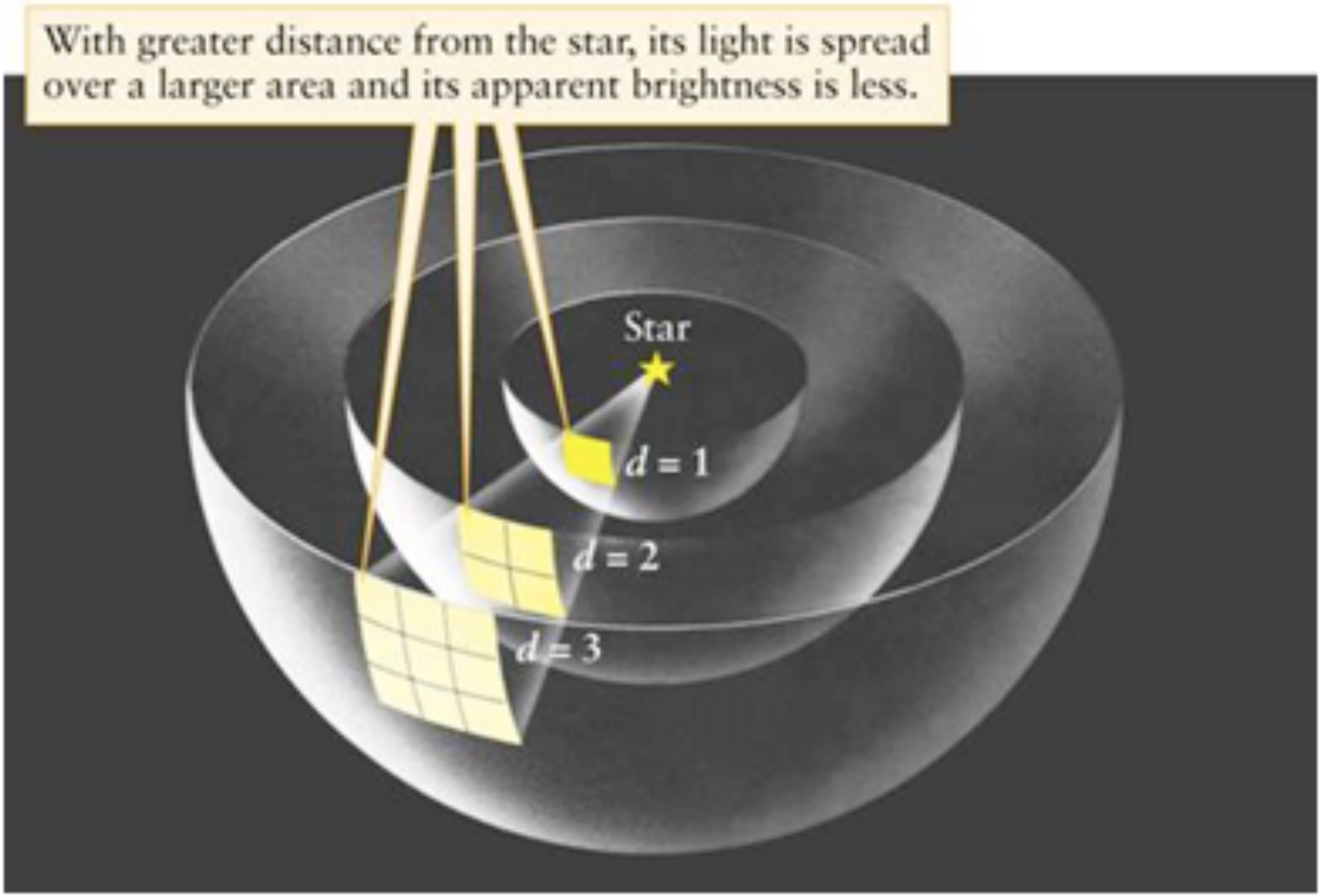
$$f = \frac{L}{4\pi d^2}$$

- Note that flux falls with the inverse square of the distance
- Hence, the luminosity can be found from

$$L = 4\pi d^2 f$$



From astronomy.swin.edu.au



From Universe textbook

Summary

- The Sun and stars radiate from their surfaces very much like a blackbody
- The effective temperature of a star can be found using Wien’s law
- The luminosity of a star can be found by measuring its flux and using the inverse square law

Class Exercise

Evaluate the total flux of radiation from the Sun reaching the Earth. Compare this with the typical power output of a solar panel.