$$F = \frac{L}{A} = \frac{L}{4\pi d^2} \quad ; \quad \text{flux}$$

$$L_{BB} = A\,\sigma_{SB}\,T^4 = 4\pi R^2 \sigma_{SB} T^4 \quad ; \quad \text{Lumins.}$$

Sun produces $L_\odot$ energy/time

Maximum energy a planet can absorb/reflect is $F(d) \cdot$ cross-section (σ_p)

$$\frac{L_\odot}{4\pi d_p^2}\,\pi R_p^2 = \frac{1}{4} L_\odot \left(\frac{R_p}{d_p}\right)^2$$

Define albedo as fraction of light reflected: $A = \frac{E_{reflected}}{E_{incident}}$

Rate of energy absorption by planet is

$$W_p = F(d) \cdot \sigma_p (1-A)$$

$$= \frac{1}{4} L_\odot \left(\frac{R_p}{d}\right)^2 (1-A)$$

If planet emits absorbed radiation like a BB, $W_p = L_p = 4\pi R_p^2 \sigma_{SB} T_p^4$

$$= \frac{1}{4} L_\odot \left(\frac{R_p}{d_p}\right)^2 (1-A)$$

$$\boxed{T_p = \left(\frac{R_\odot}{d}\right)^{1/2} \left(\frac{1-A}{4}\right)^{1/4} T_\odot}$$

Earth: $T_p \approx 250K = -23°C = \underline{-9°F}$

★ Why isn't Earth this cold???

★ Why don't astronauts on the Moon freeze on the surface?

To do calculation, need the distance
- use radar: send pulse + wait for it to reflect + return
- use Kepler's 3rd law

$$\left(P/_{yr}\right)^2 = \left(a/_{AU}\right)^3$$

Other fundamental properties: mass, dens.

(infer what they're made of)

$$p^2 = \frac{4\pi^2}{G(M+m)} a^3$$

planet ↑ satellite $m \ll M$

$$M_p \approx \frac{4\pi^2 a^3}{G p^2}$$

What about radius? Use angular size

$R_p \approx \theta d$; d is distance from us, but can figure out

The density is then $\rho = \frac{M}{V}$

$$\rho = \frac{M_p}{\frac{4}{3}\pi R_p^3}$$

Rocky: $\rho = 3000 - 5500 \text{ kg m}^{-3}$

Gas: $\rho = 700 - 2000 \text{ kg m}^{-3}$

H_2O: $\rho = 1000 \text{ kg m}^{-3}$

Detecting Exoplanets