Planets & Exoplanets
PH20104

EXOPLANETS

Gary Mathlin March/April 2023

Secondary transits

If we assume BB radiation, Planck's law is

$$I(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{\frac{hc}{\exp(\lambda k_B T)} - 1}$$

Because the planet will be cooler than the star we can use the Rayleigh Jeans approximation

$$I(\lambda, T) = \frac{2ck_B T}{\lambda^4}$$

So, for a given wavelength $I \propto T$

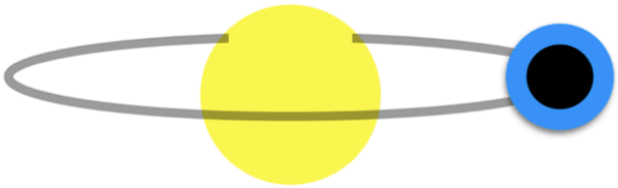
Taking the surface are of the emitter into account we have

$$I_p \propto A_p \times T_p \text{ and } I_* \propto A_* \times T_*$$

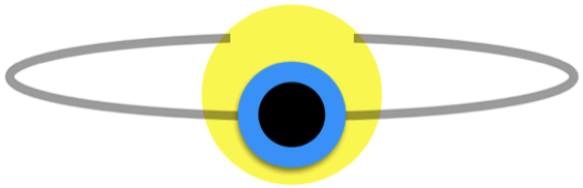
So, in the same way we derived the depth of the primary transit, the depth of the secondary transit will be

$$\Delta F_{2nd} = \left(\frac{R_p}{R_*}\right)^2 \left(\frac{T_p}{T_*}\right)$$

Transmission Spectroscopy



stellar spectrum



stellar spectrum +
absorption from atmosphere

While the planet is transiting, it blocks some of the star's light. If the planet has an atmosphere some of the star's light will be absorbed by molecules in the atmosphere.

Therefore, by comparing the spectrum of the star during and between transits, we can detect the presence (or not) of an atmosphere and begin to understand its composition.

Exoplanets and life in the Universe

The Drake equation

$$N = SFR \times f_p \times n_h \times f_l \times f_i \times f_c \times T_c$$

$N =$ the number of 'communicative' civilisations in the Milky Way Galaxy.

$SFR =$ the star formation rate in the Galaxy (number of stars per year, not mass of stars per year).

$1.5 - 3$ stars yr^{-1}

$f_p =$ the fraction of stars around which planets form.

$f_p \times n_h \sim 0.4$

$n_h =$ the average number of habitat planets per stellar system.

$f_l =$ the fraction of habitable planets that develop biotic processes. $f_l = f_i = f_c = 1$

Westby, T., Conselice, C. 2020 *ApJ* **896** 58

$f_i =$ the fraction of biotic planets that develop intelligence.

$f_c =$ the fraction of planets with intelligent life that, wittingly or unwittingly, broadcast evidence of their existence.

$T_c =$ the average length of time over which a civilisation is detectable $T_c \sim 300$ yrs

$$\sim 0 < N < 15{,}600{,}000$$

Exoplanets and life in the Universe

The habitable zone