IIAP Course Excercises Exercise 1. Consider the transiting planet WASP-11b/HAT-P-10b and the parameters given for it in astro-ph/08094295.

(a) Derive the formula for a planet's equilibrium temperature, T_{eq}, and estimate it for HAT-P-10b with the Bond albedo limit of 0.10 derived for the transiting planet HD 209458b by MOST. Discuss the uncertainties given the poorly known stellar parameters.

(b) Derive the formula for thermal atmospheric escape

$$\Phi_J = \frac{N_{ex} v_0}{2\sqrt{\pi}}(1 + \lambda_{esc})e^{-\lambda_{esc}},$$

where N_{ex} is the number density at the exobase (the lower boundary of the exosphere, the region from which escape can occur), v_0 is the mean thermal velocity, λ_{esc} is the ratio of the potential to the kinetic energy (called the escape parameter), and the rate of escape Φ_J has dimension $atoms\ cm^{-2}\ s^{-1}$. See section 4.8 in de Pater & Lissauer for more.

Use this formula to derive the rate of escape of atomic hydrogen from the upper atmosphere of HAT-P-10b. Assume that the scale height is constant in the upper atmosphere (exosphere) and that the atmosphere is isothermal ($T = T_{eq}$) due to the irradiation from the star. Discuss the assumptions. How does the loss of hydrogen affect the planet mass over its presumed age?