ASTR 792 HW 11

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15.10

$$d = 2.6\ pc$$
$$T_{eff} = 25200\ K$$
$$R = .0081 R_{\odot}$$
$$R_{\odot} = 6.96 \cdot 10^{8}\ m$$
$$\sigma_{sb} = 5.67 \cdot 10^{-8}\ W\ m^{-2}\ K^{-4}$$

a

The luminosity of Sirius B is

$$\begin{aligned} L &= 4\pi R^2 \sigma_{sb} T^4 \\ &= 4\pi(.0018 \cdot 6.96 \cdot 10^{8}\ m)^2 (5.67 \cdot 10^{-8}\ W\ m^{-2}\ K^{-4})(25200\ K)^4 \\ &= 9.1323 \cdot 10^{24}\ W \end{aligned}$$

b

The rate of H Ionizing photons is

$$\dot{N} = \frac{L}{< h\nu >}$$

Let $< h\nu >= 2.71kT = 2.71 \cdot 1.38 \cdot 10^{-23}\ JK^{-1} \cdot 25299\ K = 9.42 \cdot 10^{-18}\ J$. therefore

$$\begin{aligned} \dot{N} &= \frac{9.1323 \cdot 10^{24}\ W}{9.42 \cdot 10^{-18}\ J} \\ &= 9.49 \cdot 10^{41}\ photons\ s^{-1} \end{aligned}$$

Since 42.7% of photons have $I_H < \langle h\nu \rangle$, then

$$\begin{aligned} Q_0 &= .427\dot{N} = .427 * 9.49 \cdot 10^{41}\ photons\ s^{-1} \\ &= 4.05 \cdot 10^{41}\ photons\ s^{-1} \end{aligned}$$

c

The Stromgren radius is defined as

$$R_s \equiv \left(\frac{3Q}{4\pi\alpha n_H^2}\right)^{1/3}$$

Here, we can use Q_0 we calculated above.To calcualte α_B, we us

$$\begin{aligned}\alpha_B &= 2.56 \cdot 10^{-13} T_4^{-.83}\ cm^3 s{-1} \\ &= 2.56 \cdot 10^{-13} (7000\ k)^{-.83}\ cm^3 s^{-1} \\ &= 1.65 \cdot 10^{-16}\ cm^3 s^{-1}\end{aligned}$$

Therefore

$$\begin{aligned}R_s &\equiv \left(\frac{3 \cdot 4.05 \cdot 10^{41}\ photons\ s^{-1}}{4\pi \cdot 1.65 \cdot 10^{-16}\ cm^3 s{-1} \cdot (.05\ cm^{-3})^2}\right)^{1/3} \\ &= 6.17 \cdot 10^{19}\ cm\end{aligned}$$

d

$$\Delta R = \frac{1}{n_H \sigma_{p.i.}}$$

We can calculate $\sigma_{p.i.}$ by

$$\begin{aligned}\sigma_{p.i.} &= 6.304 \cdot 10^{-18}\ Z^{-2}\ cm^2 \left(\frac{h\nu}{Z^2 I_H}\right) \\ \rightarrow n_H \sigma_{p.i.} &= .05 \cdot 6.304 \cdot 10^{-18} \cdot .23 \\ &= 7.25 \cdot 10^{-20} cm^{-1} \\ \rightarrow \Delta R &= 1.38 \cdot 10^{19}\ cm\end{aligned}$$

where $Z = 1$, $I_H = 2.18 \cdot 10^{-18}\ J$, and $h\nu = 9.42 \cdot 10^{-18}\ J$