Homework 9

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Task 1

(a) The volume of the Strömgren sphere - i. e. the area of ionized gas around a star - can be estimated via the product of the star's photon rate Q times the recombination time $\tau_{\text{rec}} = 1/n\alpha$ divided by the particle density n. In case of the Sun, with the given (estimated) values:

$$V = \frac{4\pi}{3} r_{\text{S}}^3 = \frac{Q}{n^2 \alpha}$$
$$\iff r_{\text{S}} = \sqrt[3]{\frac{3Q}{4\pi n^2 \alpha}} = 568.4 \times 10^6 \,\text{m}$$

(b) For comparison, the Sun's radius is $R_\odot = 695.7 \times 10^6 \,\text{m}$. Of course, it doesn't make a lot of sense for r_{S} to be smaller then the star's radius.

In this case the density of the interplanetary medium was esimated incorrectly. Instead considering $n = 5 \,\text{cm}^{-3}$ one finds:

$$r_{\text{S}} \approx 2.64 \times 10^9 \,\text{m} = 3.79 \,\text{R}_\odot$$

(c) In case of a O6 star in a HII region with the provided values:

$$r_{\text{S}} = 8.5 \times 10^{15} \,\text{m} = 0.23 \,\text{pc}$$

(d) The recombination time is given as $\tau_{\text{rec}} = 1/n\alpha$.
Firstly, for $n = 5 \times 10^9 \,\text{m}^{-3}$:

$$\tau_{\text{rec}} = 7.69 \times 10^8 \,\text{s} \approx 24.39 \,\text{a}$$

And for $n = 1 \times 10^8 \,\text{m}^{-3}$:

$$\tau_{\text{rec}} = 3.85 \times 10^{10} \,\text{s} \approx 1219.61 \,\text{a}$$

(e) The values obtained above indicate that mainly young and hot stars are responsible for the development of HII clouds.