

PHYSICS OF STARS & NEBULAE

TUTORIAL 4

PROBLEM 1 – HII REGION

The hydrogen number density n_{H} in a cloud surrounding a star of radius R_* varies as

$$n_{\text{H}} = n_* (r/R_*)^{-3/2},$$

where r is the radial distance from the star. If the star produces ionizing photons, the cloud will become ionized out to some radius R_{S} . In the steady state where recombination and ionization balance, obtain an expression for R_{S} . Hence show that the ionized part of this envelope is either very close to the stellar surface or effectively at infinity, and calculate the critical value of S_* that separates these regimes.

PROBLEM 2 – SHOCK IONIZATION

How fast must a shockwave travel through a cloud of neutral hydrogen in order to ionize it? Take as the ionization criterion, a post-shock temperature sufficiently high that the thermal energy per particle matches the ionization energy of hydrogen $I_{\text{H}} = 13.6 \text{ eV}$, where $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$.

The Boltzmann constant is $k_{\text{B}} = 1.38 \times 10^{-23} \text{ JK}^{-1}$ and the mass of a hydrogen atom is $m_{\text{H}} = 1.67 \times 10^{-27} \text{ kg}$.