

Astronomy 452 Astrophysics II: Galaxies

Homework II (Due 3/9/2009, in class)

- (i) What are the spectral types for stars whose continuum spectra peak at the following wavelength: (a) 50 nm; (b) 300 nm; (c) 600 nm; (d) 900 nm; (e) 1.2 μm ; (f) 1.5 μm
- (ii) The nearby supergiant star, Betelgeuse has an effective temperature of $T_{\text{eff}} \sim 3500\text{k}$ and an angular diameter of $0.045''$, and a distance $r \sim 140\text{pc}$.
 - (a) What is its physical radius?
 - (b) What is its luminosity?
 - (c) What is its expected color?
- (iii) Your body temperature is about 310 K. Suppose it can be approximated as a blackbody.
 - (a) What is the typical wavelength of the radiation from your body.
 - (b) Is this radiation visible, infrared, X-ray, or radio?
 - (3) Suppose the surface area of a human body is about 2m^2 . How much energy does a human body radiate per second (in Watts)?
- (iv) The luminosity of the sun is $3.9 \times 10^{26}\text{W}$, and the angular diameter of the sun is $\theta = 32$ arc minutes.
 - (a) What is its physical radius?
 - (b) What is its effective temperature (assuming the sun is a blackbody)?
 - (c) What kind of color does it have and what kind of star is it according to color classification?
- (v) (a) For a main sequence star of luminosity L , how many kilograms of hydrogen is being converted into helium per second?
 - (b) Use the formula you derive to estimate the mass of hydrogen atoms that are converted into helium in the interior of the sun ($L_{\odot} = 3.9 \times 10^{26}\text{W}$).Hint: the mass of an hydrogen atom is $1m_p$ (m_p is the mass of a proton), and the mass of a helium atom is about $3.97m_p$. You need 4 hydrogen nuclei to form one helium nucleus.
- (vi) The Salpeter initial mass function (IMF) has the form $\phi(m) = Am^{-1.35}$.
 - (a) If only stars with masses between $0.1 M_{\odot}$ and $100 M_{\odot}$ are formed, what is the value of A ? Suppose we have a galaxy which contain a total of $10^{10}M_{\odot}$ of newly-formed stars. What is the total number of

these stars? How many of them have initial masses that are between $1 M_{\odot}$ and $2 M_{\odot}$?

(b) What is the total mass in stars with masses between $1 M_{\odot}$ and $2 M_{\odot}$? Make the same estimates for stars with masses between $10 M_{\odot}$ and $11 M_{\odot}$.

(c) Based on these results, do you think the stellar population (the number of stars) in the galaxy dominated by low-mass stars or by high-mass stars?

(vii) We know that the main-sequence age of a star of $1 M_{\odot}$ is about 10^{10} years.

(a) What is the main-sequence age of a star of $10 M_{\odot}$?

(b) Suppose a galaxy of mass $10^{10} M_{\odot}$ of a coeval stellar population of age 10^7 years. How many stars are still in the main sequence (assuming Salpeter IMF) in the galaxy? How many main-sequence stars with masses between $1 M_{\odot}$ and $2 M_{\odot}$ are there in the galaxy?

(c) The same as above, but for a coeval population of age 10^{10} years.

(d) Discuss the galaxy becomes redder as it ages.