

Exercises for the course on Galaxies, 2005/2006

- Generalities

1. Show that if two stars of the same luminosity form a close binary pair, the apparent magnitude of the pair measured together is ~ 0.75 mag brighter than each star individually.
2. Show that an error or uncertainty of 0.1 magnitudes in the distance modulus is equivalent to $\sim 5\%$ error in distance.

- Stellar populations and photometric evolution

3. Integrate the Salpeter mass function between a lower mass limit M_l and upper limit $M_u \gg M_l$ to find (a) the total mass; (b) the total luminosity. Show that the number and mass of stars depends mainly on the mass M_l of the smallest stars, while the luminosity depends on M_u , the mass of the largest stars. Taking $M_l = 0.3M_\odot$ and $M_u \gg 5M_\odot$, what fraction of all stars have $M > 5M_\odot$? What fraction have $M > M_\odot$?
4. The star formation rate measures the number of solar masses in stars formed per unit time.
 - (a) In the Solar neighborhood the SFR has been found to be close to constant: $\Psi(t) = A$. Show that in this case, the initial luminosity function $\Phi_0(M_V)$ is equal to the observed luminosity function $\Phi(M_V)$ for $t < T_{MS}(M_V)$, while for $t > T_{MS}(M_V)$ it is given by $\Phi_0(M_V) = \Phi(M_V) \times t/T_{MS}$.
 - (b) Suppose that the star formation rate in a population has decayed exponentially in time $\Phi(t) = e^{-\alpha t}$, and let the oldest star in the population have formed at $t = 0$. Show that the initial luminosity function $\Phi_0(M_V)$ is related to the luminosity function observed today $\Phi(M_V)$ as

$$\Phi_0(M_V) = \frac{e^{\alpha t}(1 - e^{-\alpha t})}{e^{\alpha T_{MS}} - 1} \Phi(M_V) \quad \text{for } t > T_{MS}(M_V) \quad (1)$$

5. Use the (in-class) derived evolution of the luminosity of a single stellar population $L(t)$ to:
- (a) Show that single stellar populations become fainter in time
 - (b) Compute the color evolution of a single stellar population as a function of time: $(U-B)$ and $(B-V)$. Use that $U_{\odot} = 5.40$, $B_{\odot} = 5.25$, $V_{\odot} = 4.70$. Compute the colors at $t=0.1$, 1 and 5 Gyr.