Stellar Astronomy and Astrophysics (SS11)

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Exercise 1

1. Number of Stars in the Milky Way

Does the Milky Way Galaxy contain more stars than there are grains of sand in the beach volleyball court at the Neckarwiese? Please justify your answer using simple order-of-magnitude estimates.

2. The Stellar IMF

The distribution of stellar masses at birth in the solar neighborhood can be described by the following functional form:

$$\xi(m) = \begin{cases} 0.26m^{-0.5} & \text{for} \quad 0.01 < m \leq 0.08 \\ 0.035m^{-1.3} & \text{for} \quad 0.08 < m \leq 0.5 \\ 0.019m^{-2.3} & \text{for} \quad 0.5 < m < 100. \end{cases}$$

The quantity $\xi(m)dm$ indicates the number of objects per cubic parsec, pc^3, in the mass interval m to $m + dm$, with mass m given in units of solar mass $M_\odot$. Objects with $m < 0.08$ are brown dwarfs. Their mass is too small for hydrogen burning in the center. Stars with $m > 100$ are not stable.

a: The quantity $\xi(m)$ is the differential number density in the (linear) mass interval m to $m + dm$. Often, however, it is better to consider the differential number density ξ_L in the (logarithmic) mass bin $\log_{10} m$ to $\log_{10} m + d\log_{10} m$. Calculate ξ_L and plot $\log_{10} \xi_L$ versus $\log_{10} m$.

b: What is the average stellar mass?

c: Sirius is the brightest star on the sky. Actually, it is a binary system, with Sirius A being 2.1 times heavier than the Sun (with a spectral type A1V) and Sirius B being a white dwarf. The system is at at distance of ≈ 2.6 pc. How many stars with the mass of Sirius A and heavier do you expect within a distance of 10 pc from the Sun?

3. Protostellar Collapse

Consider the idealized case of the collapse of a pressure-free isothermal sphere with constant initial density.

a How does the collapse timescale depend on density?

b For an initial density of $n(\mathrm{H}_2) = 10^5$ cm^{-3}, estimate the collapse timescale.

c Speculate on how *real* protostellar collapse may deviate from the above idealized picture. List three characteristic differences.