ASTR 404 **Homework Assignment 2**

January 26, 2018 (due February 2, 2018)

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1. The globular cluster M13 is located at the distance $d \approx 6800$ pc and has the apparent magnitude $m_V = 5.8$. It contains $N \approx 3 \times 10^5$ stars. Answer the following questions: (**a**) what is the total luminosity of M13 in solar luminosities; and (**b**) what is the mean apparent magnitude of its individual stars.

2. Main-sequence stars of the spectral class B0V ($T_{\mathrm{eff}} \approx 30000$ K) have a mass $M \approx 15\,M_\odot$. Using the mass-luminosity relation

$$\frac{L}{L_\odot} \approx 1.5 \left(\frac{M}{M_\odot}\right)^{3.5} \tag{1}$$

for the main-sequence stars of this mass, estimate their mean density and compare it with the mean density of the Sun.

3. Find the density-scale height (the parameter H in the equation $\rho(h) = \rho(0)\exp(-h/H)$) for pure hydrogen atmospheres of the Sun and a white dwarf with $M = 1\,M_\odot$ and $R = 0.01\,R_\odot$. Make reasonable assumptions about the hydrogen ionization state that should give you reasonable estimates of the mean molecular weight for the both cases.

4. Explain the presence of the minus sign in the expression

$$\varepsilon_{\mathrm{g}} = -T\frac{\partial S}{\partial t} = -\frac{\partial U}{\partial t} - P\frac{\partial V}{\partial t} \tag{2}$$

for the gravitational energy generation rate in stars.

5. A long time ago, there was the hypothesis that the solar luminosity was maintained by an ongoing process of comet accretion by the Sun. Estimate the required rate of mass accretion (in $M_\odot\,\mathrm{s}^{-1}$) and the effect of such accretion, resulting from an increase of the solar mass, on the year duration. (**Hint:** to answer the second part of the question, use Kepler's third law and Earth's orbital angular momentum conservation.)

6. What is the minimum possible rotation period of a red giant star with the mass $M = 1\,M_\odot$ and the radius $R = 1\,a$, where $a \approx 1.5 \times 10^8$ km is the astronomical unit.