Astrophysik II: Galaxien und Kosmologie

WS17/18

Übungsblatt 3

15.11.2017

Aufgabe 1. *Isothermal slab*

Consider an infinite (in x and y) static isothermal slab, symmetric about $z = 0$, supported by gas pressure and under its own self-gravity. Using the equation of state for an ideal isothermal gas and the momentum equation to show that the density profile of the slab becomes $\rho \propto \mathrm{sech}^2(az)$ where a is some constant.

$$\text{Equation of state}: \quad p = \frac{\mathcal{R}_*}{\mu} \rho T \tag{1}$$

$$\text{Momentum equation}: \quad \frac{1}{\rho} \nabla p = -\nabla \Psi \tag{2}$$

$$\text{Poisson's equation}: \quad \nabla^2 \Psi = 4\pi G \rho \tag{3}$$

Aufgabe 2. *Luminosity and distance*

An astronomer detects two stars which she believes have identical luminosities. Star A has a measured parallax of 0.15". Star B is detected to be 365 times dimmer than Star A.

(a) What is the distance to star B in pc?

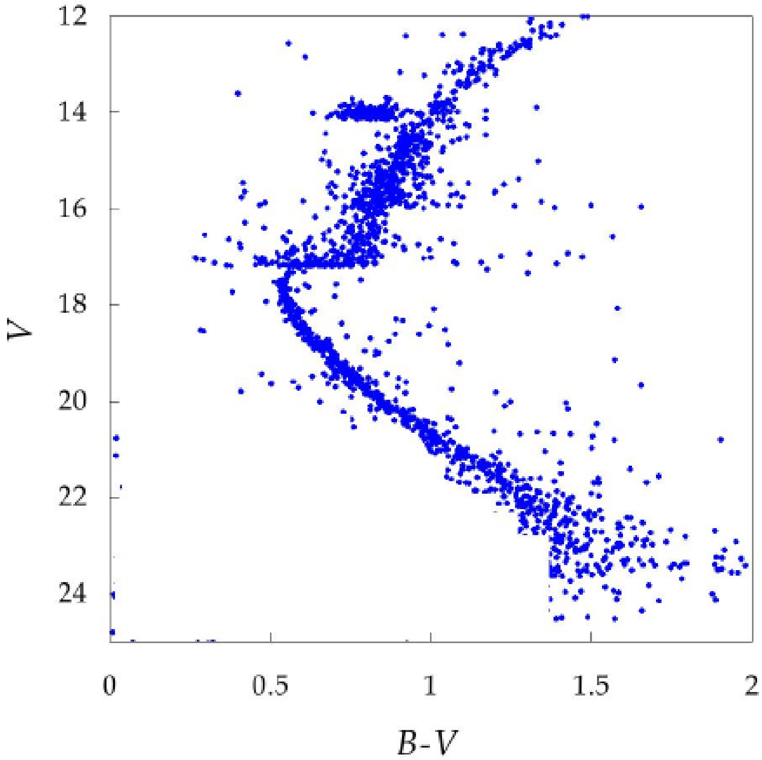
(b) What is the distance modulus to star B?

(c) Assuming star B is similar to the sun, what is its apparent magnitude as viewed from Earth?

Aufgabe 3. *Main sequence lifetime*

The image H-R diagram below corresponds to some observed cluster. Assuming all stars in the cluster formed at the same time. estimate the age of the cluster. Where $B - V = 0.64$ for the sun. And the main sequence lifetime is given by;

$$\tau_* = 10^{10} \frac{M_*/M_\odot}{L_*/L_\odot} \text{ yrs} \tag{4}$$



Aufgabe 4. *Accretion Energy*

(a) Consider a mass m that starts at rest infinitely far from a star of mass M and radius R. The initial total mechanical energy of the mass is $E = K + U = 0$. What will the kinetic energy of the mass be when it arrives at the stars surface? if this energy is converted into radiation upon impact, what is an expression for luminosity if material is delivered to the surface with rate $\dot{m}$?

(b) Now consider a mass m in a circular orbit around the same star. what is the total energy of this orbiting mass? (kinetic and potential). How does this energy change if the mass moves slowly inwards?

(c) Assuming all energy is radiated away, derive an expression for the luminosity emitted for an inward mass rate $\dot{m}$.

(d) If we assume the inward material forms a disk and at each radius the disk radiates as a blackbody, derive an expression for the characteristic temperature of the disk

(e) What mass accretion rate would be required such that $L_{disk} = L_\odot$, if $M = 1M_\odot$ and the inner disk radius $R_{min} = 2R_\odot$.

(f) Compare this to a black hole accreting with the same rate, converting 10% of this mass into radiation.