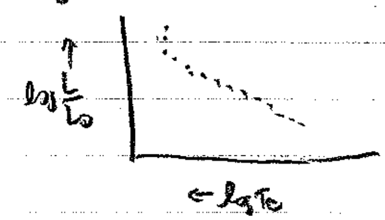
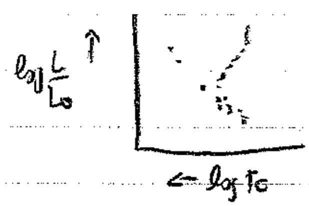
1. I am looking for approximate values so ±200Å is acceptable for λ_{eff} and bandpasses between 500-1000Å. Actual values are

	λ_{eff} (Å)	Bandpass (Å)
U	3600	660
B	4400	940
V	5500	880

2 HR Diagram of Pleiades

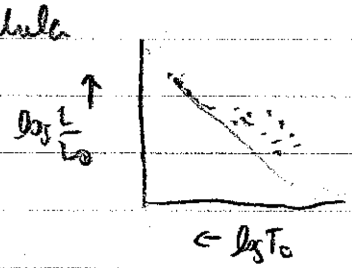


Solar Neighborhood ($\lesssim$ 100pc)



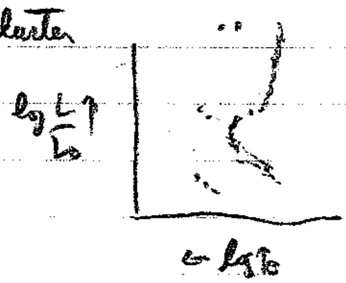
Very truncated upper ms compared to Pleiades, comparable low mass population. Absence of giant stars

Orion Nebula



Comparably populate upper ms but no indication of evolution off the ms
No lower mass ms stars. Distribution of pms stars large absent in pleiades except at low mass

globular cluster



Missing upper main sequence population
Cluster turnoff around G0
few blue stragglers
Gap along subgiant branch ⇒ rapid evolution
Well populated giant branch
Few HB stars & WDs

3 a) Approximate values of B-V are requested. ±0.1 acceptable

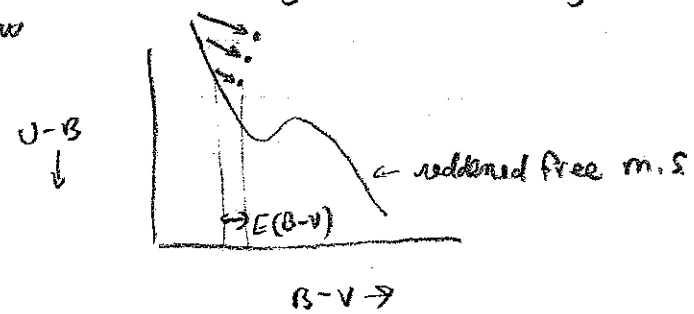
A0 ~ 0.0

G2V ~ 0.63

M0V ~ 1.40

b) Dip near U-B = 0.0 is caused by strong H absorption head which depresses the U magnitude

c) Correction for reddening & extinction using the 2-color plot is illustrated below



Reddened stars will follow a trajectory in the 2 color plot whose slope is around 0.72. The color excess, $E(B-V)$, is

$$E(B-V) = (B-V)_{obs} - (B-V)_{intrensic}$$

So $$(B-V)_{inst} = (B-V)_{obs} - E(B-V)$$

Visual extinction is corrected as

$$A_V = R\,E(B-V) \quad \text{where } R \approx 3.0$$

d) Non-uniform reddening would be revealed by the different length vectors as shown in the above diagram

e) The G2V M_V is given as 4.7. From Figure 1 at B-V ~ 0.6 V = 10.0

$$m - M = 5 \log \frac{d}{10}$$

$$\frac{10 - 4.7}{5} = \log \frac{d}{10}$$

$$10^{2.06} = d(pc)$$

$$d = 115 pc$$

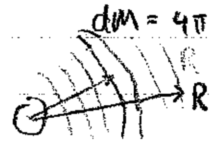
4 If you assume binaries consist of equal mass components, then each star emits the same amount of light. The vertical displacement would then be

$$\Delta V = 2.5 \log \frac{2F}{F} = 2.5 \log 2 = 0.75 \text{ magnitude}$$

Identical stars have the same B-V so there would be no horizontal displacement. The only displacement should be upward and it should be ~ 0.75 mag. This is close to the observed values, therefore, they are likely to be binaries

5 a) Derive the gravitational potential energy. This can be done in a variety of ways.

$dM = 4\pi r^2 dr\, \rho$



$$\Omega = -\int_0^R \frac{G M_r\, dm}{r} =$$

$$dm = 4\pi r^2 dr \rho = \frac{3 M r^2}{R^3} dr \qquad M_r = \frac{4}{3}\pi r^3 \rho = M\left(\frac{r}{R}\right)^3$$

$$\Omega = -\int_0^R \frac{G M_r\, dm}{r} = -\int_0^R \frac{GM}{r}\left(\frac{r}{R}\right)^3 \frac{3 M r^2}{R^3} dr$$

$$= -\frac{3GM^2}{R^6}\int_0^R r^4 dr = -\frac{3}{5}\frac{GM^2}{R}$$

b) Half of this energy is available to be radiated, so at constant L

$$\Delta E = -(E_f - E_i) \quad \text{if } R_i \gg R_f \quad \Delta E \sim -E_f \rightarrow E_f = \frac{3}{10}\frac{GM^2}{R} \text{ or } t = \frac{3}{10}\frac{GM^2}{RL}$$

$$\frac{t}{t_\odot} = \left(\frac{M}{M_\odot}\right)^2 \Big/ \left(\frac{R}{R_\odot}\frac{L}{L_\odot}\right) \Rightarrow t \sim \left[\left(\frac{M}{M_\odot}\right)^2 \Big/ \left(\frac{RL}{R_\odot L_\odot}\right)\right] t_\odot$$

$$\sim \frac{(0.5)^2}{(0.6)(0.1)} t_\odot \sim 4 \times t_\odot \sim 4 \times 3 \times 10^7 \text{ yrs} \approx 10^8 \text{ years}$$

This is the amount of time the M0V would use to reach the MS. Since the cluster is only 10^7 yrs old, the M0V would be seen as a pms star.

6 (a) Given: $V = V_0 + kX$ and $\sigma(V) = AX^{p}$

$$k = \frac{V_2 - V_1}{X_2 - X_1} = \frac{V_2 - V_1}{X_2 - 1}$$

Propagation of errors

$$\sigma^2(k) = \sigma^2(V_2)\left(\frac{\partial k}{\partial V_2}\right)^2 + \sigma^2(V_1)\left(\frac{\partial k}{\partial V_1}\right)^2 =$$

$$= \left(AX_2^{p}\right)^2\left(\frac{1}{X_2-1}\right)^2 + A^2\left(\frac{-1}{X_2-1}\right)^2$$

$$= \left(\frac{A}{X_2-1}\right)^2\left[X_2^{2p} + 1\right]$$

$$\text{Var} = \boxed{\frac{\sigma^2(k)}{A^2} = \frac{X_2^{2p}+1}{(X_2-1)^2} = \frac{1}{(X_2-1)^2} + \frac{X^{2p}}{(X_2-1)^2}}$$

(b)

$$\frac{\partial \text{Var}}{\partial X_2} = \emptyset = \frac{-1}{(X_2-1)^4} + \frac{(X_2-1)^2(2p)X^{2p-1} - X^{2p}\,2(X-1)}{(X-1)^4}$$

$$= -1 + (X-1)pX^{2p-1} - X^{2p} = \emptyset$$

If $p = 2$ and $X_2 = 2.1$

$$-1 + (X-1)2X^3 - X^4 = \emptyset$$

$$-1 + (1.1)2(2.1)^3 - (2.1)^4 \stackrel{?}{=} \emptyset$$

$$-1 + 20.37 + 19.45 = 0.08 \sim \emptyset$$

(c) (1) $V = v_0 + \alpha(B-V) + \beta$

↑ zero pt difference between observers system and UBV system

color effect accounts for Black Body slope of stellar emission

V is related to gain extra-atmospheric v_0

(2) To determine α, a range of stars with different B-V are needed