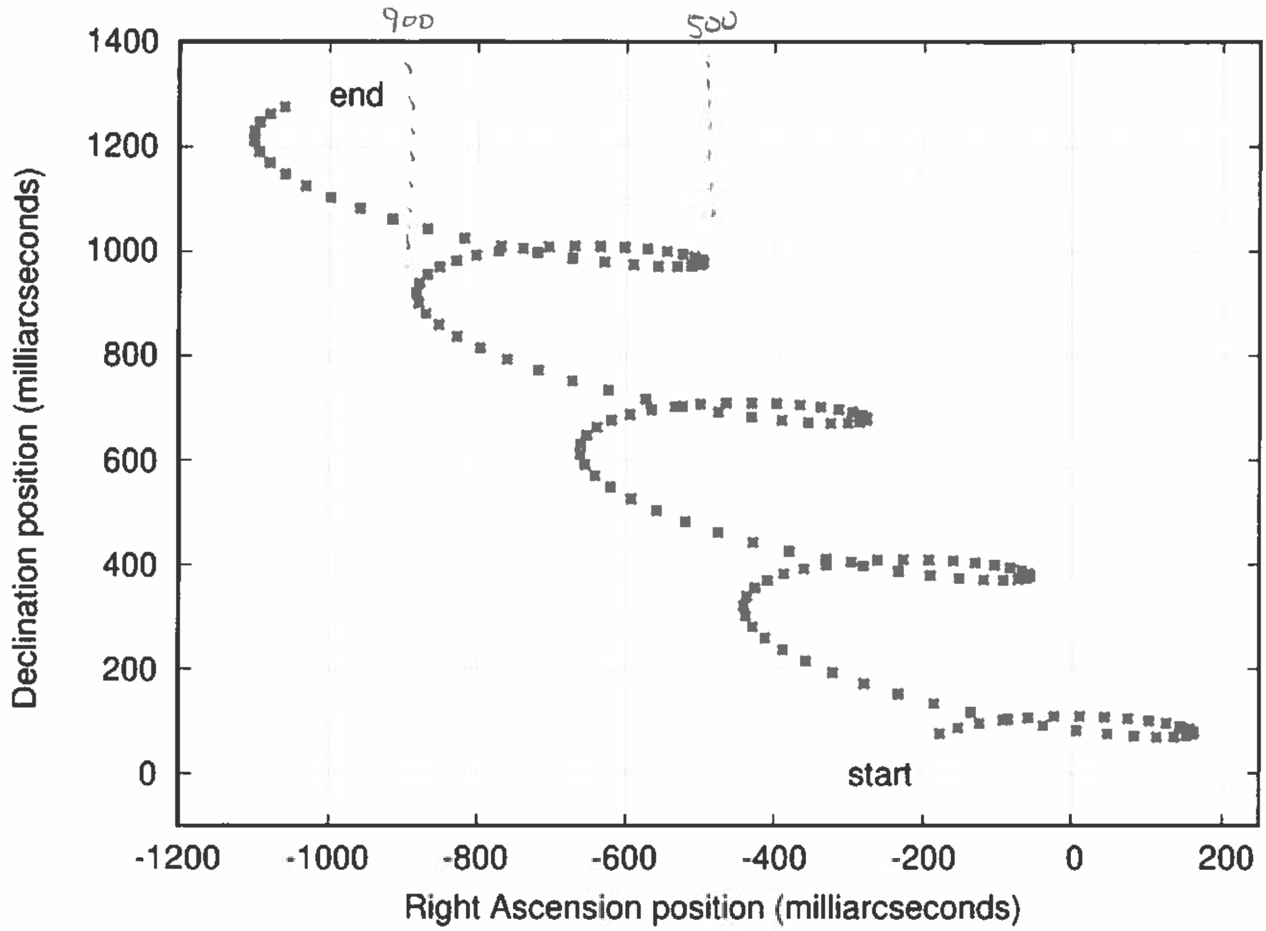
9:26 — 9:33



Problem 1

The graph above shows the position of a star measured very carefully over a period of time.

4 a. What period of time do these measurements cover?
3 b. Estimate the parallax of this star, expressed in milliarcseconds
3 c. What is the distance to this star?
2 d. **(*) Grad** Estimate the proper motion of this star.
2 e. **(*) Grad** Compute the transverse components this star's space velocity, in km/s.

a) 4 years

b) $\pi \simeq \frac{900-500}{2} = 200$ mas

note proper motion $\mu_{RA} \approx \frac{-1050+200}{4} = 212 \frac{mas}{yr}$

$= 106$ mas/6

so $\pi = \frac{(900+106)-500}{2} \approx 250$ mas is better (+1)

+1

c) d = 5 pc if 200, 4 pc if 250

d) $\mu_{RA} = -212 \frac{mas}{yr}$

$\mu_{Dec} = \frac{1300-100}{4} = 300 \frac{mas}{yr}$

e) $V_{RA} = -212 \frac{mas}{yr} * \frac{1 \text{ rad}}{206265000 \text{ mas}} * \frac{3.08 \times 10^{...}}{pc}$

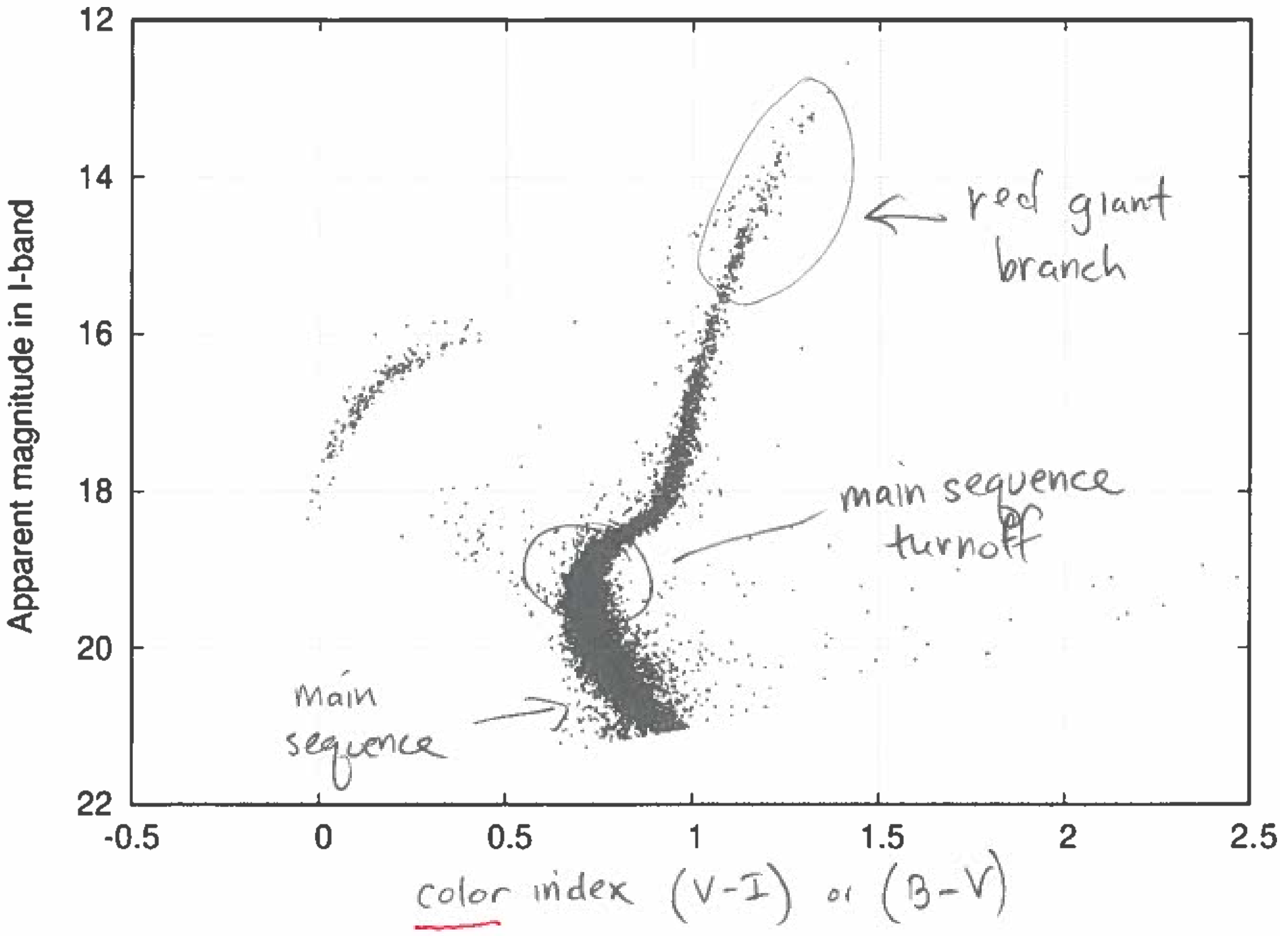
$* 5 pc * \frac{1 yr}{3.15 \times 10^7 s} = -5$ km/s

(-4 km/s)

$V_{Dec} = +7$ km/s

(+5.5 km/s)

9:34 - 9:38



Problem 2

The figure above shows the observed HR diagram of a cluster of stars.

3 a. Write a label for the X-axis.

b. Clearly label each of the following:

1 i. main sequence

1 ii. main sequence turnoff

1 iii. red giant branch

2 c. Is it possible to use this diagram to estimate the age of the cluster? If so, describe how one would do it. It is not necessary to provide an age.

2 d. Estimate the distance to this cluster. Explain your work liberally.

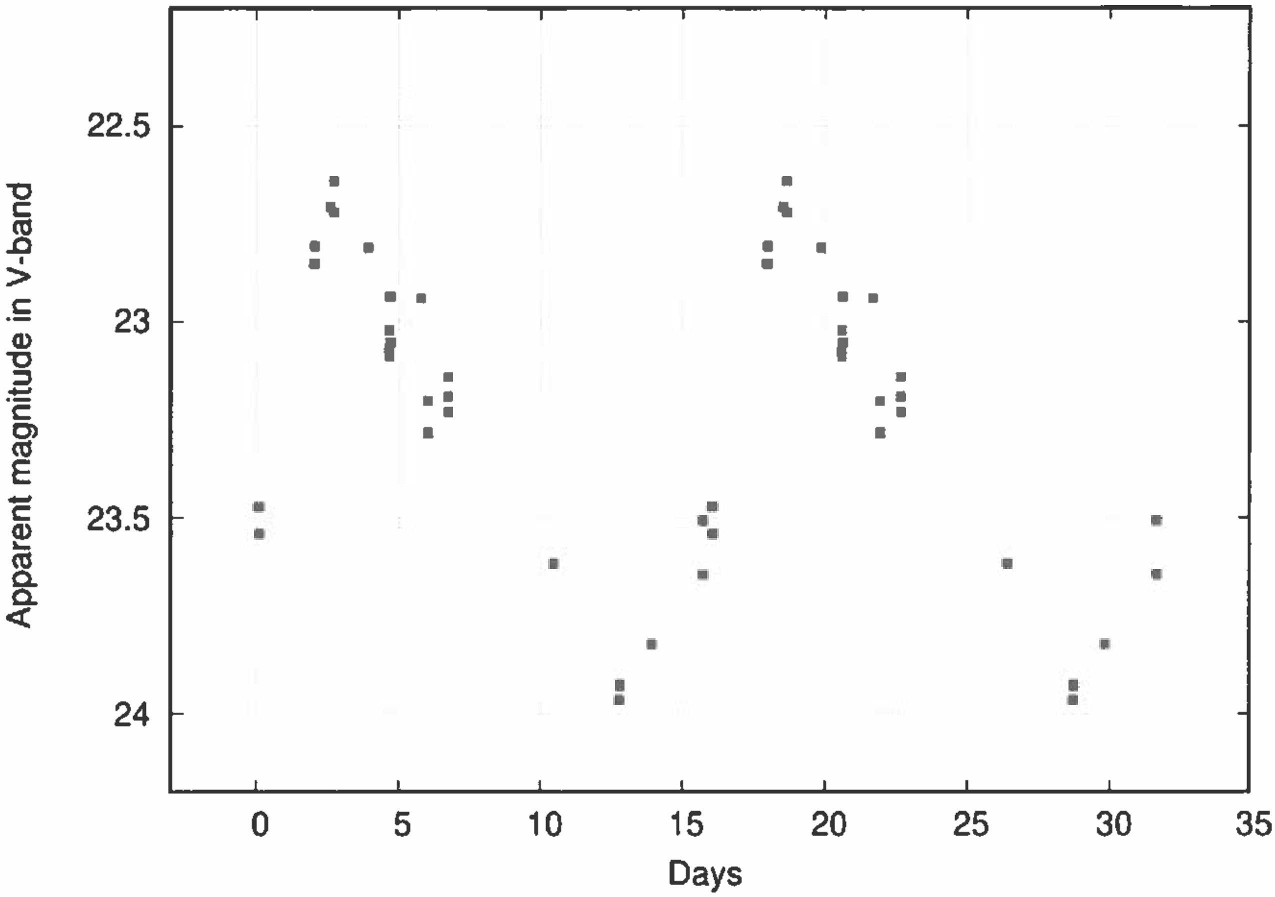
a) see graph

b) " "

c) yes. Measure location of main-sequence turnoff. Look at models of stellar populations of various ages, and choose the age which matches the main-sequence turnoff position.

d) Tip of red giant branch $m_I \approx +14$. We know $M_I \approx -4$, so $(m-M) = 18$ mag $\Rightarrow d = 10^{0.2([m-M]+5)} = 4\times10^4$ pc

9:38 – 9:43



Problem 3

The graph above shows the light curve of a pulsing variable star.

a. What is the period of the star?
b. What type of star is this?
c. What is the mean apparent magnitude of the star?
d. Estimate the distance to the star.
e. Is this star a member of our Milky Way? Explain.
f. **(*) Grad** The color excess of the star is **E(B-V) = 0.41.** Compute the distance to the star, given this extra information.

2 a) $P = 16^d$

2 b) Cepheid (period too long for RR Lyr)

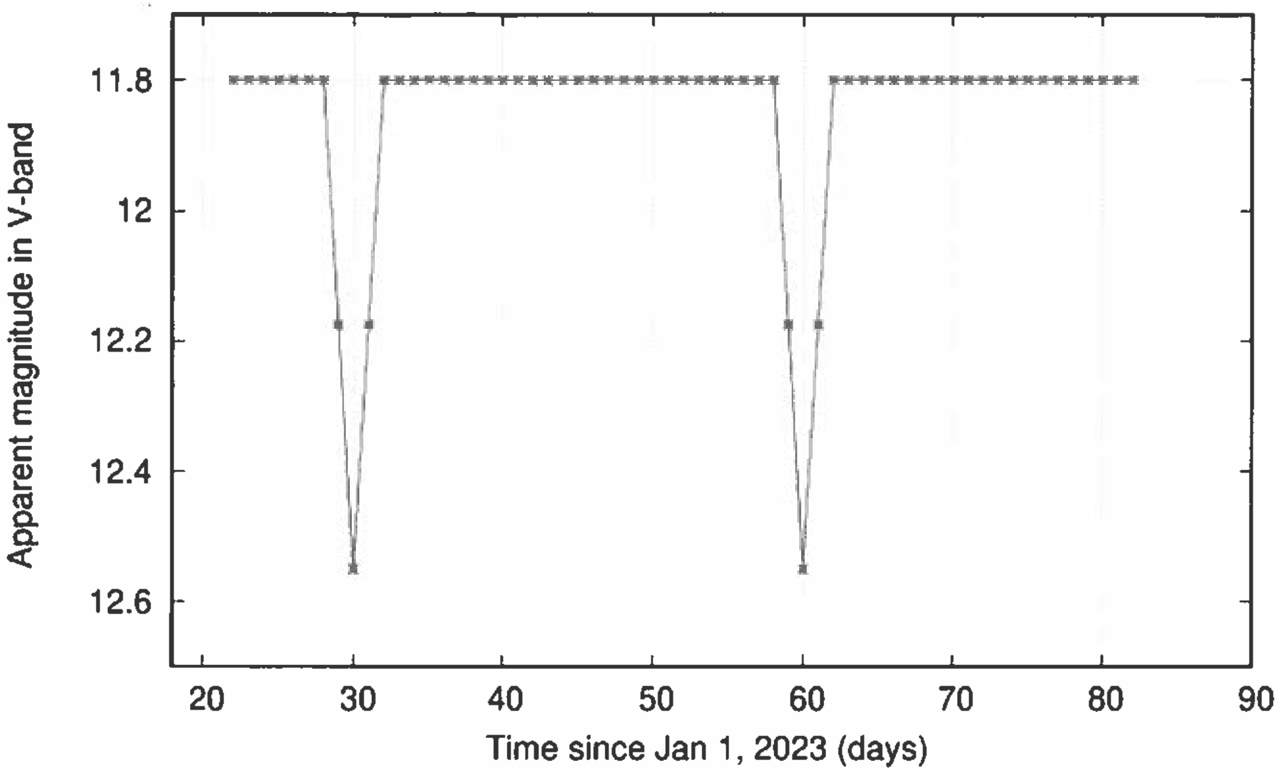
2 c) $\langle m_V \rangle \approx 23.3$

2 d) $M_V \cong -2.678 \log P - 1 = -4.22 \Rightarrow m - M = 27.5$
$\Rightarrow d = 3.2$ Mpc

2 e) Far outside Milky Way ($d \approx 100$ kpc)

2 f) $A_V = 3.1\,E(B-V) = 1.27$ mag $\Rightarrow (m-M) = 26.23 \Rightarrow d \approx 1.8$ Mpc

9:43 - 9:53



Problem 4

The graph above shows one period of the light curve of an eclipsing binary star in which both stars have exactly the same size and the orbit is edge-on. Spectroscopy has revealed that the stars are moving in circular orbits with a speed of **v = 90,000 m/s**, and that the temperature of each star is **T = 5700 K**.

2 a. What is the period of the orbit?
2 b. What is the size of each star?
2 c. Compute the luminosity of one star; express in Watts and in solar luminosities.
2 d. Compute the absolute magnitude of one star in V-band; in this case, the bolometric correction is zero.
1 e. Estimate the distance modulus to the binary system.
1 f. What is the distance to the system?
4 g. **(*) Grad** Compute the mass of each star.

a) $P = 60^d$

b) $R_* = \frac{1}{2} \cdot V \cdot (\text{duration of eclipse}) = \frac{1}{2}(90\times10^3 \frac{m}{s}) * (4 * 86{,}400\,s) = 1.55\times10^{10}\,m$

c) $L_* = 4\pi R_*^2 \sigma T^4 = 1.82\times10^{29}\,W = 471\,L_\odot$

d) $M_* = M_\odot - 2.5\log\left(\frac{L_*}{L_\odot}\right) = 4.83 - (6.68) \simeq -1.85$

e) during eclipse, see 1 star $m_V = 12.55 \Rightarrow (m-M) = 14.40 \Rightarrow d = 7600\,pc$

if use $m_V = 11.8$, get $(m-M) = 13.65 \Rightarrow d = 5400\,pc$ $\longrightarrow$

f) $\frac{v^2}{r} = \frac{Gm}{(2r)^2} \rightarrow m = \frac{4v^2 r}{G} = \frac{4\left(90\times10^3 \frac{m}{s}\right)^2 \left(3.71\times10^{10}\right)}{6.67\times10^{-11} \frac{N.m^2}{kg^2}}$

$= 1.8\times10^{31}$ kg

$= 9.1 M_\odot$

but what is radius of orbit r?

$2\pi r = v.P = \left(90\times10^3 \,m/s\right)\left(30 \times 86400\,s\right)$

$= 2.33\times10^{11}$ m

$\rightarrow r = 3.71\times10^{10}$ m