АСТРОНОМИЧЕСКОЕ ОБЩЕСТВО — EURO–ASIAN ASTRONOMICAL SOCIETY

Round TPr

Group α β

XII Международная астрономическая олимпиада
XII International Astronomy Olympiad

язык / language: English

Крым, Симеиз 29. IX. – 07. X. 2007 Simeiz, Crimea

Practical round. Sketches for solutions

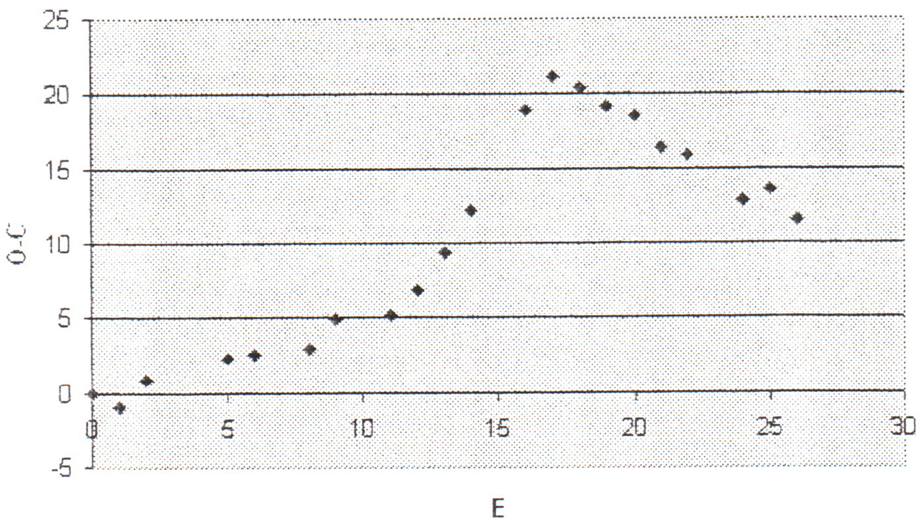
Note for jury and team leaders. The proposed sketches are not full; the team leaders have to give more detailed explanations for students. But the correct solutions in the students' papers (enough for 10pts) may be shorter.

6α. The O-C diagram.

1. Use the given value of period P = 302.0^d we can calculate «O-C» values for all the moments of maximum light and fill in the big table. It should be taken into account that not all maximums were observed. So the number of cycle E is not equal to the number of the moment of maximum given in the table.

N	JD 244.... (O)	JD 244.... (C)	E	O–C
1	42551.0	42551	0	0
2	42852.1	42853	1	-0.9
3	43155.8	43155	2	0,8
4	44063.3	44061	5	2,3
5	44365.5	44363	6	2,5
6	44969.9	44967	8	2,9
7	45273.9	45269	9	4,9
8	45878.2	45873	11	5,2
9	46181.8	46175	12	6,8
10	46486.4	46477	13	9,4
11	46791.2	46779	14	12,2
12	47401.9	47685	16	18,9
13	47706.2	47383	17	21,2
14	48007.4	47987	18	20,4
15	48308.1	48289	19	19,1
16	48609.5	48591	20	18,5
17	48909.4	48893	21	16,4
18	49210.8	49195	22	15,8
19	49811.8	49799	24	12,8
20	50114.6	50101	25	13,6
21	50414.5	50403	26	11,5

2. Using the data from this table we can plot «O-C» versus the number of cycle E:



3. There are three regions on the plot where the experimental points may be approximated by lines, the real period of pulsation in these regions slightly changes from cycle to cycle but is stable in general. These three regions are separated by sudden period change points near E=11 and E=17.
4. The mean pulsational period for each of the three zones can be found as calculated period plus tan(inclination angle) of the approximational curve. The filled table is below:

E	ΔJD	<P>
0-11	0-45878.2	302.75
11-17	45878.2-47706.2,	304.3
17-26	47706.2-50414.5	301.04

6β. **Supernova.** Using Hubble formula Vr = H*r estimate the receding velocity of our SN Ia. With H = 71km/s and $r=2.5*10^3$Mpc one gets Vr ≈ 180000 km
Vr=180000 = 0.6c(where c is the light speed). Thus, to find the redshift we need to use relativistic formula:

$$z = \sqrt{\frac{1+\frac{Vr}{c}}{1-\frac{Vr}{c}}} - 1 = \sqrt{\frac{1+0.6}{1-0.6}} - 1 = 1$$

Using the mean typical absolute magnitude value for SN Ia $M=-19^m.5$ and given Hubble diagram we get:

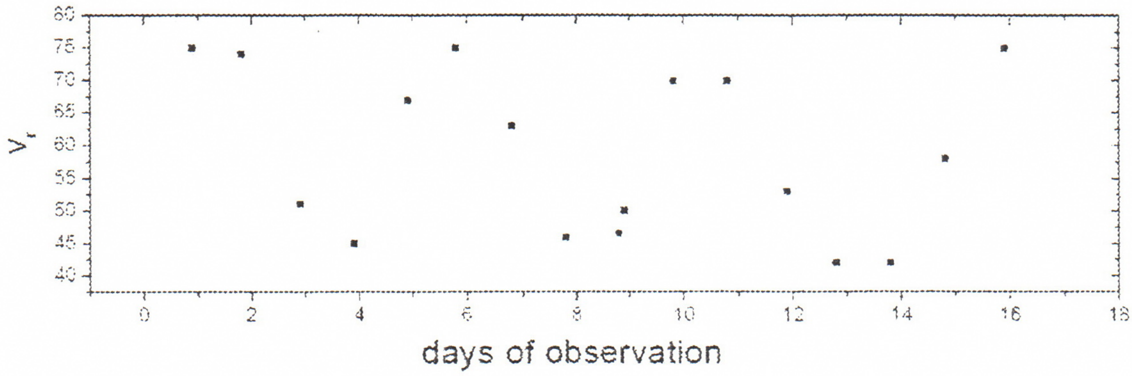
$$m-M \approx 44$$

$$m = 44+M = 44-19.5 = 24^m.5$$

7α. **Radial velocity.**
1. Use the data from table to plot heliocentric radial velocity Vr versus time.
2. Determine approximately pulsational period of cepheid from the plot (P ≈ 5 d).
3. Use the given plot M_v - log P to determine the mean absolute magnitude of cepheid ($M_v \approx -3^m.3$).
4. Determine the heliocentric distance of cepheid using the known formula:

$$m - M_v = 5*\log r - 5$$

(interstellar absorption is ignored). With a given mean apparent magnitude $m = 6^m.2$ one gets r = 800 pc.
5. Use the plot V_r versus time to find approximate radial velocity of the center of mass of pulsating star (i. e. velocity of its space motion relatively to the Sun).



Thus, roughly we can estimate $\langle V_r \rangle \approx$ +60 km/s and conclude that our cepheids recedes from the Sun.
6. During 2 million years ($2*10^6$ y) the star passed with such a velocity the distance:

$$d \approx 2*10^6 * 3*10^7 * 6*10^6 \text{ cm} \approx 3.6*10^{20} \text{ cm} \approx 100 \text{ pc}.$$

Here $3*10^7$ is the number of second in one years.
2 million years ago our star was 100 pc closer to the Sun than now ,thus, its distance was at that time 700 pc. With such a distance its apparent magnitude was:

$$m = M_v + 5*\log r - 5 = -3.3 + 5*\log 700 - 5 \approx 5.9$$

Here we neglected again the interstellar absorption and possible variations of the absolute magnitude of our cepheid during considered time interval. Thus, we conclude that 2 million year ago the star could be seen.

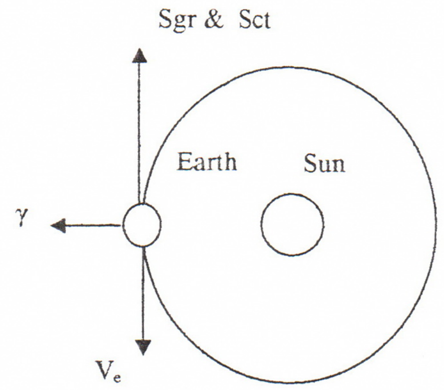
7β. Radial velocity.

1. Use the data from table to transform redshift H alpha wavelength to the radial velocities Vr of Cepheid relatively to the Earth (rotation of the Earth can be neglected). Remember that laboratory wavelength of Hα is 6562.8A

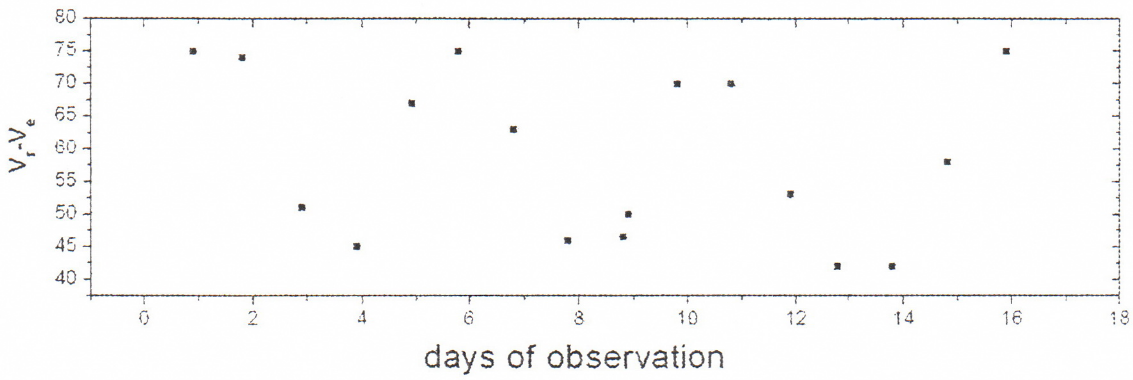
2 Take into account that:

- Our target Cepheid is situated very close to the ecliptic (border of constellations Sct and Sgr);
- Observation were made in September near equinox.

Therefore obtained Vr include the term Ve = 30km/s (where Ve is orbital speed of the Earth)



3. Plot the data on heliocentric radial velocity (Vr -Ve) versus time,taking into account that Ve is the roughly the same for 16 days of observations.
4. Determine approximately pulsational period of Cepheid from the plot (P=5d).
5. Use the given plot Mv - logP to determine the mean absolute magnitude of Cepheid (Mv=-3m.3).
6. Determine the heliocentric distance of Cepheid using the known formula m-Mv = 5logr -5 (interstellar absorption is ignored). With a given apparent magnitude m=6m.2 one gets r=800kpc.
7. Use the plot (Vr-Ve) versus time to find approximate heliocentric radial velocity of the center of mass of pulsating star (i.e. velocity of its space motion relatively to the Sun).



We roughly estimate the mean heliocentric velocity to be = 60km/s. We conclude that our Cepheid recedes from the Sun

8. During 2 million years (2*106 y) the star passed with such a velocity the distance:

$$d \approx 2*10^6 * 3*10^7 * 6*10^6 \text{ cm} \approx 3.6 *10^{20} \text{ cm} \approx 100 \text{ pc}.$$

Here $3*10^7$ is the number of seconds in one year.

9. 2 million years ago our star was 100 pc closer to the sun than now ,thus, its distance was at that time 700 pc. With such a distance its apparent magnitude was:

$$m = Mv + 5*\log r - 5 = -3.3 + 5*\log 700 - 5 \approx 5.9$$

Here we neglected again the interstellar absorption and possible variations of the absolute magnitude of our cepheid during considered time interval. Thus, we conclude that 2 million year ago the star could be seen.