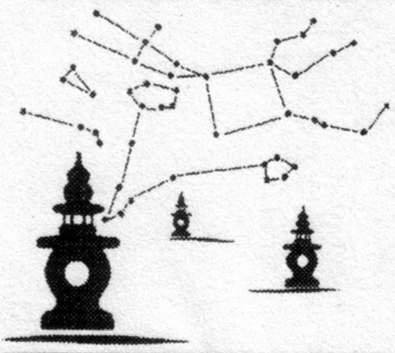

XIV Международная астрономическая олимпиада
XIV International Astronomy Olympiad

Китай, Ханчжоу 8 – 16. XI. 2009 Hangzhou, China

язык / language	***English***

Practical round. Problems to solve

6. Motion of a planet. Most of the time, planets move from west to east relative to the background stars. Occasionally, however, they change direction and temporarily undergo retrograde motion. After a few weeks, the direction is changed again. The apparent motion of a planet was observed in Hangzhou this year. Table 1 lists the values of the 24 hour angular displacement of the planet relative to the background stars (simplified as ADRS) on the day that the observation was made. Modified Julian Day (MJD = JD – 2400000.5) are used for the dates. Minus means the direction is from east to west.

6.1. Find the date (MJD) when the planet is at stationary point (simplified as STP) and at opposition (simplified as OPP) graphically, respectively. Accurate to one day. Write your answer in table 2.

6.2. What's the value of 24 hour angular displacement of the planet per day when it is at opposition? Write your answer in table 2.

6.3. On the basis of the result of question 2, estimate the radius of the planet's orbit in astronomical units. Suppose the orbits of Earth and the planet are both circular and the planet is in ecliptic plane.

Table 1

Modified Julian Day	ADRS (degrees/day)
54944	0.15
54965	0.1
54975	0.07
54989	0.03
55001	-0.01
55014	-0.05
55020	-0.07
55032	-0.1
55043	-0.12
55055	-0.13
55062	-0.13
55074	-0.12
55084	-0.1
55092	-0.08
55099	-0.06
55109	-0.03
55121	0.01
55133	0.05

Table 2

MJD of STP	MJD of OPP	ADRS on the day of OPP

Practical round. Problems to solve

6. Light echo. Light echoes are produced when the initial flash from a rapidly brightening object (such as a nova) is reflected by the surrounding interstellar dusts which may or may not be associated with the object. Light from the initial flash arrives at the viewer first, while light reflected by the dusts begins to arrive shortly afterward. The variable star V838 Monocerotis was seen to have a violent outburst in March 09, 2002 (Modified Julian Day 52342).

Then the Hubble Space Telescope (HST) captured its light echoes from the surrounding dusts in the next few months. Figure 1 presents two photos observed by HST. The black box shows a field of view of 97" × 97".

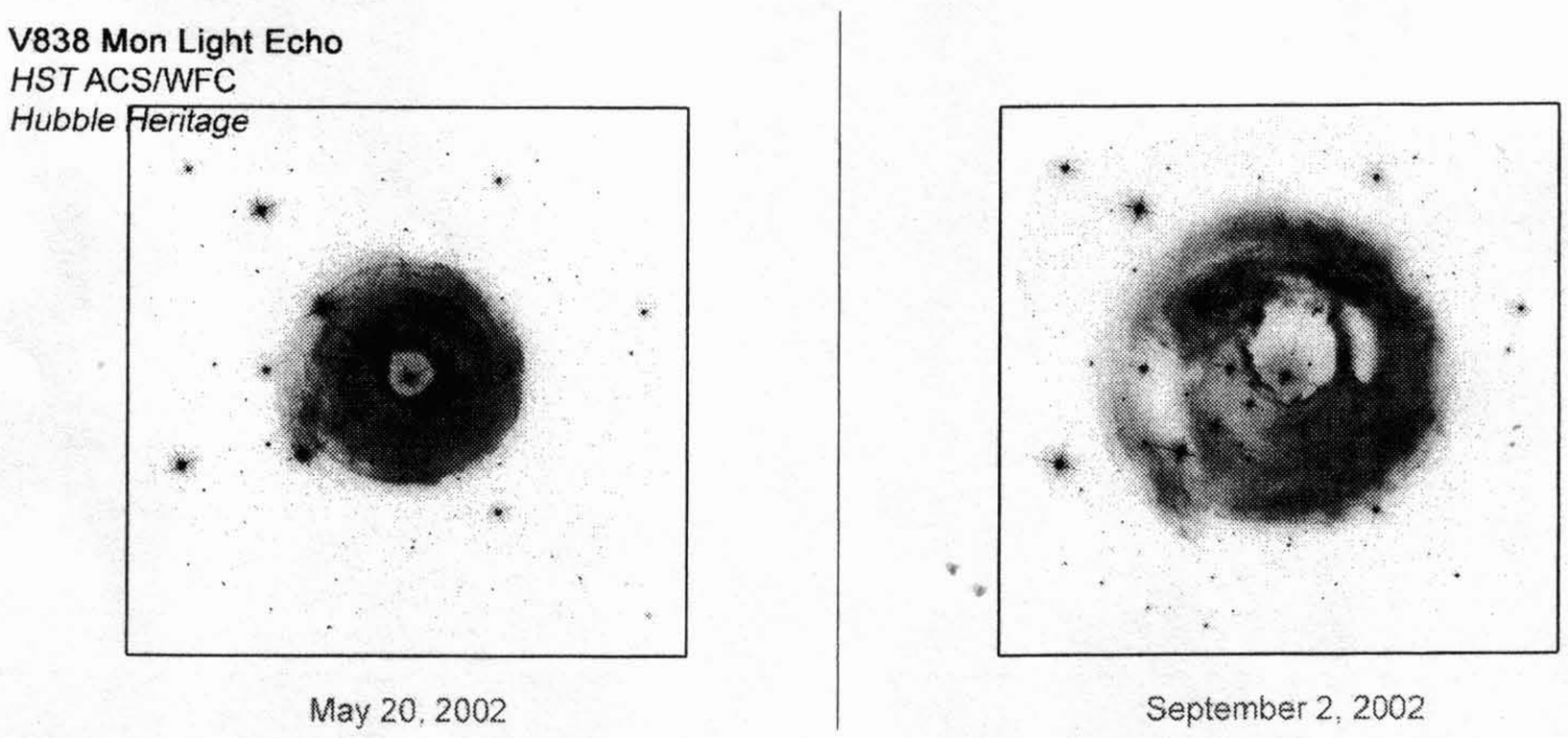

Figure 1

Recently, astronomers found Monoceros V838 and other three adjacent main sequence stars are all members of an open cluster. Table 1 gives some observed data of the three stars, where V and B is apparent magnitude in V and B band, V_0 and B_0 is apparent magnitudes with extinction correction. M_V is absolute V magnitude. It is known that for the cluster the interstellar extinction is 2.6^m in V-band and 3.44^m in B-band.

Number	Spectral type	V	B	B_0-V_0	V_0	M_v
N1	B6 V	16.02	16.73	-0.15		
N2	B4 V	15.00	15.63	-0.19		
N3	B3 V	14.79	15.41	-0.205		
Distance to the open cluster in light years (ly):						

Table 1

6.1. According to the Hertzsprung-Russell diagram (Figure 2) and the known data in Table 1, fill in the blank of Table 1.

6.2. An astronomer at the Shanghai Observatory proposed a theoretical model for V838 Mon. He found the velocity of the expanding envelope of V838 Mon varies with time, as listed in table 2. Plot the data in figure 3 and estimate the angular diameters of the envelopes when the photos in figure 1 were taken. Write your answers in Table 3.

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6.3. According to the two photos of figure 1, estimate the radii of the dust shells which produced the outermost light echoes. Write your answers in Table 3.

Modified Julian Day	velocity (km/s)
52351	800
52397	630
52421	560
52435	503
52467	432
52583	333
52676	305
52769	263
52825	227
52895	220
52988	200
53095	190
53174	180
53267	158
53351	150

Table 2

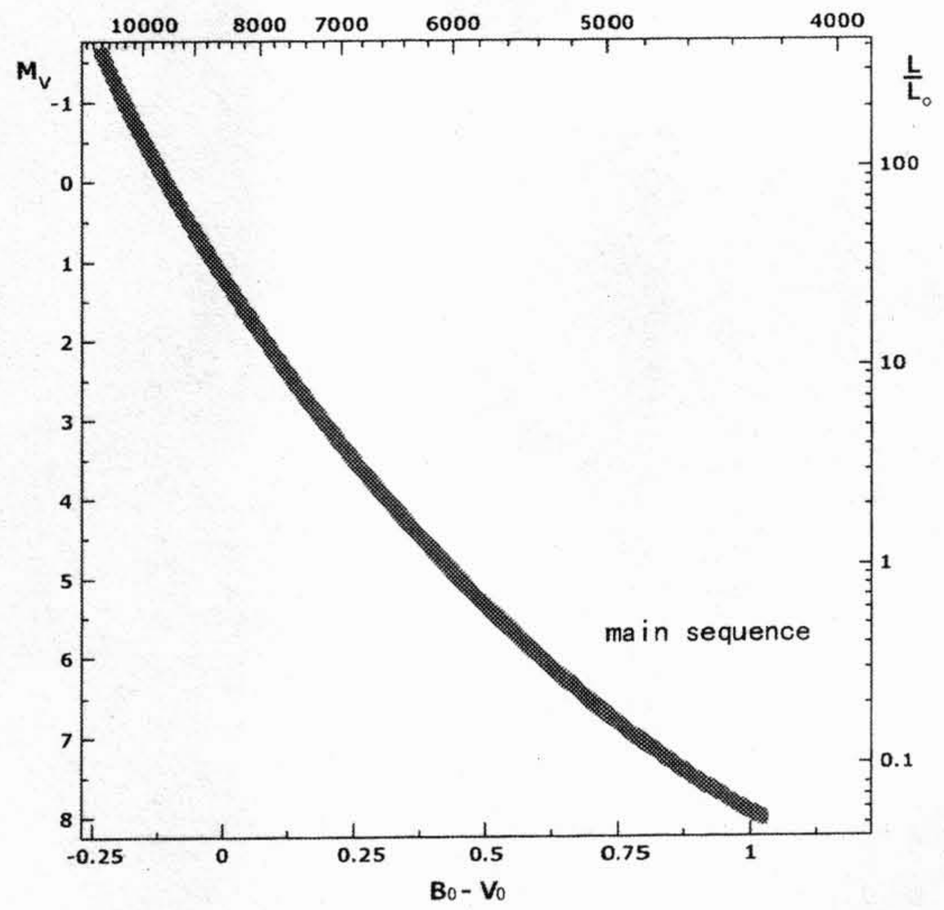

Figure 2

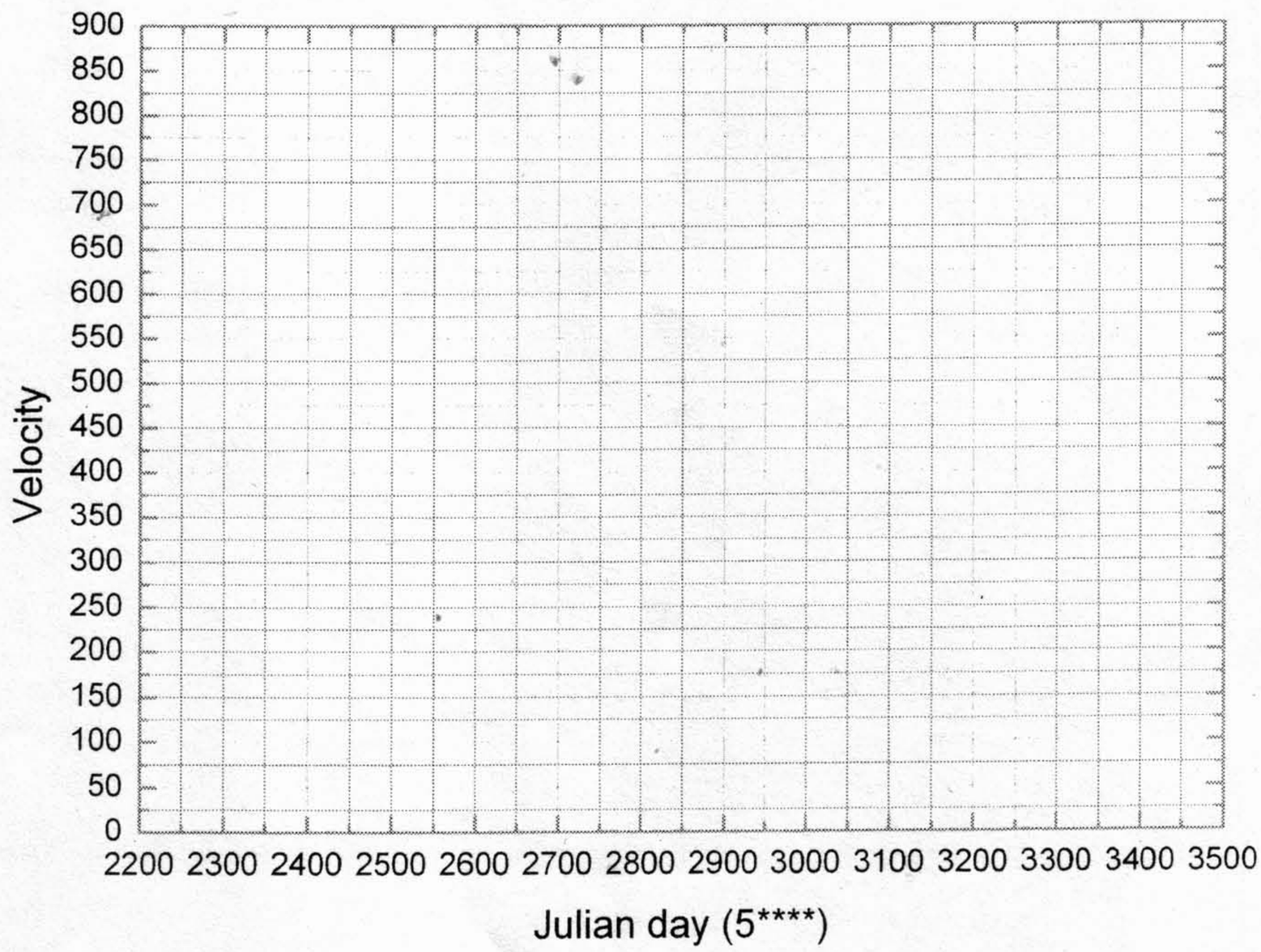

Figure 3

time (days from 3/9/2002)	Visual diameter of stellar envelope (″)	Visual diameter of dust shell(″)	Radius of dust shell (ly)

Table 3

Practical round. Problems to solve

7. **The Vernal Equinox Day of Saturn.** One day this year, Saturn ushers in its own vernal equinox day. Through observations and calculations, a research group of Beijing Planetarium obtained the inclination angle of Saturn's ring which is varying with time. The result is plotted in figure 1. The horizontal axis is Julian Day and the vertical axis is the observed inclination angle in degrees. The curved line is the result observed from Beijing Planetarium and the (almost) straight line is the result observed by an imaginary observer on the Sun. The differences between them result from the revolution of the Earth and the inclination of the orbital plane of Saturn which inclines to the ecliptic plane with an angle of 2°29'.
On January 13, 2005 (Julian day 2453383), Saturn is at opposition. Saturn's orbital period is known as 29.46 years, and its equator inclines to its orbital plane with an angle of 26°43'. Suppose the Earth and Saturn's orbits are circular and the radius of Saturn's orbit is 9.54 AU.

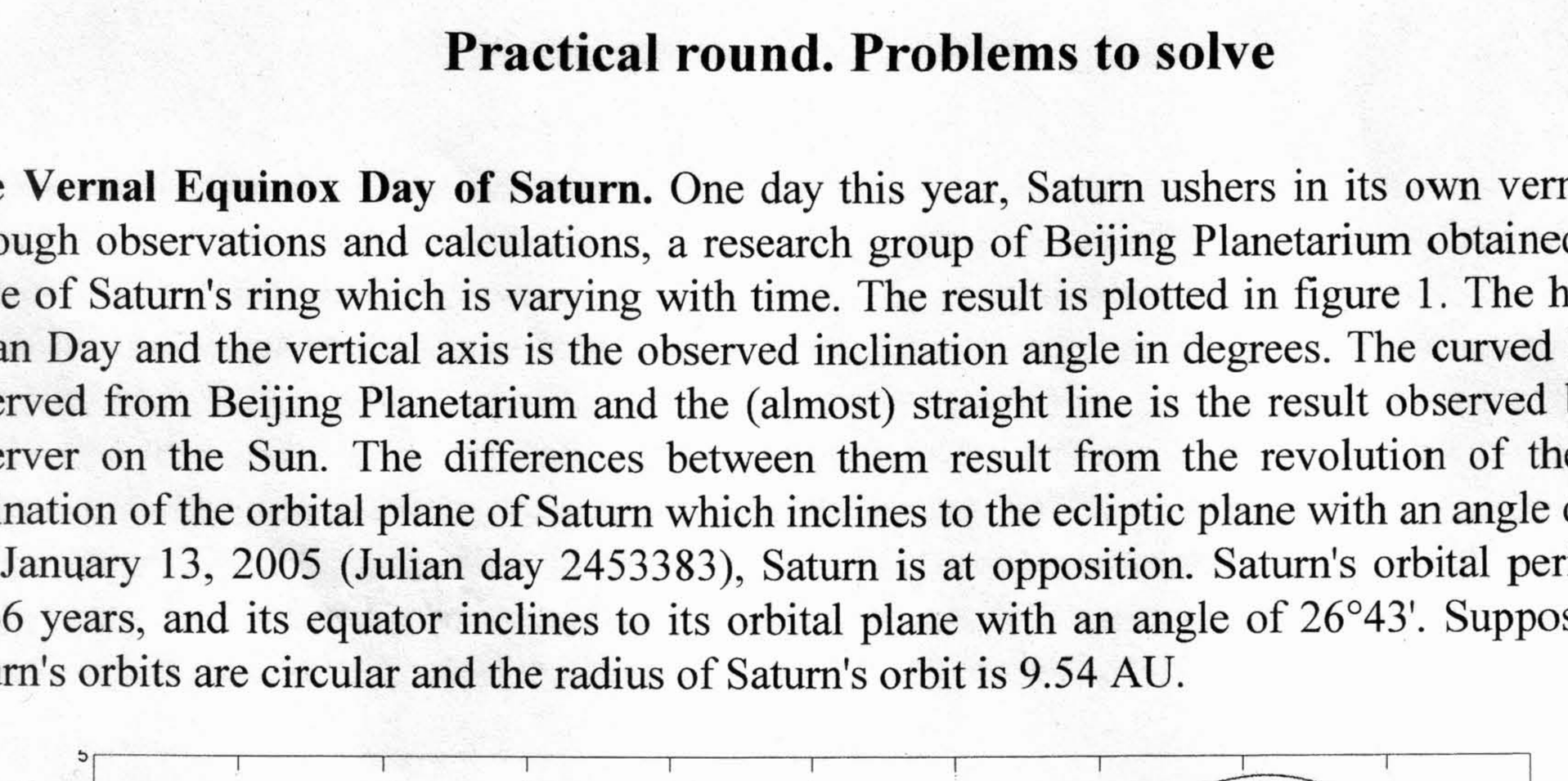

Figure 1

7.1. According to Figure 1, find out which day is Saturn's Vernal Equinox Day. Give the integer value of Julian day. And mark it in Figure 1 as "Spr".

7.2. According to Figure 1, estimate the largest inclination angle of Saturn's ring that can be observed from Beijing Planetarium and the Sun.

7.3. Mark the approximate position of the Earth and Saturn on Saturn's Vernal Equinox Day in Figure 2. Please indicate on the figure the angular relationship of the Earth, Saturn, and Sun. The inner circle is Earth's orbit and the outer is Saturn's (not to scale). Jan means the 1st of January, Feb means the 1st of February, and so on.

7.4. On Saturn's Vernal equinox day, what's the distance between Earth and Saturn (in AU)? Ignore the inclination of Saturn's orbit.

7.5. (group β only) Ignoring the inclination of Saturn's orbit, calculate the maximum difference of the inclination angle of Saturn's ring between Beijing Planetarium and the Sun-observer (at the same moment).

Practical round. Figure 2 for problem 7

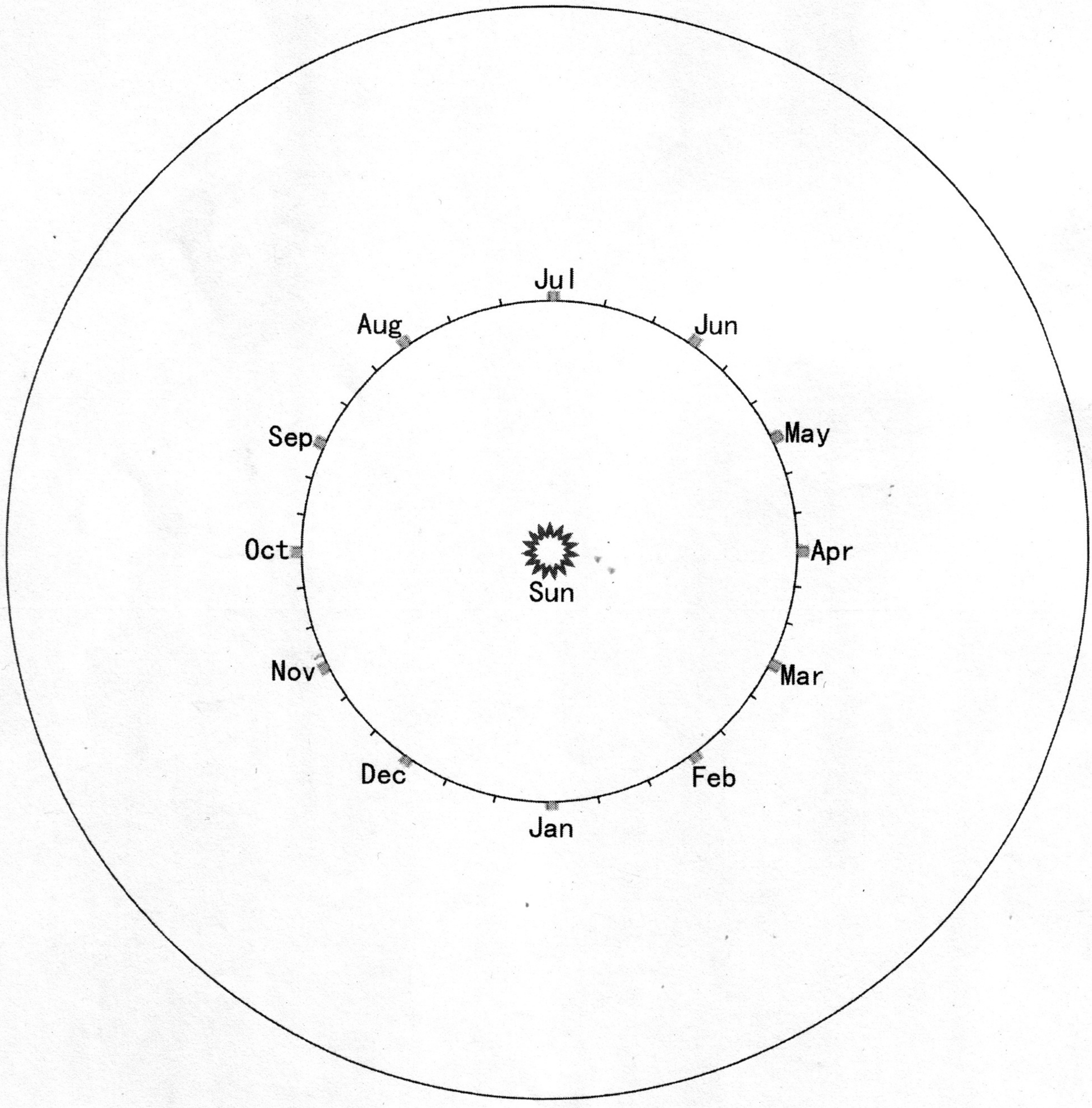

Figure 2