Practical round. Problems to solve

7. Asteroid.

Analysis of observations of a near earth asteroid.

Astronomers of two observatories, which are located at a distance of 3172 km from each other, took CCD images of a certain region of the sky for the search of a near earth asteroid. Two images were obtained by Observatory 1 during the same night at 4^h53^m UT and at 7^h16^m UT. These images (negatives) are shown in Figs. 7.1 and 7.2, respectively. The next two images obtained on the same night were made at Observatory 1 .and Observatory 2 simultaneously. These images (negatives) are shown in Figs. 7.3 and 7.4. The scale of all the images is the same as shown in Fig. 7.1.

7.1. Identify and mark the asteroid in the given Figs.
7.2. Measure the angular displacement (in arcsec) of the asteroid as seen from Observatory 1 and calculate its angular velocity in arcsec/s.
7.3. Measure the parallax of the asteroid (in arcsec) and calculate its distance from the earth.
7.4. Calculate the tangential linear velocity (velocity perpendicular to the line of sight) of the asteroid.

Note: You are provided a transparency for measurements of angular displacements of the asteroid.

7. Asteroid. **7. Астероид.**

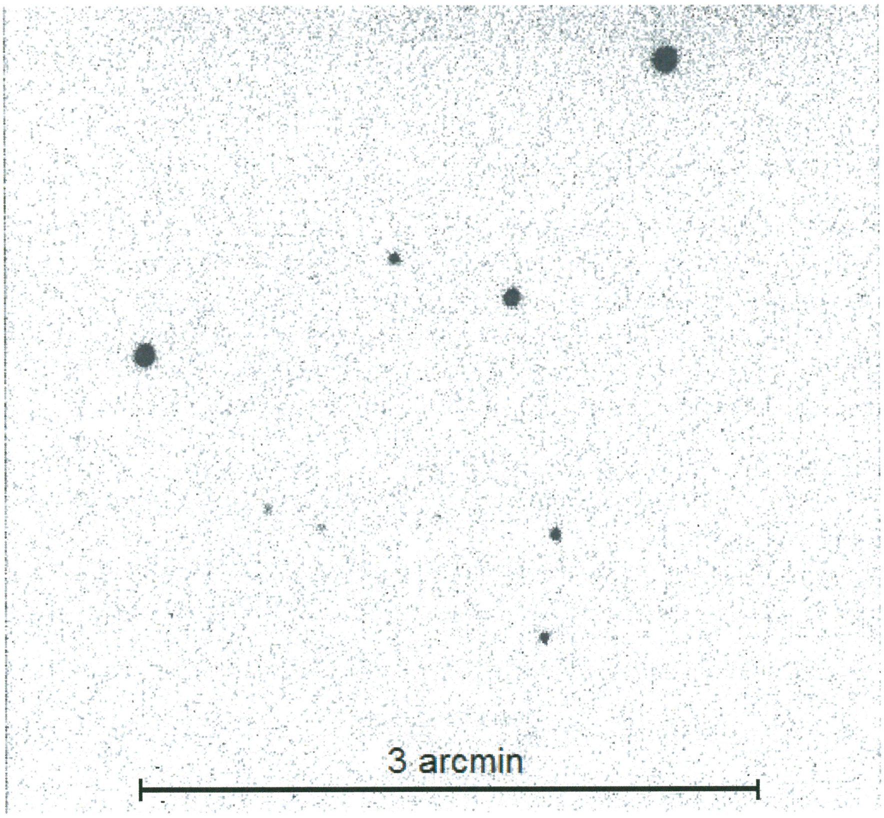

Fig. 7.1. 4:53 UT Рис. 7.1.

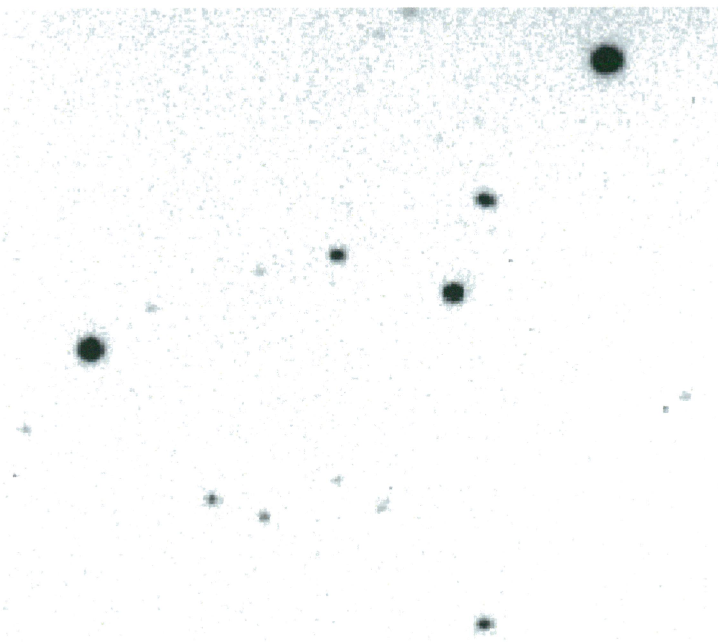

Fig. 7.2. 7:16 UT Рис. 7.2.

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7. Asteroid.

7. Астероид.

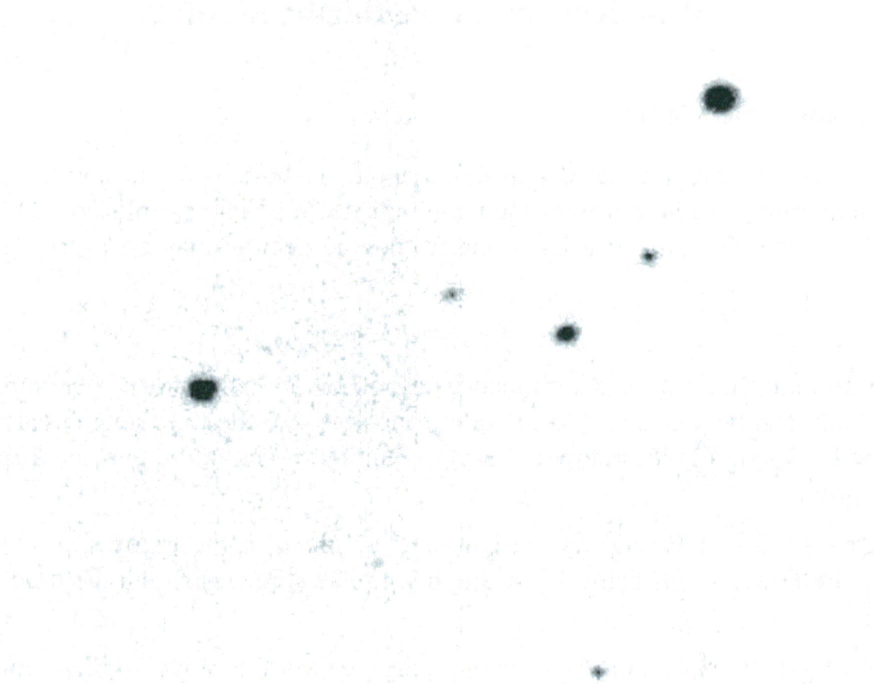

Fig. 7.3. *Observatory 2* *Рис. 7.3.*

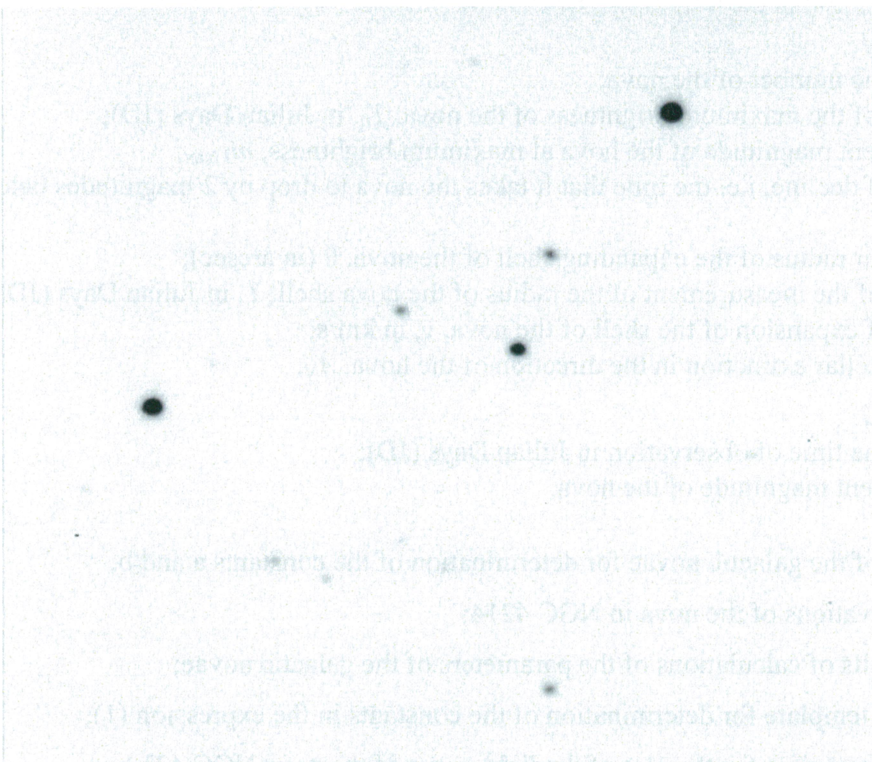

Fig. 7.3. *Observatory 1* *Рис. 7.3.*

Practical round. Problems to solve

7. Distance to the galaxy NGC 4214

The usage of novae in outbursts as distance indicators is based on the correlation of their absolute magnitudes at maximum brightness with their rates of decline. The simplified relationship between the absolute magnitude at maximum of a nova and its rate of decline may be expressed through the linear expression:

$$M_{Vmax} = a + b\log t_2 , \tag{1}$$

where a and b are constants to be determined using observational data of a certain number of galactic novae with spatially resolved shells, t_2 is the rate of decline, i.e. the time (expressed in days) that it takes the nova to drop by 2 magnitudes below its light maximum. t_2 should be evaluated from the graph of the light curve of a nova.

7.1. Using data of Table 1 determine the constants a and b in the expression (1). The results of the calculations should be written in Table 1a. A graph template (Fig. 1a) should be used for determination of constants a and b.

7.2. Using the obtained expression and photometric data of a nova, which erupted in the galaxy NGC 4214, calculate the distance to this galaxy. Photometric data of this nova are given in Table 2. A graph template (Fig. 2a) should be used for the plot of the light curve of the nova.

Data of Table 1:
1st column is the number of the nova;
2nd – the time of the maximum brightness of the nova, T_0, in Julian Days (JD);
3rd – the apparent magnitude of the nova at maximum brightness, $m_{V\max}$;
4th – the rate of decline, i.e. the time that it takes the nova to drop by 2 magnitudes below maximum, t_2, in days (d);
5th – the angular radius of the expanding shell of the nova, θ (in arcsec);
6th – the time of the measurement of the radius of the nova shell, T, in Julian Days (JD);
7th – the rate of expansion of the shell of the nova, v, in km/s;
8th – the interstellar extinction in the direction of the nova, A_V.

Data of Table 2:
1st column is the time of observation in Julian Days (JD);
2nd – the apparent magnitude of the nova.

Table 1. Data of the galactic novae for determination of the constants a and b;

Table 2. Observations of the nova in NGC 4214;

Table 1a. Results of calculations of the parameters of the galactic novae;

Fig. 1a. Graph template for determination of the constants in the expression (1);

Fig. 2a. Graph template for the plot of the light curve of the nova NGC 4214.

7. Distance to the galaxy NGC 4214.

7. Расстояние до галактики NGC 4214.

Table 1. **Таблица 1.**

No.	T_{max} (JD)	m_{Vmax}	t_2, (d)	θ (arcsec)	T (JD)	v (km/s)	A_V (mag)
1	2412083	4.5	45	9	2444798	600	1.3
2	2442655	1.9	2	1.5	2445707	1500	1.4
3	2427794	1.6	39	10	2444798	500	0.3
4	2438061	3.5	22	3.5	2445707	1100	0.6
5	2428340	2.0	5	11	2444798	1600	0.8
6	2430676	0.7	6	9	2450898	800	0.3

Table 2. **Таблица 2.**

Time (JD)	Apparent magnitude m_V
2455233.1	17.6
2455233.8	17.3
2455234.5	17.6
2455236.5	18.7
2455237.5	19.4
2455238.5	19.8

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7. Distance to the galaxy NGC 4214.

7. Расстояние до галактики NGC 4214.

Table 1a. **Таблица 1a.**

No.	Δt (JD)	R (AU)	d (pc)	$M_{V\max}$	$\log t_2$
1					
2					
3					
4					
5					
6					

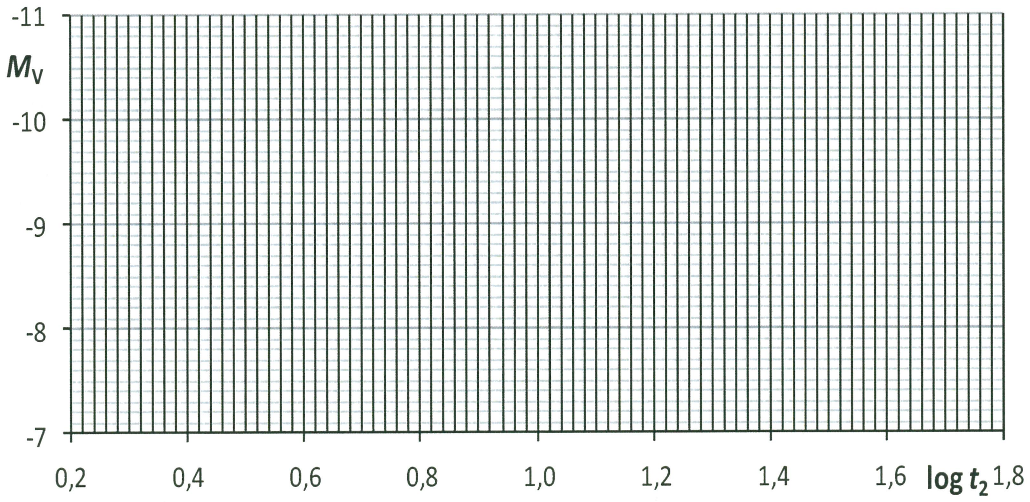


Fig. 1a.

Рис. 1a.

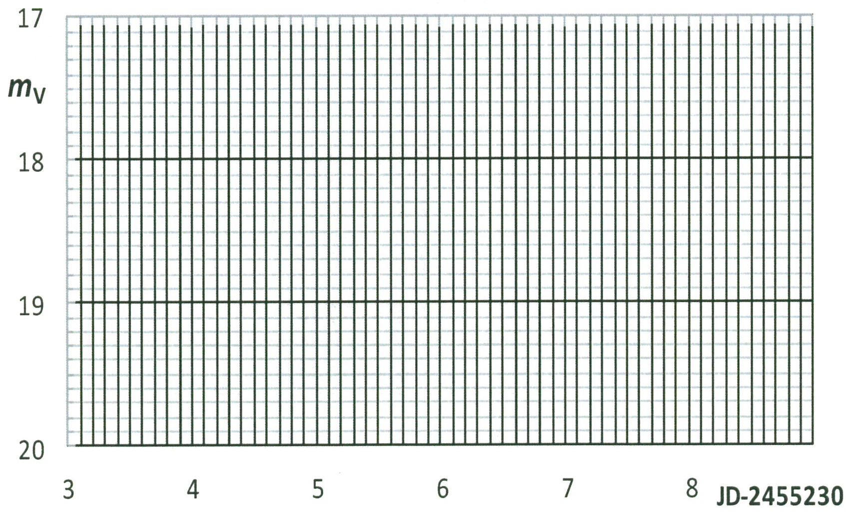


Fig. 2a.

Рис. 2a.

Practical round. Problems to solve

αβ-8. Jupiter. Analysis of observational data of Jupiter and its moons

Observational data of Jupiter and its moons are given on separate sheets.
Your answers (measured values, results of calculations, used formulas) must be written in corresponding tables.

A. See separate sheet.

B. Equatorial rotational period and radius

Two CCD images of Jupiter are shown in Figs. 2 and 3. The vertical lines in figures marks the position of the projection of Jupiter‘s rotation axis (we assume it is perpendicular to the line of sight). The rotation period can be obtained from horizontal shifts of stable atmospheric features located relatively close to the equator.

B.1. What time interval in seconds (**dt**) separate these images?
B.2. One feature useful for measurements is already marked "**1**". Select and mark two additional features as "**2**" and "**3**" in both pictures.
B.3. Measure distances from the central vertical line to the marked features in both images ($\mathbf{x_1}$ and $\mathbf{x_2}$, respectively) and to the Jupiter limb at the feature's latitude ($\mathbf{L_x}$).
B.4. Calculate the rotational angle (**ϕ**) for each feature.
B.5. Calculate the averaged value of rotational angle (**ϕ_avg**).
B.6. Calculate the rotational period ($\mathbf{P_{Je}}$), in hours.
B.7. Calculate Jupiter‘s equatorial radius ($\mathbf{R_{Je}}$), in km.

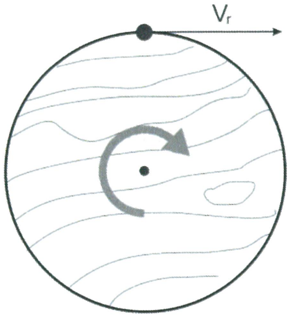
C. Mass and density

Figs. 4-6 display observations of three Jupiter moons obtained during five successive nights in September 2011. Abscissa in those figures is time of observation measured in hours from the beginning of the observing session. Ordinate is the angular distance (in angular minutes) of the moon from the center of Jupiter at the moment of observation. The equatorial radius of Jupiter in the angular seconds is also given for some moments.

C.1. Estimate the period of revolution of each Jupiter‘s moon ($\mathbf{P_m}$), in hours.
C.2. Estimate the semimajor axis of the orbit of each Jupiter‘s moon expressed in Jupiter‘s equatorial radii (**a_Je**) and convert it into meters (**a**).
C.3. Use your mesurements of each moon to calculate the mass of Jupiter ($\mathbf{M_J}$) independently.
C.4. Calculate the averaged value of Jupiter mass ($\mathbf{M_J}$**_avg**).
C.5. From Jupiter image estimate the ratio of Jupiter‘s polar and equatorial radii ($\mathbf{R_p/R_e}$).
C.6. Calculate the mean radius of Jupiter ($\mathbf{R_J}$**_avg**).
C.7. Calculate the density of Jupiter ($\boldsymbol{\rho_J}$).

8.

A.



$V_r = 12.6$ km/s

Practical round. Problems to solve

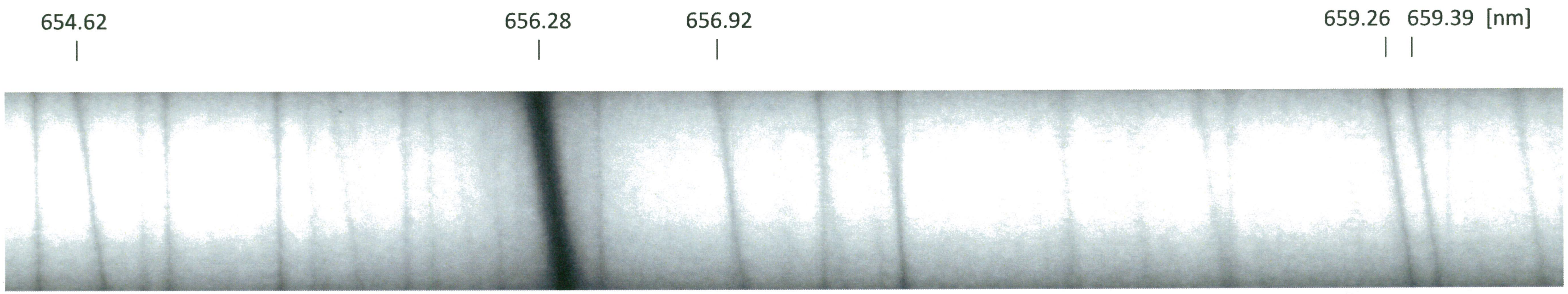
β-8. Jupiter.

A. Rotational velocity

Spectrum of Jupiter (Fig. 1) was obtained when the slit of a spectrograph was aligned along the planet's equator. Wavelengths (**λ**) of several recognized lines are shown. Due to Jupiter rotation the reflected Sunlight was affected by the Doppler effect. The spectral lines become inclined, because the spectrum of light reflected from the receding part of Jupiter is red-shifted, and of light reflected from the approaching part is blue-shifted. Non-inclined lines, which are visible in the spectrum, were formed in the Earth atmosphere.

A.1. Evaluate the mean scale of the given spectral interval (**N**), in nm per mm.
A.2. Measure the difference between the uppermost and the lowermost end of an inclined spectral line in mm (**dx**) and convert it into nm (**dλ**). Do this for 3 lines independently.
A.3. Calculate the equatorial rotational velocity of Jupiter (**v_r**) for each measured line and the final averaged value (**v_r_avg**).

Fig. 1



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Group	α β

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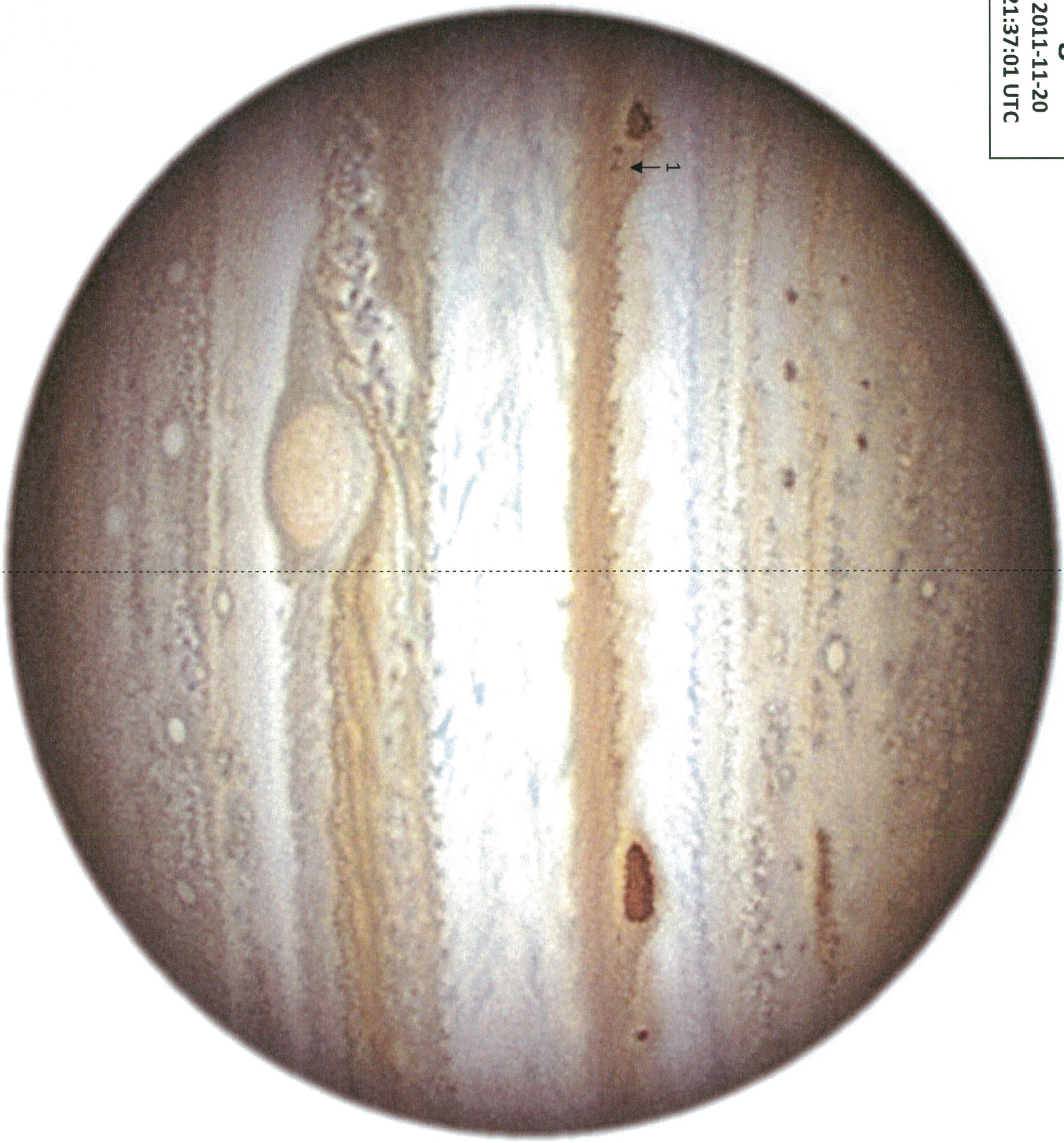
Fig. 2
2011-11-20
21:37:01 UTC



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Group α β

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Fig. 3
2011-11-20
23:28:36 UTC

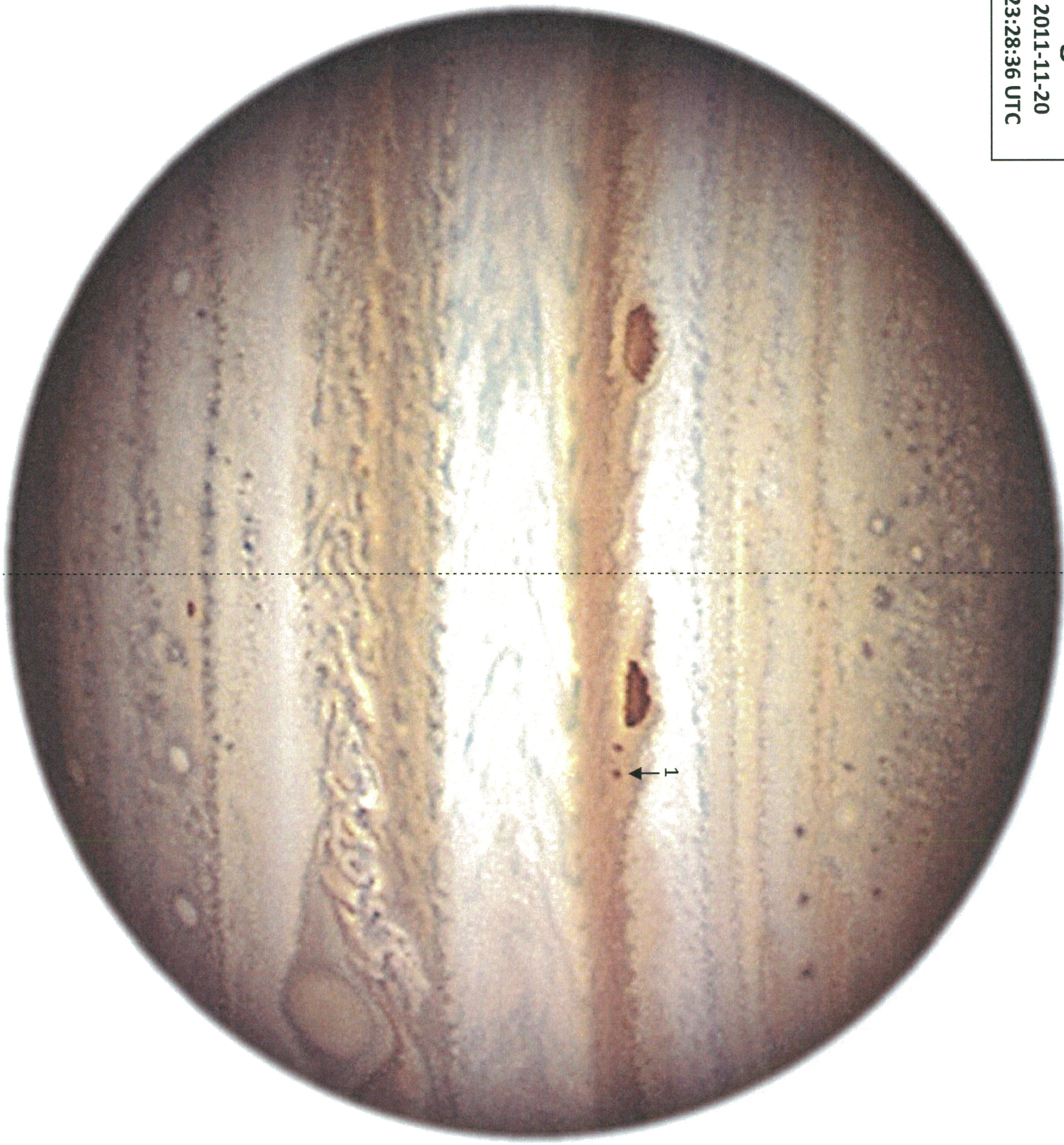

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Fig. 4. Moon-1

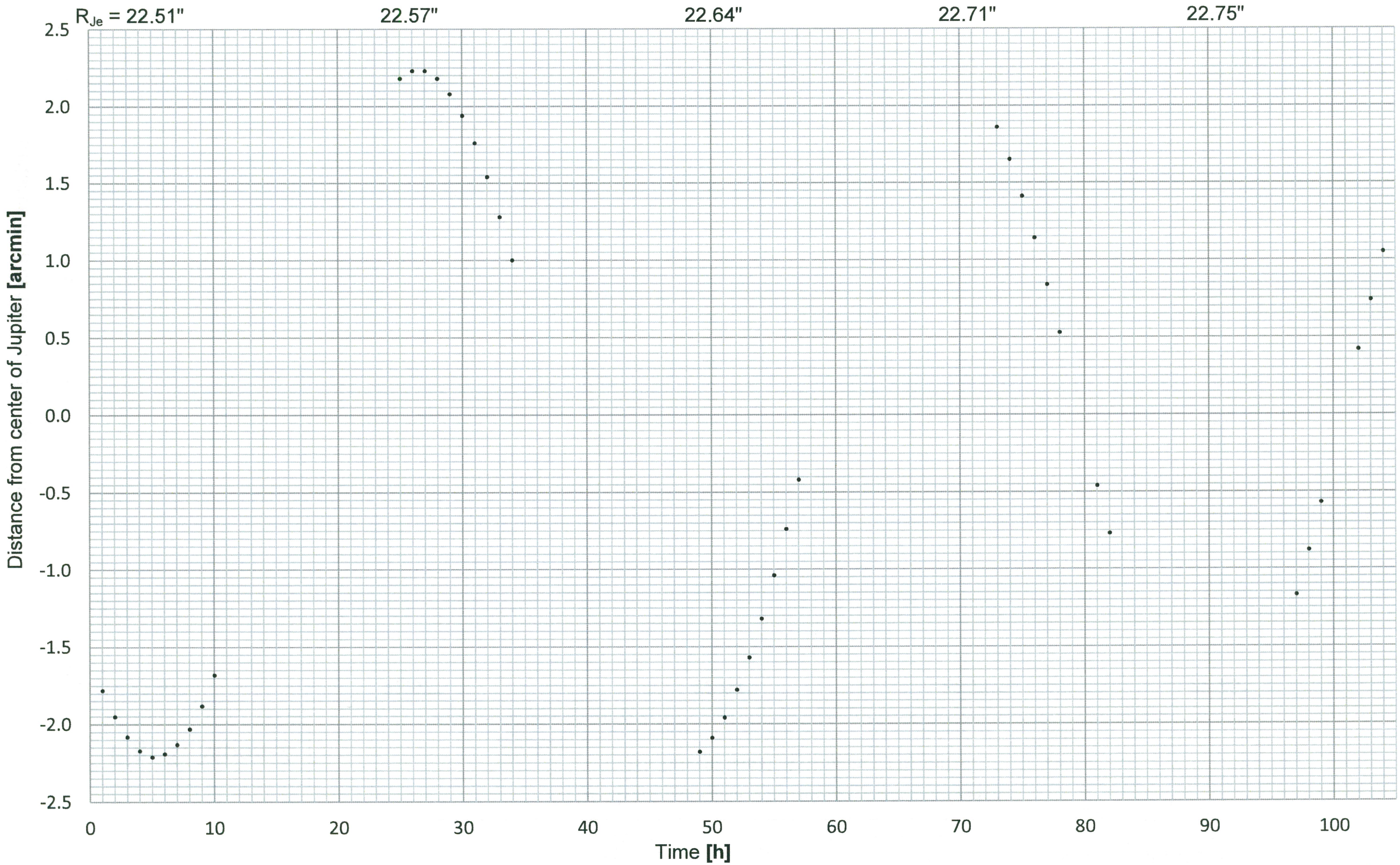


Fig. 5. Moon-2

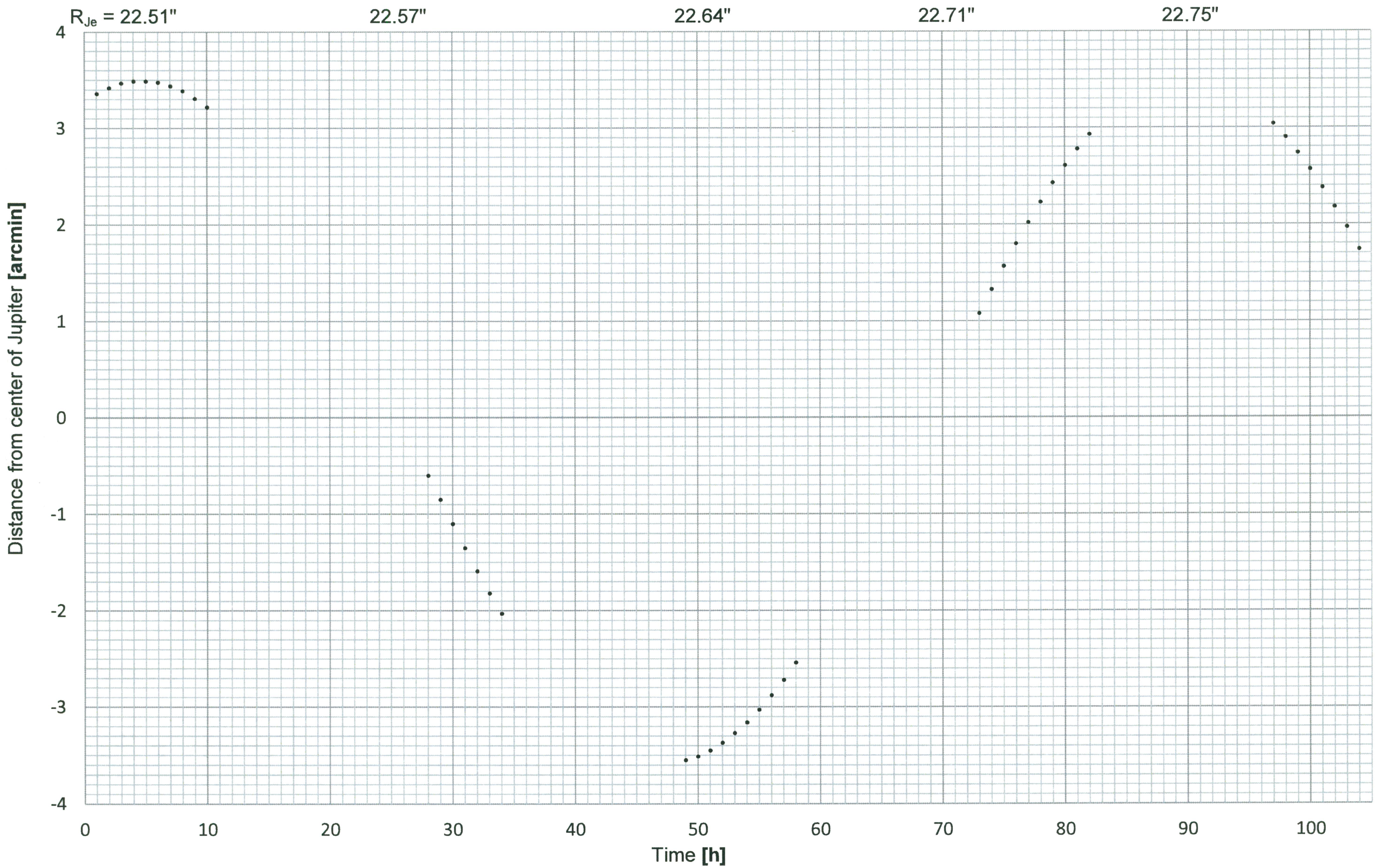
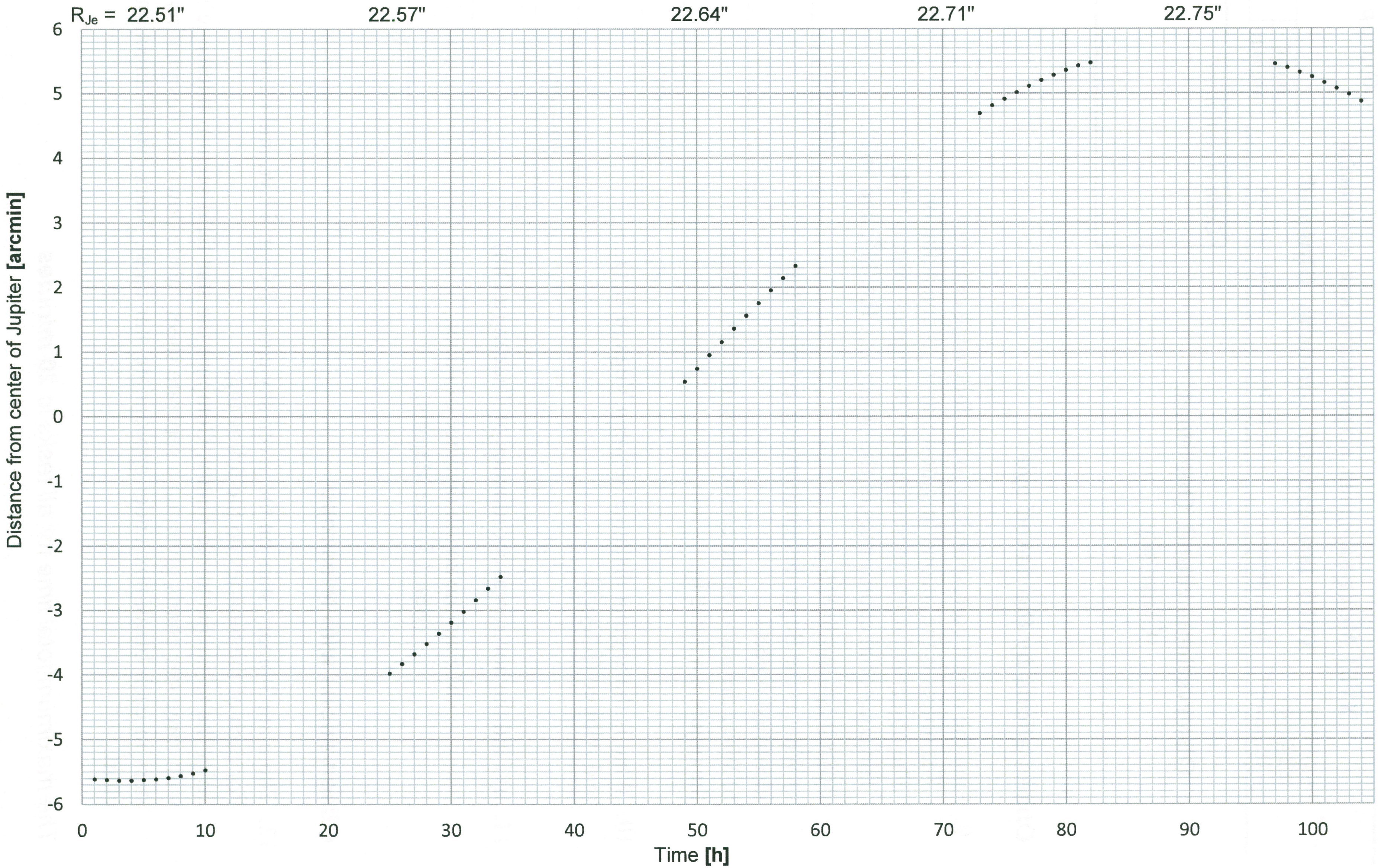

R_{Je} = 22.51"
22.57"
22.64"
22.71"
22.75"
Distance from center of Jupiter [arcmin]
4
3
2
1
0
-1
-2
-3
-4
0
10
20
30
40
50
60
70
80
90
100
Time [h]

Fig. 6. Moon-3


R_{Je} = 22.51"
22.57"
22.64"
22.71"
22.75"
Distance from center of Jupiter [arcmin]
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
0
10
20
30
40
50
60
70
80
90
100
Time [h]