Solution

Table A

N [nm/mm] =	(659.39-654.62)/215.5 ≈ **0.0221**

λ [nm]	dx [mm]	dλ[nm]	v_r [km/s]
654.62	~5	~0.1105	~12.65
656.92	~5	~0.1105	~12.61
659.26	~5	~0.1105	~12.56
		v_r_avg [km/s] =	**~12.6**

FORMULAE

Because of the Doppler effect the wavelength shift , dλ, observed at the edge of Jupiter's disk can be obtained through the following formula:

$$\mathbf{v_r = \frac{1}{4} \cdot \frac{d\lambda}{\lambda} \cdot c}$$

,where c – speed of light in the vaccum.

Coefficient $\frac{1}{4}$ comes into effect due to the fact that:

-the sunlight, illuminating the planet, is reflected, therefore it was affected by Doppler effect twice,

- measurements are done at the edges of the disk and not relative to the non-shifted center, thus doubling the measured shift value.

Table B	
dt[s] =	6695

Feature	x_1 [mm]	x_2 [mm]	L_x [mm]	ϕ [°]
1	66	33	92	66.86
*2**	*57*	*46*	*92.5*	*67.86*
*3**	*44*	*54*	*87*	*68.75*
			ϕ_avg =	**~ 67.8**

only as example - acctual values depends on choosen feature and accuracy of measuremets

P_{Je} [h] =	**~ 9.9**
R_{Je} [km] =	**~71470**

FORMULAE

$$\varphi = \arcsin\left(\frac{x_1}{L_x}\right) + \arcsin\left(\frac{x_2}{L_x}\right)$$

$$P = \frac{360°}{3600\ s} \times \frac{dt}{\varphi}$$

$$R_{Je} = \frac{v_r \cdot P_{Je}}{2\pi}$$

Table C				
Moon	P_m [h]	a_Je	a [m]	M_J [kg]
1	~ 43	~ 5.9	~ 4.22×10^8	~ 1.86×10^{27}
2	~ 85	~ 9.4	~ 6.70×10^8	~ 1.90×10^{27}
3	~ 172	~ 14.9	~ 10.65×10^8	~ 1.86×10^{27}
			M_J_avg [kg] =	**~ 1.87×10^{27}**

R_p/R_e =	174 mm / 186 mm ≈ **0.9355**
R_J_avg [m] =	**~ 69900×10^3**
V [m^3] =	**~ 1.43×10^{24}**
ρ_J [kg/m^3] =	**~ 1310**

FORMULAE

In case of a moon orbiting a much more massive planet, the mass of the central body (planet) can be obtained from Kepler`s Third Law:

$$\mathbf{M_J = \frac{4\pi^2}{G} \cdot \frac{a^3}{P^2}}$$

, where G – gravitational constant, a – semi-major axis of moon orbit in meters, P – period in seconds

The mean radius for a slightly oblate ellipsoid is:

$$\mathbf{R_{J}\_avr} = \sqrt[3]{\frac{R_p}{R_e} R_e R_e^2} = \mathbf{R_e} \times \sqrt[3]{\mathbf{R_p/R_e}}$$

Distance to the galaxy NGC 4214

Solution

7.1. Distances of the novae from Table 1 are calculated using their shell radii assuming that their rates of expansion are constant. Linear radius of the nova's shell:

$$R = v \times \Delta t ,$$

where v is the expansion rate of the nova's shell , and Δt is the time interval that elapsed from the nova's outburst up to time when the angular radius of nova's shell have been measured. Radii of the shells should be expressed in astronomical units (au). Since 1au=1.496·10^8 km and 1day=24h·3600s=86400s we get

$$R(\text{au}) = \frac{86400}{1.496 \cdot 10^8} v\Delta t = 5.775 \cdot 10^{-4} v\Delta t$$

Distance to a nova is calculated by the formula:

$$d = \frac{R}{\tan\theta}$$

Since θ is a small angle and is measured in arcsec, and R is expressed in au, we get the distance expressed in parsecs:

$$d = \frac{R}{\theta}$$

Then absolute magnitudes of the novae are calculated by the formula:

$$M_V = m_V - 5\log d + 5 - A_V$$

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

No.	Δt (JD)	R (au)	d (pc)	$M_{V\max}$	log t_2
1	32715	11336	1260	-7.3	1.65
2	3052	2644	1763	-10.7	0.30
3	17004	4910	491	-7.2	1.59
4	7646	4857	1388	-7.8	1.34
5	16458	15207	1382	-9.5	0.70
6	20222	9343	1038	-9.7	0.78

Now we plot the graph $\log t_2 ; M_{V\max}$ and draw the straight line best fitted through the points (Fig. 1b).

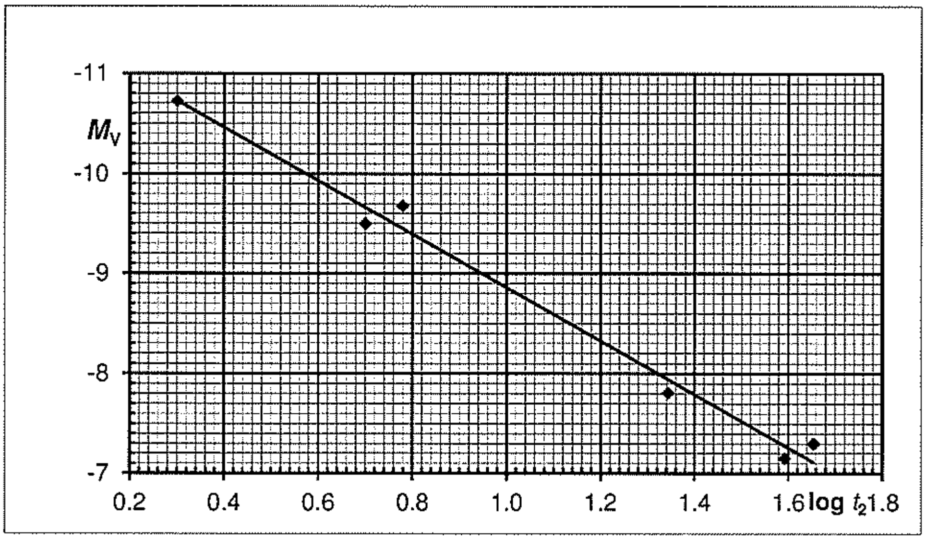

Fig. 1b. Graph for determination of the constants in the expression (1)

The equation of the line is

$$M_{V\,\max} = -11.53 + 2.67 \log t_2 \qquad (1a)$$

7.2. We use the data of Table 2 to plot the light curve of the nova in NGC4214 (Fig. 2).

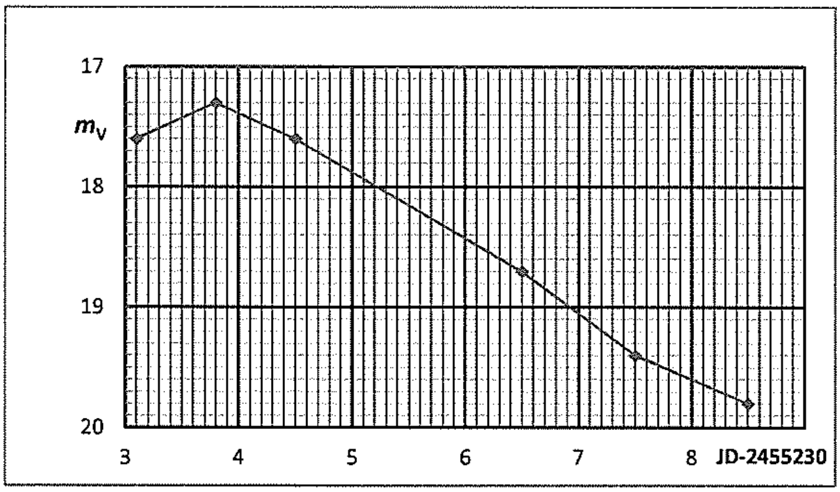

Fig. 2b. Light curve of the nova NGC 4214

From this graph we see that the nova reached its light maximum, m_V=17.3, at JD=2455233.8. Brightness of the nova dropped by 2 mag from its maximum at about JD=2455237.35. So we get the time $t_2 = 2455237.35 - 2455233.8 = 3.55$ days.

Using the relation (1a) we get the absolute magnitude of the nova NGC 4214 at its maximum

$$M_{V\,max} = -11.53 + 2.67 \log 3.55 = -10.06$$

We assume that interstellar extinction in the direction of the nova (as well as NGC 4214) is negligible and calculate distance to the galaxy NGC 4214:

$$\log d = \frac{m_{V\,max} - M_{V\,max} + 5}{5}$$

$$\log d = \frac{17.3 + 10.06 + 5}{5} = 6.47$$

$$d \approx 3.0 \times 10^{6} \text{ pc}$$

Answer: ***Distance to the galaxy NGC 4214 is 3.0 Mpc.***