For translation only. **Practical round. Problems to solve**

α-6. Pulsation period of a variable star. SZ Lyn is a δ Scuti (δ Sct)type short period pulsating star. The star is observed in **B** band at Mount Abu Observatory, India. The light curve data are given table 6. The differential magnitudes were taken by observing a comparison star in the same field. The time is in Julian Days (JD). This data set is only for one observation night and therefore integer part of the JD does not change. You are asked to produce the light curve for this observation.

6.1. Plot the data points, differential magnitude against the Julian Day (JD).

6.2. Draw a smooth light curve through the data points.

6.3. The period of pulsation is assumed to be the time between consecutive maxims in the light curve. Estimate the pulsation period (**P**) of SZ Lyn.

6.4. Calculate the absolute magnitude of SZ Lyn, if the period–luminosity relationship for δ Scuti type stars is given by empirical formula

$$M_B = -2.36 \lg P - 0.62.$$

6.5. If the apparent magnitude (m_B) of SZ Lyn is 9.7^m, estimate the distance to SZ Lyn.

β-6. Binary system S Ant. S Ant is an eclipsing binary which was observed in spectroscopy using 45 cm Cassegrain telescope at Arthur C Clarke institute, Sri Lanka. The figure 6.X shows the Hα absorption line profiles of S Ant observed in different phases (phases are indicated on the right) of the binary orbit. The two stars are very close by and the secondary component is merged with the primary so that the primary component is only visible in the spectrum. The secondary component was recovered by special image processing program method (deblending) and the radial velocities are given in the table 6. The spectra are shifted in Y axis for the clarity.

6.1. Draw a table for the first three columns as shown in table 6. Measure the wavelength shift of the Hα lines assuming Hα is 6563 Å and fill the table. Calculate radial velocity of the primary component.

6.2. Plot the radial velocities of primary and secondary components vs phase in the same sheet of graph paper.

6.3. Draw the smooth best fit radial velocity curves for primary and secondary components.

6.4. Calculate velocities of the primary (V_p) and secondary (V_s) components in km/s.

6.5. Calculate masses of the components of the system if the period P = 0.65 days.

Inclination angle of the system orbit is i = 70°.

αβ-7. Calibration of solar spectrum. The spectrograph equipped with 45 cm Cassegrain telescope at Arthur C Clarke observatory, Sri Lanka, observed the Sun. A part of the solar absorption spectrum is shown in figure 7.1. The spectrum is colour inverted for the clarity of the spectral lines. The bottom line is the solar absorption spectrum and the top line is the emission spectrum of Fe-Ne lamp. This emission spectrum is used for calibration of the solar spectrum. Both spectra are in same image frame.

Figure 7.2. demonstrates solar absorption spectrum and the Fe-Ne emission spectrum. The red line is solar absorption spectrum and black line is Fe-Ne emission spectrum. The wavelength in angstrom (Å) of few emission lines of Fe-Ne are given in the figure 7.2. Y axis is the normalized flux. Assume the X axis is pixels of the CCD image.

7.1. Copy the table 7. to your answer book and read out the corresponding pixel using the grid in figure and fill the table.

7.2. Plot the wavelength (Å) vs pixels for the data in table 7.

7.3. Draw the best fit straight line through the data points.

7.4. Hence determine the wavelength of the marked absorption line (**L1**) in figure 7.2.

αβ-8. Star variability analysis. For any periodic variable star, the period is one of the most important and most informative of its observable parameters. Studying the periods of variable stars, and their changes in periods is an important part of the analysis of variable stars. If a star is perfectly periodic, then every period is exactly the same. In that case we can predict its cycles in advance.

8.1. Any perfectly periodic star with epoch time t_0 (the time of maximum (or minimum) for cycle number zero) and period P, shows its next maximum at time $t_0 + P$. This maximum time is known as calculated-time of maximum (or minima) for cycle number one (C_1).

Using this pattern write an equation for the calculated-time of maximum (C_n) for any cycle number n of a perfectly periodic star with a period of P and epoch of t_0

$C_n =$ ....

8.2. The table 8 lists times of minima of an eclipsing binary star which has epoch: t_0 = JD 2442502.726 (JD: Julian Date) and period: P = 0.971534 day. Substituting these values to the equation you wrote above, compute the calculated time of minima for each cycle of the table and fill the "JD-Calculated" column of the table.

8.3. Fill the "(O-C) (in days)" column of the table. (O-C = observed value minus calculated value)

8.4. Convert (O-C) values that you calculated in previous chapter into minutes and fill the "(O-C) (in minutes)" column of the table.

8.5. Using the data of this completed table, construct (O-C) (in minutes) graph vs the number of cycle and fit a trend line for your plotted data. (Graph papers are provided. Use maximum range of the graph paper).

8.6. According to your results mention whether this star is perfectly periodic, almost periodic or not periodic. Write English words:

"(1) **perfectly periodic**", "(2) **almost periodic**" or "(3) **not periodic**".

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JD 2456664.0+	Differential magnitude
0.23	-1.60
0.24	-1.73
0.25	-1.98
0.25	-2.24
0.26	-2.33
0.27	-2.22
0.28	-2.07
0.29	-1.95
0.30	-1.84
0.31	-1.72
0.32	-1.68
0.32	-1.66
0.33	-1.64
0.34	-1.63
0.35	-1.67
0.36	-1.72
0.37	-1.89
0.37	-2.09
0.38	-2.29
0.39	-2.27
0.40	-2.05
0.41	-1.95
0.42	-1.84
0.43	-1.78
0.44	-1.71
0.45	-1.64

Table 6.

Practical round

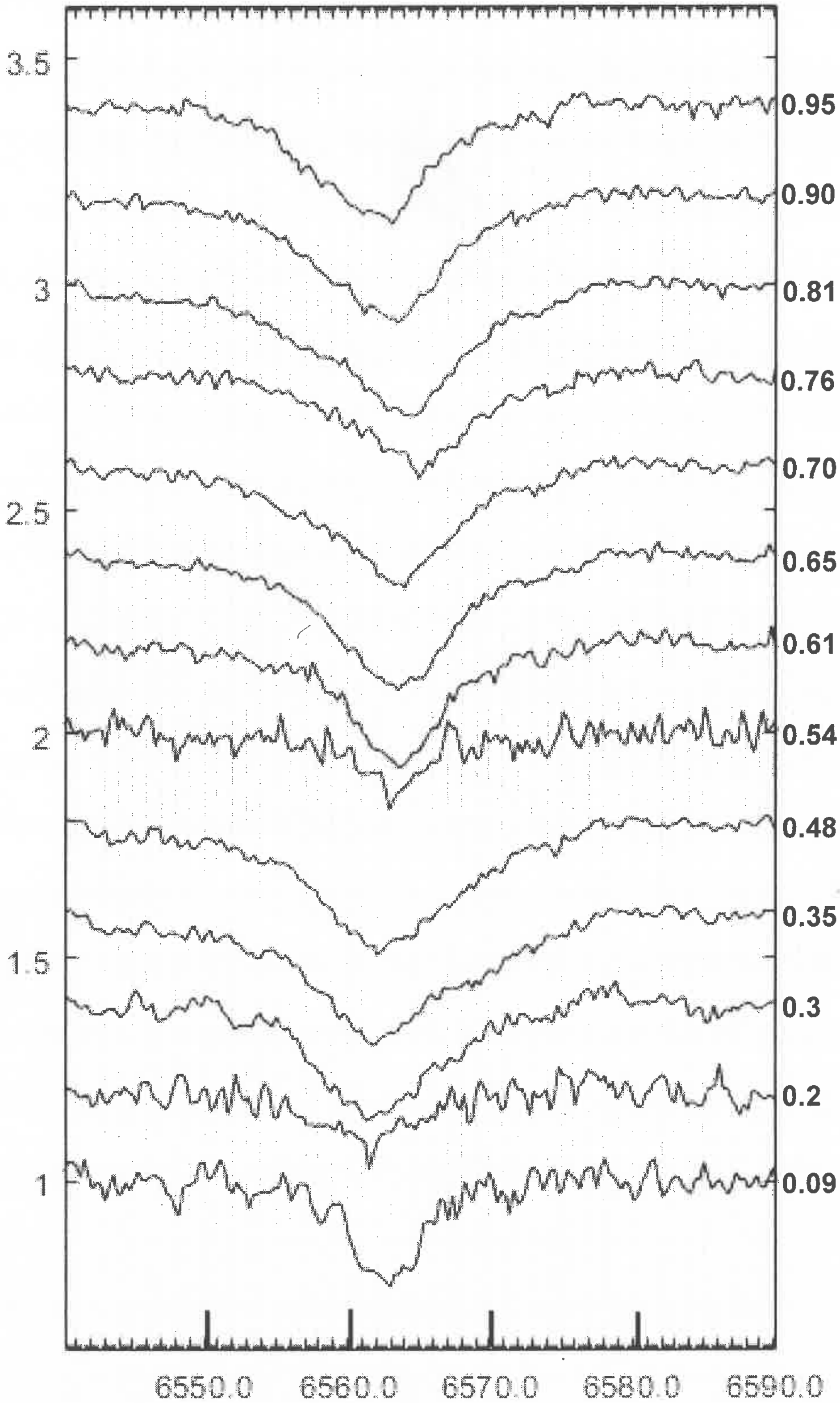

Fig. 6.

Practical round

Phase	Δλ (Å)	Radial velocity of primary (km/s)	Radial velocity of secondary (km/s)
0.09			Not available
0.20			211
0.30			235
0.35			189
0.48			Not available
0.54			Not available
0.61			Not available
0.65			-171
0.70			-267
0.76			-224
0.81			-148
0.90			Not available
0.95			Not available

Table 6.

Practical round

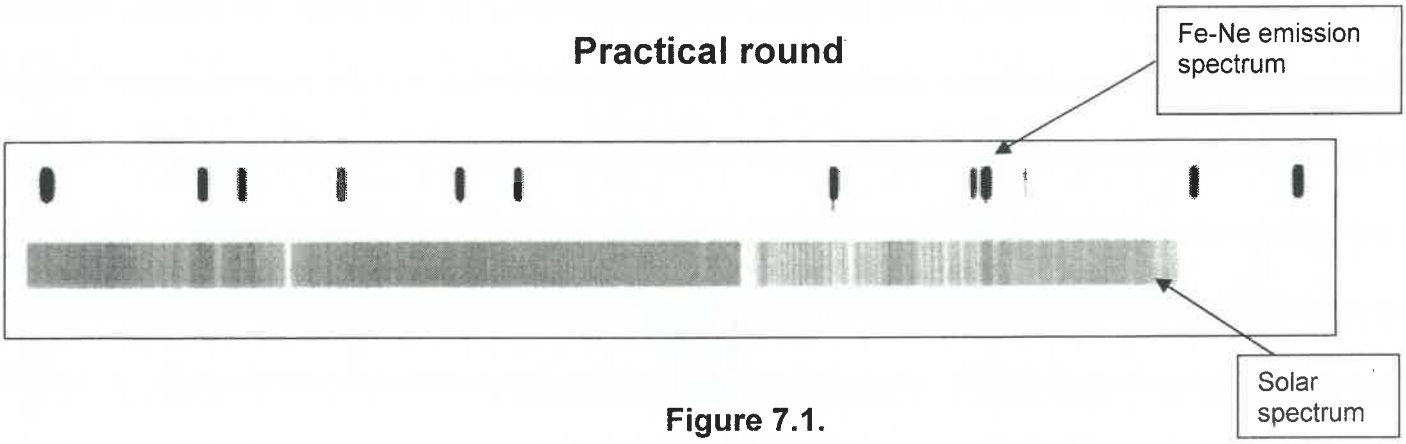

Figure 7.1.

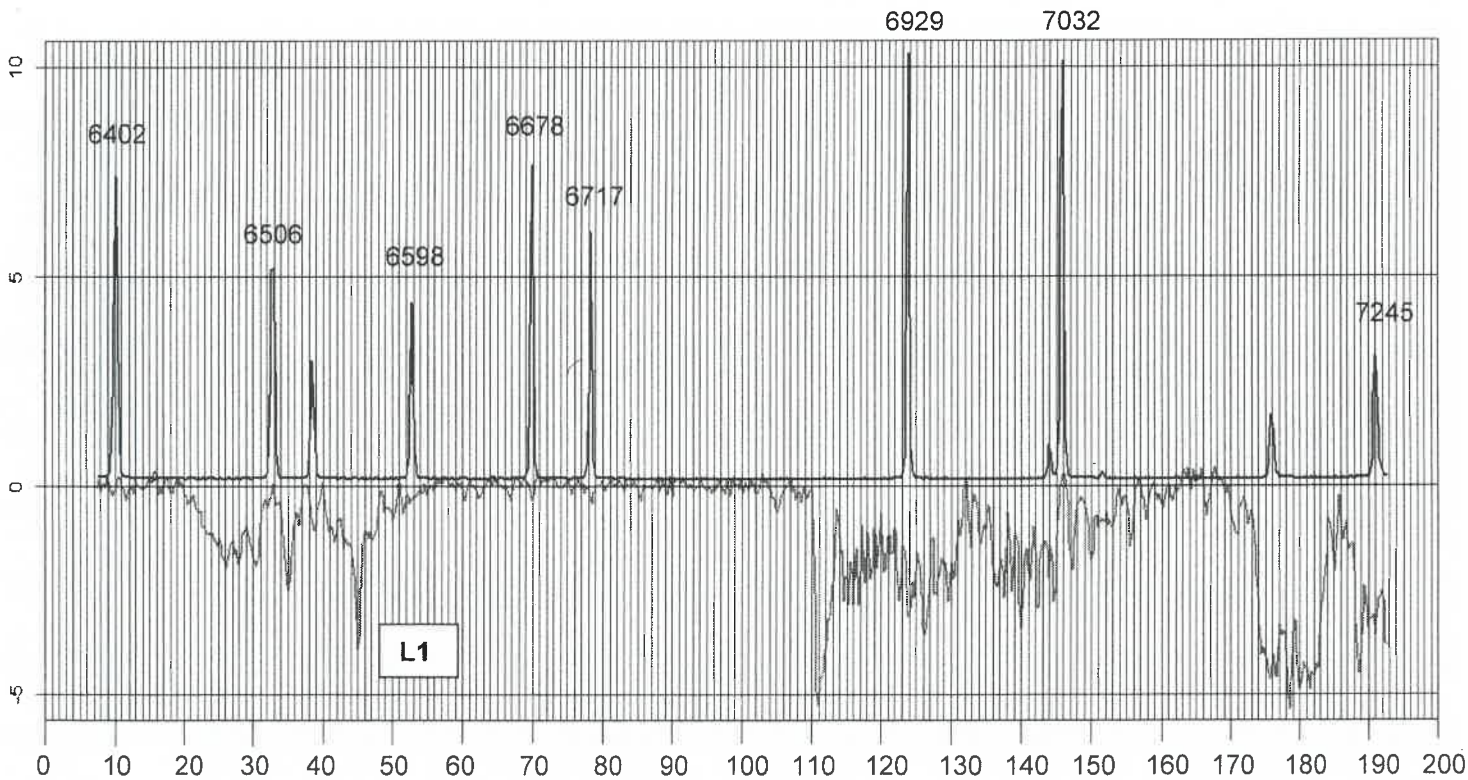

Figure 7.2.

Wavelength (Å)	Pixel
6402	
6506	
6598	
6678	
6717	
6929	
7032	

Table 7.

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Cycles	JD-Observed (Obs)	JD-Calculated (Cal)	O-C (days) (Obs - Cal)	O-C (minutes) (Obs - Cal)
300	2442794.1804			
500	2442988.4867			
950	2443425.6757			
1000	2443474.2563			
1250	2443717.1386			
1350	2443814.2934			
1400	2443862.8687			
1700	2444154.3285			
1750	2444202.9077			
1850	2444300.0622			
2100	2444542.9444			
2400	2444834.4039			
2550	2444980.1353			
3200	2445611.6366			
3250	2445660.2111			
3500	2445903.0947			

Table 8.