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Solar observations as educational tools

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Abstract. Solar observations are very handy tools to expose the students to the joy of research. In this presentation I briefly discuss the various experiments already done here with a small 6″ Coude refractor, like rotation estimates using spots and Doppler measurements, identification of elements from solar spectrum (from published high resolution spectrum), limb darkening measurements, deriving the curve of growth (from published data). I also describe future plans to develop this as a platform for motivating students towards a career in basic science research.

Keywords : Sunspots, solar rotation, Doppler measurements, solar spectrum, curve of growth

1. Introduction

Solar physics is taught to students at the under-graduate levels after introducing fairly deep foundations of physics. Thus the students will be able to appreciate the physics of the sun and extend it to the stars in general. Since the practical sessions involving the sun require a telescope not many colleges will be in a position to carry them out. Here some experiments are suggested for studying the sun and also to utilise the archival data.

1.1 Rotation of the sun by sunspots

The rotation of the sun is inferred directly from the sunspots. Many observatories have been providing the images of the sun. Thus in principle it is possible to monitor the

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spots almost continuously. For this work, the daily images of the sun from the orbiting observatory SOHO are downloaded. The images during October – November 2001 are chosen since the spots were distributed over a range of latitudes during this period.

The first task is to mark the centre of the sun, which is done by geometrical constructions. In general, drawing the equator is a little tricky; but that is taken care of in the SOHO images. The latitudes of the different spots are read out.

The motion of the spot is read out from every image in terms of the longitude and compiled. Finally, the readings are converted into rotation periods in terms of degrees per day.

Since the spots are available at different latitudes, the variation of the rotation speed with latitude is worked out.

1.2 Rotation of the sun from spectra along different latitudes

The method of spots for determining rotation is restricted to latitudes for which the spots are available. On the other hand by placing a slit across the sun and obtaining the spectrum the rotation will be registered as the Doppler shift at the edges. For this purpose a spectrograph with a slit long enough to fit diametrically along the suns image is required. Spectra obtained this way are available (Kesley et al. 1971) at very high resolution, extending from 629nm to 630 nm. The spectra also include the sharp lines of atmospheric oxygen, which can be used as references for measuring the Doppler shift. The sharp contrast between the oxygen lines and the solar lines are useful in identifying the Doppler shifts at the diametrically opposite points. The tilt of the solar lines are also quite obvious.

The result of these two exercises namely the latitude variation of the rotation rate is shown in Fig. 1.

2. Limb darkening measurements during an eclipse

The 6″ Coude refractor has been used for projecting a large image of the sun of diameter about 50cm. With a simple luxmeter the limb darkening of the image has been measured. The results are shown in Fig. 2.

3. Identification of elements in solar spectrum

Very high solar spectrum is available online from http://csep10.phys.utk.edu/astr162/lect/sun/spectrum.html which was used by students for identifying lines in the spectra.

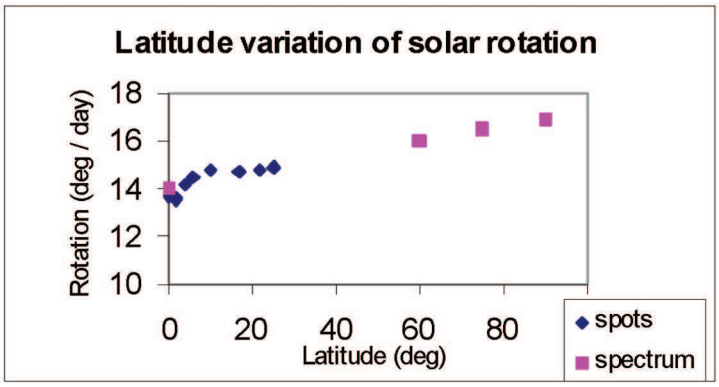

Figure 1. The variation of the solar rotation with latitude as derived from spots and spectra.

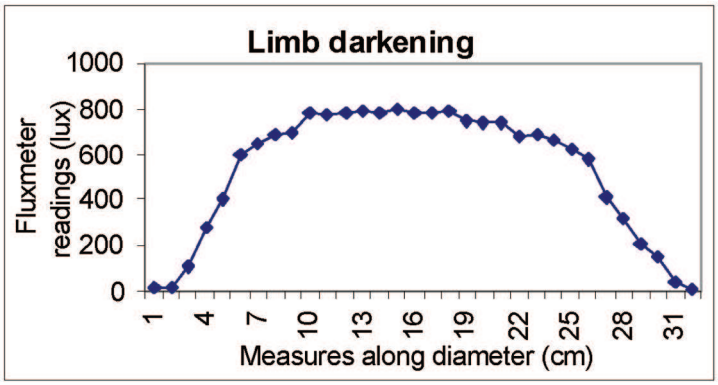

Figure 2. The limb darkening measurements from a 52cm dia image of the sun.

For example, all the Balmer lines were identified very easily by high school students. The students with a good exposure to spectral line formation were able to identify other spectral lines also. For example, all the lines of helium were identified at their respective wavelengths. This was a very useful exercise for using the input from the study of atomic spectra.

3.1 Measurements of the speeds of Mercury and Venus during transits

Transits are rare events of the inner planets Mercury and Venus passing in front of the sun. The inferior conjunction also marks the retrograde motion of these planets. This idea was utilised on 06 May 2003 and 08 June 2004 to measure the speed of the planet by noting down the positions at regular intervals of time. The procedure required incorporating a

correction for the rotation of the image from the Coude telescope. Necessary correction for the motion of the earth was applied.

4. Curve of growth from published data

This was carried out by some of the postgraduate students. The equivalent width is a measure of the product of the number (N) of atoms/cc absorbing that particular line and the oscillator strength (f). The curve of growth indicates variation of the equivalent width with the number of absorbing atoms. From the published data on Ti1 and Fe1 lines the curve of growth was prepared. The excitation temperature was calculated for these two lines as well, as described in the reference (Kleczek 1987).

5. Future plans

The solar observations and data analysis provide excellent opportunities for understanding the physics of the sun and stars in general in the class room. To achieve this aim, instead of depending on the published data, it is planned to generate such data from a simple spectroscopic arrangement. The Coude telescope needs to be attached with a beam splitter so that imaging and spectroscopy can be done simultaneously. The orientation of the slit for different latitudes is automatically achieved by the rotation of the image through out the day. This is a big advantage, since it avoids any mechanical arrangement required for the purpose. The imaging can be done in Ca II lines so that the images can be used for chromospheric studies apart from the above mentioned project of monitoring the spots.

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References

Kleczek, J., 1987, in Exercises in astronomy, ed. J Kleczek, D Reidel, Dordrecht, 115

Kelsey, L. K., Hoff, D.B., & Neff, J. S., 1971, in Astronomy- activities and experiments, Kendall, 105

http://csep10.phys.utk.edu/astr162/lect/sun/spectrum.html