PAPER 19

ASTROPHYSICAL APPLICATIONS OF SELECTIVE MAGNETIC ROTATION

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When measuring the magnetic fields of sunspots the astronomer assumes that the magnetic field revealed by the inverse Zeeman effect is the same as if the splitting were produced by emission lines instead of absorption lines. No doubt this is in general a very fair approximation, but we have reason to remember sometimes that line absorption in the presence of magnetic fields is a very complicated process. In the immediate neighbourhood of absorption lines effects of magnetic rotation of the plane of polarization and magnetic double refraction may appear in the spectrum.

It is interesting to investigate whether such effects as magnetic rotation and magnetic double refraction may influence the measurements of solar fields. It is evident that no complication will appear if the magnetic field does not change its direction when we follow the line of sight through the gases contributing to the absorption line. But if considerable deviations of the field appear we may expect rather complicated effects which may influence our measurements.

One such effect which may be expected to appear sometimes is the possible disappearance of the central component, when we observe the Zeeman splitting of sunspots very near the solar limb and use for this purpose the conventional method of alternating strips. It is very well possible that longitudinal faint fields may in this case appear in the line of sight though the field of the spot itself has a direction perpendicular to the line of sight. In fact this would be expected on the general model of the magnetic field of sunspots [1]. When observing spots near the limb (Fig. 1) a device is generally attached to the spectrograph giving a number of strips where, say, the odd numbers are polarized parallel to the limb, and the even numbers perpendicular to this direction. In this way the simple Zeeman triplet shows the central component in one strip, the outer components next one, and so on.

Suppose now that a longitudinal field in the outer layers (Fig. 1), corre-

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sponding to a smaller optical depth, gives a certain rotation of the plane of polarization. The central component may then be rotated 90° by this longitudinal field, whereas the outer components in the Zeeman pattern will be more or less uninfluenced. When studying therefore the Zeeman splitting with the method of alternating strips we will see all three components in one strip and only a very weak central component or none in the perpendicular vibration.

The writer wants to draw attention to this possible effect. If the effect is found, it might give interesting possibilities in the study of external

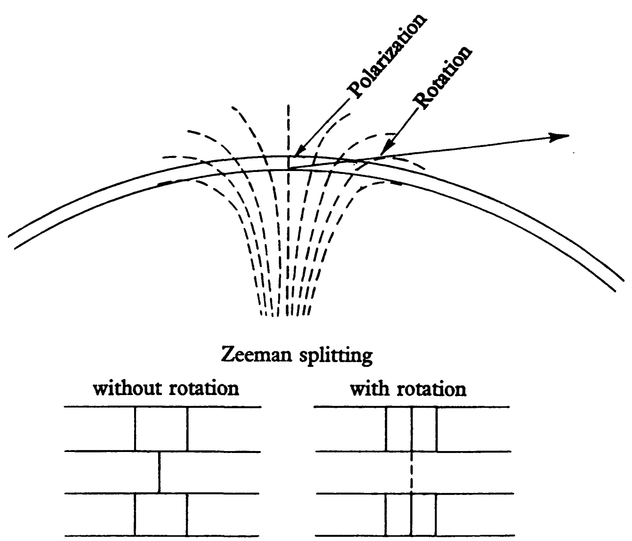

Fig. 1

fields of sunspots and the magnetic rotation of different lines, some of which cannot easily be excited in the laboratory.

When we observe instead of longitudinal Zeeman splitting, when sunspots are situated near the centre of the sun, it is evident that effects of magnetic rotation will have no influence on the measurements. If on the other hand magnetic double refraction is present it might influence the measurements in such cases when the two perpendicular fields in the line of sight have comparable strength. The primary components are otherwise too much displaced to be affected by this double refraction. Whether this effect may be of interest for the measurements of faint solar fields or not, is difficult to say without a thorough investigation.

It has been pointed out by me recently [2] that magnetic rotation may be found useful when studying the chromospheric structure of the sun in selected wave-lengths. In fact a solar monochromator based on the principle of magnetic rotation is very near at hand when considering the original observations of magnetic rotation made by Macaluso and Corbino.

When using a tube of length l between crossed polarizers in a magnetic field of strength **H** the intensity of the transmitted light of frequency ν is given by the following formula:

$$I_\nu = I_0 \sin^2 \chi_\nu \exp(-\kappa_\nu l), \tag{1}$$

where I_0 is the intensity of frequency ν transmitted by the first polarizer, χ_ν the angle of rotation and κ_ν the absorption coefficient.

For the calculation of χ_ν and κ_ν reference is made to expressions given by W. Kuhn [3] and G. Stephenson [4]. As is well known χ_ν is proportional to H whereas both χ_ν and $\kappa_\nu l$ are proportional to the number of atoms of the absorbing vapour in the tube.

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Discussion

Dungey: Is there a method for detecting the component of the magnetic field at right-angle to the plane of your diagram?

Öhman: As I indicated, I do not think that the chances are too good to fit spots situated near the centre of the solar disk because this effect assumes that the light is plane polarized before it enters the gas where the rotation takes place. But there is an analogous effect which implies double refraction. The double refraction can affect the circular polarization. On the other hand in laboratory experiments the magnetic double refraction is not so clearly seen as the magnetic rotation. So I do not think this is a sensitive method of detecting fields.