CONTINUOUS MAGNETIC CALIBRATION OF (VELOCITY) SENSITIVITY OF OSCILLATION SPECTROMETERS

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ABSTRACT. Modulation of the magnetic field in optical resonance spectrometers in order to calibrate the slope of the observable intensity ratios in terms of differential velocities is described.

1. INTRODUCTION

Optical resonance scattering spectrometers have been used extensively in the study of global solar oscillations(1-3). These spectrometers rely for their velocity calibration on the large daily velocity variations due to the Earth's spin when located at temperate latitudes(1,2) and on the very much slower annual variations when located at the South Pole(3) or at the Lagrangian point in the case of ESA's SOHO mission(4). The curvature of the Fraunhofer line and possible temporal variations in that curvature give rise to complications which have been allowed for, to first order, for some years(5), but the need for a direct method of calibration still exists(6).

A nearly ideal method of calibration would be to impose a known rapid velocity variation, comparable to those due to solar or stellar oscillations, by bouncing the light under investigation off a rapidly moving mirror. The technique is relatively difficult and it may not be possible to implement it at remote sites or in space.

This brief note reports on another method of calibration in which the Zeeman splitting is modulated with a known amplitude and at a frequency which is slow compared with the response times of the detection equipment but rapid compared to the looked for oscillations. This method is easily implemented and can be applied to the resonant scattering systems as well as the magneto optical filters(7) (MOF), although in the latter case it can only be used as a transfer standard with the observers known velocity variations acting as a primary standard.

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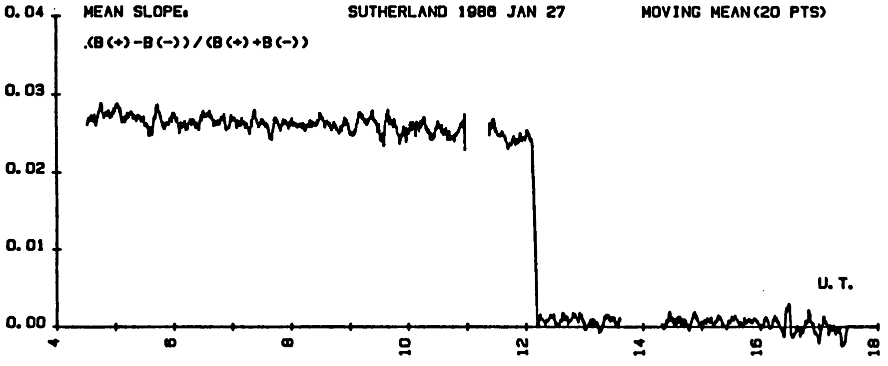
2. METHOD

In order to continuously measure the local slope of the absorption line and the velocity sensitivity of the instrument a variation of Zeeman scanning is used. In our spectrometer a magnetic field of 0.16 T is produced by a permanent magnet. The field is modulated by a pair of pseudo-Helmholtz coils on the pole pieces of the permanent magnet. A constant current is fed to the coils via a relay, which allows the direction of the current to be reversed, thereby reversing the resultant additional magnetic field in a square wave manner so changing the positions of the Zeeman components of the laboratory line. In our application we find it convenient to reverse the small additional magnetic field every eight seconds. For our configuration the relation between switched current i (Amperes) and field B (Tesla) is $\Delta B = 0.032$ i and was checked to be linear to 1% up to 0.35 Amperes.

The field was measured using a Hall probe which was calibrated using NMR techniques in a more homogeneous magnetic field. The corresponding velocity shifts of the Zeeman components of the 770 nm line of potassium are given by $v(ms^{-1}) = 445$ i (Amperes). Thus in this arrangement ±0.1 mT shifts the Zeeman components of the atomic vapour in the spectrometer by an equivalent 3.3 ms^{-1} and requires a power of only 0.9 mW.

In the case of the resonant scattering system the positions of the instrumental lines correspond to Zeeman components. For the MOF (refs.7,8) the situation is complicated as the positions of the instrumental lines now depend on Faraday rotation, and thus on the vapour pressure in the cell. The calibration of such a system can be performed in the laboratory using e.g. absorption lines of K vapour in an adjustable magnetic field. Alternatively the observable variations can be interpolated from orbital and diurnal spin velocity changes. Under our particular operating conditions the ratio of the MOF splitting to that of the Zeeman splitting was measured to be 1.15.



The variation of the slope of the 769.9 nm Fraunhofer absorption line of sunlight as it moves relative to the laboratory standard during the day is shown in the figure. The mean slope agrees within a few

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percent with an independent laboratory calibration and the slight decrease during the day is consistent with the mean curvature of the solar spectral line. The sudden jump near 12 UT is due to a deliberate reduction of the current feeding the modulation coils from 332 mA to 9.5 mA

3. CONCLUSIONS

It has been demonstrated that magnetic modulation requiring very low power consumption can be used to calibrate optical resonance spectrometer. Such a technique is particularly attractive for both of the proposed velocity spectrometers on the SOHO mission of the European Space Agency.

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