CCD Field Polarimetry with EFOSC

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1. Field Polarimetry as the Sixth Observing Mode of EFOSC

This is a report on the installation of a Wollaston prism in EFOSC, the ESO Faint Object Spectrograph and Camera (1, 2). By inserting the prism in the parallel beam space of the instrument it is now possible to obtain for each object in the CCD field of view (3.'5 × 5.'6) two images characterized by perpendicular linear polarizations. The amount ϱ and the position angle Φ of the polarization can be derived from a cosine fitting to the relative intensity differences of the two images as measured at different orientations of the Wollaston. The change in the position angle of the polarization vector is achieved by the rotation of the adaptor flange on which EFOSC is mounted.

The analysis of the test data obtained in October 1986 indicates that 1% polarization can be easily measured for objects as faint as 20th magnitude. By averaging multiple frames of the same field and by taking special care in the flat-field procedure, it should be possible to improve both this limiting magnitude and the accuracy of the measurement.

The polarimetric observing mode of EFOSC can be used on the same night with any of the other observing modes of EFOSC: imaging, slit grism spectroscopy, multiple object spectroscopy, échelle spectroscopy and grism slitless spectroscopy.

2. The Wollaston Prism in EFOSC

We were motivated to introduce this observing option by the work of K. Meisenheimer and A.J. Röser of the Max-Planck-Institut für Astronomie in Heidelberg.

In November 1985 they used a double calcite plate (called a Savart plate) on EFOSC. The Savart plate was mounted below the aperture wheel in the diverging beam of the instrument and produced on the CCD double images of all objects in the field (3, 4). While successful in the detection of polarization in faint objects (4), the Savart plate could not be easily removed from the optical beam and required a change of focus either of the telescope or the EFOSC optics. At ESO we thus opted for the use of a Wollaston prism to be placed in the parallel beam space that performs the same function as the Savart plate, that is the splitting in two orthogonally polarized images.

A quartz Wollaston prism of 48 mm free diameter and an angle of 13.°44 was selected, antireflection-coated, and mounted on the grism wheel in a standard grism cell (Fig. 1). It produces a pair of images for each object in the field separated bey 10.4 arcsec on the CCD. The split images are usually aligned with the CCD columns; different orientations can be obtained by rotating the prism in its mounting.

The polarization standard HD 23512 (m_v = 8.1, P = 2.3%) was observed at intervals of 15° in position angle. The star was too bright for standard CCD observations so we had to defocus the telescope and use a narrow band filter. The accuracy of the photometric measurement on the two images is reduced as the outer isophotes overlap. Notwithstanding this limitation we derive a fine cosine curve from the sequence of measurements, which indicates that the instrument-induced polarization effects are smaller than 0.2% and the polarization angle shift smaller than 5°. As our measurements are carried out at a different wavelength than the standard (500 versus 600 nm) and are of limited photo-

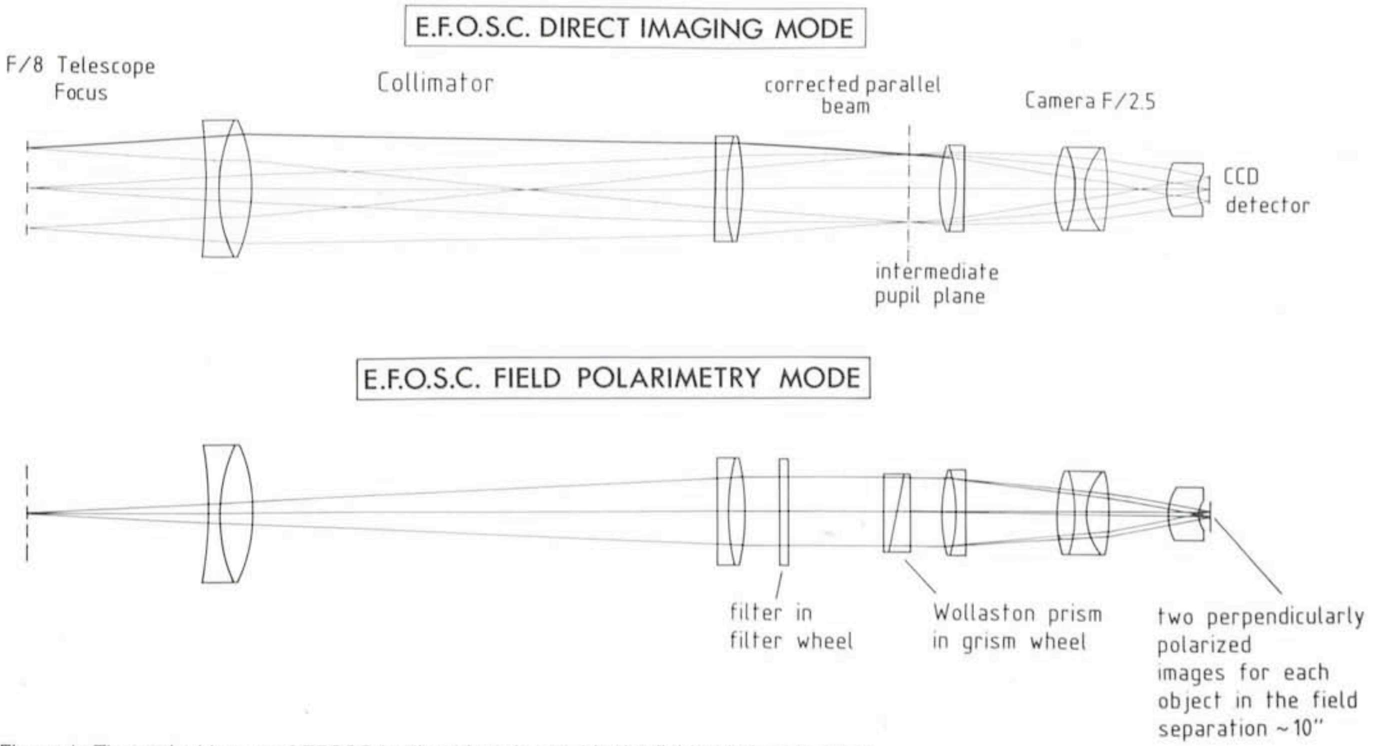

Figure 1: *The optical layout of EFOSC in direct imaging and in the field polarimetry mode.*

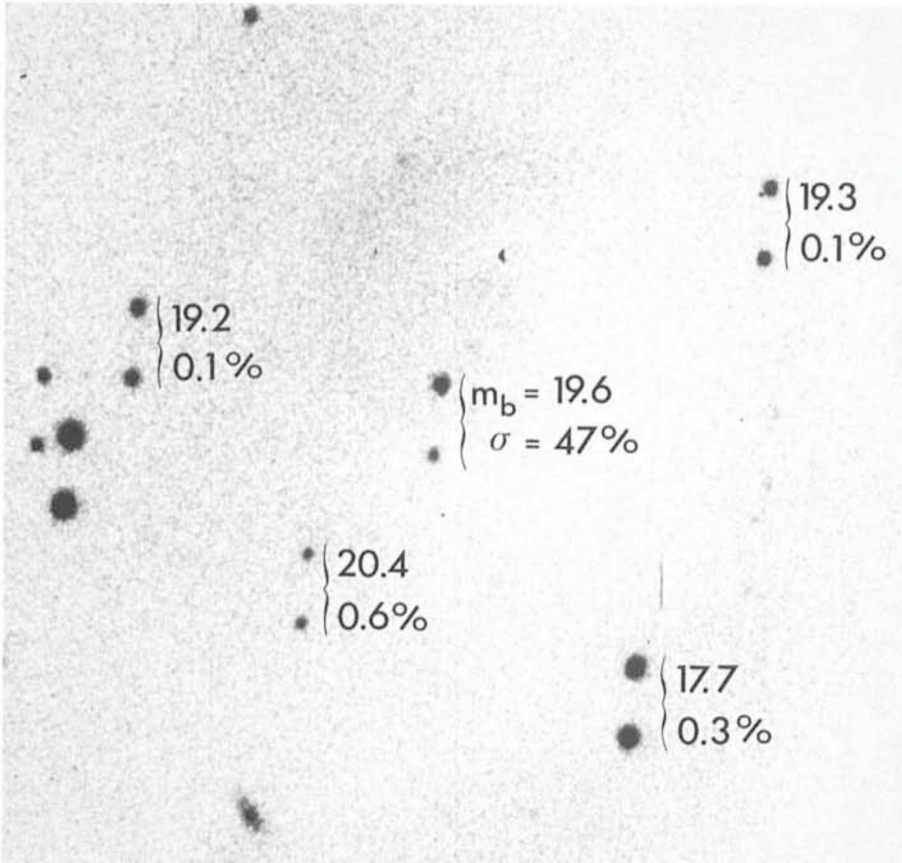

Figure 2: *The field centred on the western hotspot of the double lobe source Pictor A (0518-456) observed with the Wollaston prism in EFOSC. The position angle was 289°3, visual apparent magnitudes and the intensity difference $\sigma = 100\ (I_1 - I_2)/(I_1 + I_2)$ are indicated. The highly polarized object was discovered by Röser and Meisenheimer (4) and identified with the radio hotspot.*

metric accuracy as explained above, these values are likely to be upper limits.

The standard star measurements reveal however a systematic shift of ~0.6% for all the measurements, that is one of the two images is systematically brighter than the other one. More data will be needed to understand whether this effect, which is easily taken into account during data reduction, is peculiar to the standard star measurements or indicates a systematic instrumental effect like a slightly higher transmission for one of the two beams produced by the Wollaston.

3. The Observations of the Highly Polarized Object in a Radio Lobe of the Radio Galaxy Pictor A

A highly polarized object was identified by Röser and Meisenheimer (4) as the optical counterpart of the western radio hotspot of the double lobe source Pictor A (0518-456). They identified the object in an EFOSC observation through their Savart plate and a B filter, and measured a linear polarization of 29.6% with splitting in the N-S direction.

We repeated the observations with the Wollaston in the same B colour and at three different position angles. Figure 2 shows a part of a 20-min CCD frame including the object and listing the B magnitudes for the stars in the field and the relative intensity difference

$$\sigma = 100\ (I_1 - I_2)/(I_1 + I_2)$$

The magnitudes were derived from comparison with a standard field by Graham observed on the same night and should be accurate to 0.1 magnitude. A quarter of moon provided a relatively bright sky background which can limit the accuray of the photometry at faint magnitudes. The high resolution RCA (pixel = 15 μm = 0″34) was used. Images of stars have FWHM around 1 arcsec; the high-polarization object has a non stellar structure as found by Röser and Meisenheimer (4).

Our three polarization measurements give the following results: P.A. 174°3 σ = 25%, P.A. 244°3 σ = 19%, P.A. = 289°3 σ = 47.5% where the accuracy of the polarization is about 1% at 20th magnitude. This limit could be improved with multiple observations taken in dark time and an optimized data reduction technique as e.g. described in (5). The results confirm the exceptional nature of the object and the suggestion by Röser and Meisenheimer that the optical polarization could be higher than 50% at a position angle close to the one of the radio polarization. They also represent a most encouraging start for this new observing mode of EFOSC.

Acknowledgements

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References

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MIDAS Memo

ESO Image Processing Group

1. Application Developments

Several upgrades of commands have been made and will be released in the next MIDAS release 87JAN15. Major improvements were made on the Multivariate Analysis package which now includes many new methods and commands. In particular, it is now possible to do discriminant and correspondence analysis on tables. A new module was written in the Data Analysis part of MIDAS. It implements three methods to analyse Time Series Analysis with unequally spread data.

Collaboration with external sites is now starting to give some results. We have received a programme from IUE/VILSPA to read GO tapes from IUESIPS directly into MIDAS. The table editor has been upgraded by the SDAS group at STScI in Baltimore. We will distribute these programmes together with the standard MIDAS release.

2. FITS

Two major issues have been discussed in the FITS committees in the last years, namely: generalized FITS extensions with application to table and