Small-Telescope Astronomy on Global Scales
ASP Conference Series, Vol. 246, 2001
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Cometary Polarimetry

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Abstract. Comets are known to have a high (2-10 percent) polarization, caused mainly due to dust scattering and resonance fluorescence emission. Since near earth comets are generally bright (integrated visual magnitudes of 10 or even brighter) and as they show high polarization near earth-sun location, one can try to perform imaging polarimetry of such objects with small (40 cm or even smaller) telescopes. By using a dichroic polaroid sheet either in front of the telescope tube or before the imaging detector at the Cassegrain plane, one can record cometary images with a good signal to noise ratio. By rotating the dichroic sheet in three discrete steps and then reducing the corresponding three comet images to a single image, one can determine the linear polarization value at each pixel location on the image. The error in polarization will typically be the inverse of the 'signal to noise ratio'. Such polarization images of a comet help us to determine its dust properties and also to look for possible dust jet activities. This type of work is possible with small telescopes and minor instruments.

1. Introduction

There are several mechanisms which produce linear and circular polarizations in astrophysical environments, such as synchrotron emission, dust scattering, electron scattering etc. Polarimetry consists of mainly two classes: photographic imaging polarimetry with a low precision (1 %) and modulator polarimetry with a high precision (0.01 %). In Modulator Polarimeters two orthogonal polarization beams are measured with the same detector, within a very short time interval. Photographic low precision imaging polarimetry is suitable for high polarization objects (viz. comets, nebulae) and relatively bright objects ($\delta p \sim \frac{\delta I}{I}$).

2. Measurement of Cometary Polarization

Cometary polarization is mainly caused by the scattering of solar radiation by cometary dust and resonance fluorescence emissions in the molecular band. (Leborgne et al. 1987; Sen et al 1989). Cometary polarization in the continuum is a function of the size and composition of cometary dust and the scattering angle (θ). The study of cometary polarization places useful constraints on the size and composition of the dust particles (Mukai et al. 1987; Sen et al. 1991).

https://doi.org/10.1017/S0252921100079057 Published online by Cambridge University Press

However, since dust properties vary within the comet, one should aim at imaging polarimetry rather than aperture integrated polarimetry.

3. Some Cometary Polarimetry Results

Aperture polarimetry: The heterogeneity of a cometary coma was first found in comet Halley, by Bastein (1986) and Dolfus & Suchail (1987), by using aperture scan polarimetry. By using all the available polarization data, Chernova et al. (1993) and Levasseur-Regourd et al. (1996) established synthetic curves. Using their data on comet Halley, Mukai et al. (1987) and Sen et al. (1991) commented that its grains are either dirty ice/silicate/CHON type.

Imaging polarimetry: Work on comet Halley by Eaton et al. (1988) and Sen et al. (1990), comet Okazaki-Levy-Rudenko by Eaton et al. (1991), comet Ashbrook-Jackson by Renard et al.(1996) etc. indicate that high polarization dust blobs characterised by fine grains were detected. Eaton et al. (1988) used modulator type two-channel polarimeters, whereas Renard et al. (1996) used a non-modulator type instrument (polarizer+ CCD) and Sen et al. (1990) used only a polarizer and a photographic plate.

Sen et al (1990) placed a polaroid sheet in front of the tube of a Celestron-14 telescope. Polarization (p) was then calculated from three images (I1,I2,I3) recorded at three positions on the polaroid sheet, with p expressed as :

$$p = \frac{2\sqrt{I1(I1-I2)+I2(I2-I3)+I3(I3-I1)}}{I1+I2+I3}$$

This work has shown that a small (submeter class) telescope with only minor instruments can be a good facility for performing 'cometary polarimetry', resulting in useful science.

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