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Imaging polarimetry of comet Austin

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Abstract. Comet Austin ($1989c_1$) was observed during April and May 1990 when its phase was between 106° and 110°. No unusual activity in the form of jet is seen in the polarization map. Polarization is low near the nucleus and high (~ 16%) in the outer region (mean distance of 190,000 km on west side), suggesting segregation of grains.

Key words : comet—polarimetry

1. Introduction

Cometary polarization in continuum is produced by scattering of sunlight by cometary dust particles. The degree of polarization depends on the nature of dust particles and density distribution. Spatial distribution of dust in comet is affected by several mechanisms like jets, rotation of comet nucleus, ejection velocities, etc. Imaging polarimetry is a powerful tool to study the eruption and subsequent evolution of blobs in Comets. Such observations on comet Halley (Sen *et al.* 1990; Eaton *et al.* 1988) and on Okazaki-Levy-Rudenko (Eaton *et al.* 1991) have already revealed high and low polarization regions and dust jets which are hardly seen on normal intensity images. Polarization observations are also used to probe the nature of the dust by investigating its variations with phase angle and wavelength. The dust grains in Halley, as inferred from polarization work, are large (Sen *et al.* 1991). Dolffus (1989) has summarized the observations of dust components in comet Halley as determined by various workers. This work shows that the grains giving rise to the polarization are large, rough and dark fluffy aggregates such as Brownlee particles.

Comet Austin ($1989c_1$) is a dynamically new comet on its first apparition. A jet, emerging from the nucleus, was seen during pre perihelion phase in January 1990 (West 1990); no such activity was reported afterwards. Our photopolarimetric work during post perihelion phase, May 2-4, 1990, shows that the comet Austin contains finer grains compared to comet Halley (Sen *et al.* 1991) and also the comet appears bluer compared to solar analog (Joshi

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et al. 1992). In order to study the polarization within the different parts of the comet Austin, we have carried out imaging polarimetry over an extended area during the post perihelion phase.

2. Observations and data analysis

Comet Austin was observed from Mt. Abu on April 30, May 1, 2 and 3, 1990 with a Celestron-14 telescope equipped with an image intensifier placed at the focal plane. An additional focal reducer lens was placed in front of the image intensifier to cover larger field. The effective focal ratio is *f*/8.7 which corresponds to a plate scale of 68 arcsec per mm. A polaroid sheet was placed in front of the primary mirror. Kodak-2415 film was used for photographic recording. The polaroid sheet, image intensifier, the photographic plate and the optics of the system together in combination has almost a flat response over the wavelength range of 0.33 μm to 0.68 μm, with a sharp cutoff towards the longer wavelength side. Three exposures of Comet Austin were taken in three different orientations (0, 120, 240 degrees) of the optic axis of the polaroid sheet with respect to the celestial NS axis. These images were digitized on PDS machine at IIA, Bangalore. Images were displayed on an IBM-PC and sky brightness was determined from the histogram of the images and subtracted from the respective images before calculating polarization. Three images were displayed simultaneously on a colour monitor and matched interactively before calculating polarization for individual pixel. Polarization for individual pixel was calculated using the method given by Clark (1971). Detailed procedure is discussed by Sen *et al.* (1990). In the present paper we have discussed the results based on the observations made on April 30, 1990.

3. Results and discussions

Figure 1 shows the polarization map of comet Austin on April 30, 1990 along with the sky subtracted images in three different orientation of the polaroid. One of the success of imaging polarimetry of comets has been the detection of morphological features, jets and blobs without the need for image enhancement (Eaton *et al.* 1988, 1991; Sen *et al.* 1990). In January 1990 jets were detected in Austin (West 1990), but no such activity was reported afterwards (Eaton *et al.* 1992).

Figure 1 is the polarizations image on April 30, 1993 which shows regions of high (~16%) and low (0-2%) polarization. The polarization near the nucleus is almost zero; in the near vicinity the value is 4-6%. There is a small feature south of comet nucleus showing relatively high polarization (8%). High polarization (~16%) region, nearly in the form of a shell, is distinctly seen in the outer coma of the comet. The mean distance of the shell on the west side is about 450 arcsec. The high polarization may be due to dust scattering by smaller grains (implying segregation of grains) and also the total molecular emission in the outer region may be low.

Strong jets or other unusual activity, as has been observed in comet Halley (Sen *et al.* 1988; Eaton *et al.* 1988), is not seen in the polarization map. However, the polarization map shows mild streaming on the western side. Eaton *et al.* (1992) have reported imaging polarimetry on comet Austin through VRI filters performed during May 30 and June 4, 1990 and the results show no activity. Their measurements have been made close to the nucleus and the phase (between 26° and 8°) of the comet was not very suitable for such observations. Lower level activity on extended region will be difficult to detect during small phase angles.

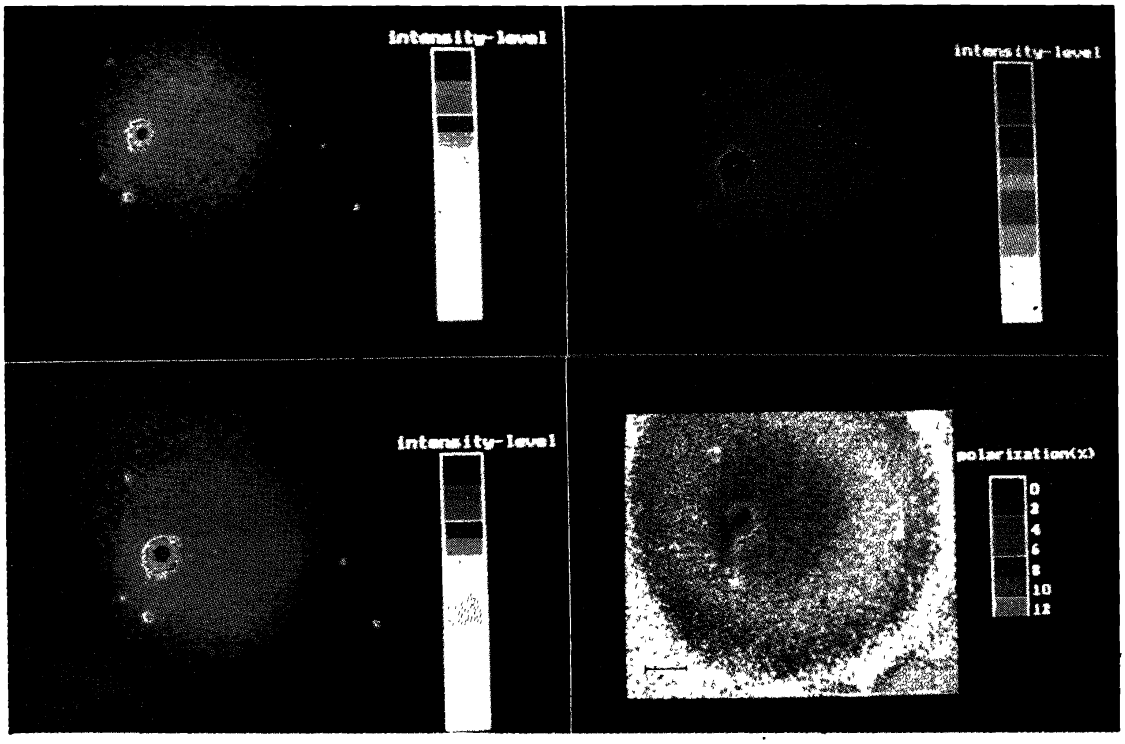

Figure 1. Comet Austin polarization image is shown along with the three images taken with three orientation (0°, 120° and 240°) of a polaroid sheet fixed in front of the 14 inch Celestron telescope. Polarization image in the lower right corner has been generated with the three images shown in the figure. The line marked on the lower left corner of polarization image corresponds to linear distance 50000 km on projected comet image.

In the present work typical value of polarization in the vicinity of nucleus is between 4-6% which appears to be lower than the polarization measured at the nucleus using aperture (60 arcsec) polarimetry in continuum bands on May 2 and 4; in fact the polarization in continuum bands is found to increase from 6% in ultraviolet band at 3650A to 20% in red band at 6840A and molecular bands show low observed polarization (Joshi *et al.* 1992). The values of polarization on April 30 are not expected to be very much different than the values observed on May 2 and 4 as the phase angle has not changed much. Since the imaging polarimetry has been performed through a wide spectral band, the net polarization is expected to be low as the comet is relatively brighter in blue wavelength (Joshi *et al.* 1992) where the polarization is low and there are several strong molecular bands having low polarization. Thus the polarization measurements based on imaging polarimetry seem consistent with the aperture polarimetry.

Segregation of dust particles is expected in the tail direction due to solar radiation pressure. The plate scale of the telescope being 68 arcsec per mm and the pixel size of the digitized image is 60 μm, each pixel corresponds to 4.08 arcsec which corresponds to a linear distance ~ 1700 km at comet distance on April 30. The mean distance of the high polarization region from the nucleus on west side is estimated about 190,000 km.

Our photopolarimetric observations on Austin made on May 2-4 show the strong red dependence i.e. polarization increasing with increasing wavelength (Joshi *et al.* 1992) and polarization is perpendicular to the scattering plane. The observation on May 30, 1990

(Eaton *et al.* 1992) shows nearly neutral wavelength dependence of polarization. This change from a blue wavelength dependence of polarization in the positive branch to a neutral dependence in the negative branch may be due to change in the grain population or a change in the scattering properties of the grains themselves. The present imaging polarimetry shows a region of high polarization nearly symmetrical with respect to the nucleus indicating segregation of grains. This suggests that the grain population across the comet has changed with time.

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