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MAGNETIC FIELDS IN BRIGHT-RIMMED CLOUDS AND COMETARY GLOBULES TRACED USING R-BAND POLARIZATION OBSERVATIONS

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ABSTRACT

We present results of our $R-$band polarimetry of a bright-rimmed cloud, IC1396A (with BRC 36), associated with the H II region S131 and the cometary globule LDN 1616 to study their magnetic field geometry. The distances of these clouds have been reported to be $\sim$ 750 pc and $\sim$ 450 pc, respectively in the literature. The young open cluster Trumpler 37 in the vicinity of IC1396A and the high mass stars in the Orion belt near L1616 are found to be responsible for the structure of these clouds. We made polarimetry of foreground stars inferred from their distances measured by the Hipparcos satellite to subtract the foreground contribution to the observed polarization results. We discuss the optical polarimetric results and compare our findings with MHD simulations towards BRCs and CGs.

Key words: journals: ISM: Globule; polarisation: dust; ISM: magnetic fields; stars: emission-line

1. INTRODUCTION

When a massive star forms, it photoionizes its surroundings, forming an H II region. The ionizing photons emitted (at rates of $10^{47} - 10^{50}$ s^{-1}) by a massive star (OB-type) rapidly ionize its environment and result in an over-pressurized ionized bubble. This bubble expands by driving a shock away from the ionizing source which results into the formation of irregular structures either due to instabilities (Giulianin, 1979; Garcia-Segura & Franco, 1996; Williams, 1999) or due to the presence of preexisting dense structures in the ambient interstellar medium (Reipurth, 1983). The photoionization induced collapse of a dense, isolated cloud that is illuminated from one side by a source of ionizing radiation is explained by the radiation driven implosion (RDI) process.

The significance of magnetic fields in the photonization of dense globules was initially addressed by Bertoldi (1989) with an approximately analytical approach. Based on two-dimensional MHD simulations, Williams (2007) showed the dynamical importance of magnetic fields in the structural evolution of photoionized globules. The first three-dimensional radiation-magnetohydrodynamic simulations of the photoionization of a dense, magnetized globule by an external ionizing source was carried out by Henney et al. (2009).

Magnetic field maps of molecular clouds are made using polarization measurements of background starlight at optical wavelengths. The observed polarization is due to the selective extinction of the light as it passes through elongated dust grains that are aligned with their minor axis parallel to the local magnetic fields of the cloud. The polarization angles in optical wavelengths trace the plane of the sky orientation of the ambient magnetic field at the periphery of the molecular clouds (with $A_V \sim$ 1-2 mag; Goodman, 1995, 1996). In Section 2 we describe the observations and data reduction procedure and in Section 3 present the results and discussion.

2. OBSERVATIONS AND DATA REDUCTION

Polarimetric observations of the clouds were carried using the Aries IMaging POLarimeter (AIMPOL) (Rautela et al. 2004) mounted at the Cassegrain focus of the 104-cm Sampurnanand telescope of Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India, coupled with TK 1024×1024 $pixel^2$ CCD camera. AIMPOL consists of an achromatic half-wave plate (HWP) modulator and a Wollaston prism beam-splitter. The observations were carried out with a standard Johnson R R_{kc}=0.760μm filter (for details see Soam et al., 2013)

3. RESULTS AND DISCUSSION

We show the results obtained by polarimetric studies towards LDN 1616 (L1616) and IC1396A. The left panel in Figure 1 shows the magnetic field geometry in the L1616 and CB 28 clouds (see head and tail). The dense

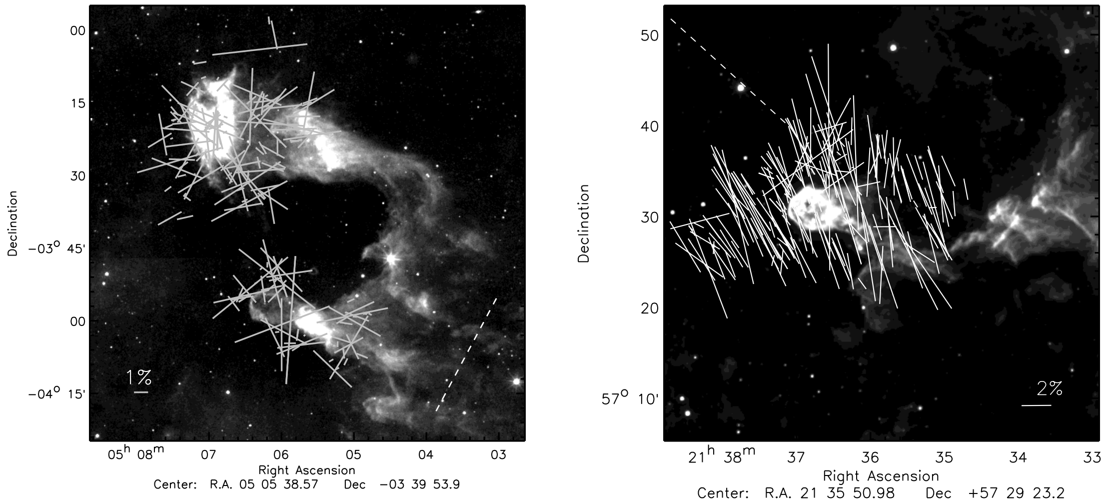

Figure 1. Left panel shows the optical polarisation vectors overplotted onto the 1.3° × 1.3° wide 12 μm image containing L1616. The dashed line represents the Galactic plane at the latitude of the cloud. A vector with 1% polarisation has been shown for reference. Right panel shows the optical polarisation vectors overplotted onto the 0.8° × 0.8° wise 12 μm image containing IC1396A. The dashed line represents the Galactic plane at the latitude of the cloud. A vector with 2% polarisation has been shown for reference.

head of the cloud complex is pointing towards the east and faces the bright Orion belt stars. L1616, like many other cometary clouds off the main Orion star forming regions, clearly shows evidence of ongoing star formation activity that might have been triggered by the strong impact of UV radiation from the massive luminous stars in the Orion belt. We mapped the magnetic fields in the low density region of this cometary globule (CG) using the optical polarimetric technique. Polarisation vectors corresponding to 192 sources (including the lower part, CB28) are shown in Figure 1. The mean value of P is found to be 2.1±1.7%. The mean value of θ_p and the standard deviation obtained from a Gaussian fit to the position angles are found to be 96° and 48°. The magnetic field geometry in the head of L1616 looks highly chaotic which may be due to the weak magnetic field lines being affected by the high energy radiation from the nearby high mass stars.

Optical polarimetric measurements were carried out towards IC1396A. We obtained polarization measurements of 181 stars that are projected on the entire area containing this cloud. We show the polarization vectors overplotted towards this cloud in Figure 1. The mean value of P is found to be 2.0±1.4%. The mean value of the θ_p and the standard deviation obtained from a Gaussian fit to the position angles are found to be 39° and 16°. In IC1396A, the magnetic field is almost perpendicular to the long axis of the cloud. There is the formation of an additional globule structure in this cloud, BRC36. This is similar to the case where Mackey et al. (2011); Henney et al. (2009) consider a strong magnetic field almost perpendicular to the ionising front. In that case the globule is swiftly flattened along the longer axis and the the shadowed tail region accretes gas along the field lines from the ambient medium to either side, due to higher thermal pressure in the ionised gas. At later stages (after $\sim 10^5$ years), the instabilities in the shocked globule continue to grow. In the globule head these cause fragments of dense neutral gas to be separated from the main globule forming smaller globules. We have removed the foreground polarisation from these observations to obtain the intrinsic polarisation towards these clouds (detailed paper in preparation).

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