Cosmic Magnetic Fields: From Planets, to Stars and Galaxies
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Magnetic fields in massive star forming regions: wide-field NIR polarimetry of M 42 and Mon R2

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Abstract. Magnetic fields are believed to play an important role in star formation. We observed M42 and Mon R2 massive star forming regions using the wide-field ($8' \times 8'$) near-infrared imaging polarimeter SIRPOL in South Africa. Magnetic fields are mapped on the basis of dichroic polarized light from hundreds of young stars embedded in the regions. We found "hourglass shaped" magnetic field structure toward OMC-1 region, which is very consistent with magnetic fields traced by using dust emission polarimetry at sub-mm to FIR wavelengths. In the Mon R2 region, we found "S-shaped" magnetic field structure across the massive protostar IRS 1 and IRS 2. We will present the results of comparison of magnetic fields at NIR with those at other wavelengths.

Keywords. Stars – ISM: individual (M42, Mon R2) – polarization – stars: formation

1. Introduction

Wide-field polarimetry of star forming regions, particularly at near-infrared wavelengths, is a powerful tool to reveal their magnetic field structure through the measurements of dichroic extinction due to magnetically aligned dust grains. However, NIR imaging polarimetry has been conducted in relatively small regions (e.g., near IRc2 or BN - Simpson *et al.* 2006). We conducted wide-field NIR imaging polarimetry of M42 and Monoceros R2 core region using a near-infrared imaging polarimeter SIRPOL (Kandori *et al.* 2006) on the IRSF 1.4-m telescope in South Africa.

2. Magnetic Field in M42

We carried out software aperture polarimetry of 314 point sources on the combined intensity images for each wave plate angle (I_{0°, $I_{22.5^\circ}$, I_{45°, $I_{67.5^\circ}$) in M42. Polarization degrees P and angles θ were obtained by the Stokes parameters.

We found good consistency between H and 350μm vectors (see. fig 1 left). The average position angles show almost same angle ($\sim$ 125 degree). Both of these are, mainly, due to dichroic absorption in this field and suggest the magnetic field direction projected on the sky. Consequently, wide-field NIR aperture polarimetry can trace the magnetic field.

3. Magnetic Field in Mon R2

As we discussed M42, we carried out software aperture polarimetry of 321 point sources in Mon R2. Based on aperture photometry data of each angle image, polarization degree P and angle θ for each source were derived by the Stokes parameters. Then we found "S-character" structure. Figure 1 (Right) clearly shows the magnetic field structure to

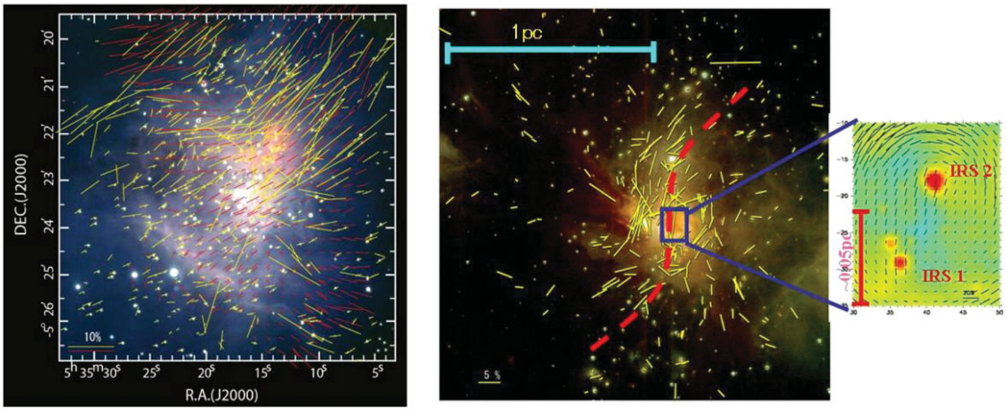

Figure 1. Left — H band polarization vectors (yellow) and 350μm polarization vectors (red) are superposed on the $JHKs$ color composite image of M42 (Kusakabe *et al.* 2008). Right — H band aperture polarization vectors (yellow) on the JHKs color composite image. The dashed red line indicate "S-character" geometry. The close-up view of the central region is also shown in the right side.

be twisted around the center where there are IRS 1 and IRS 2 which has been alleged to result from gravitational distortion caused by the IRS 2 and/or IRS 1. Although some vectors are aligned in north-east or south-west direction, the vectors seem to associate with the foreground molecular cloud with elongated shape located north-east to the Mon R2 core. To check the "S-character" geometry, we calculate vectors which are located within 135 arcsec around IRS 1 using simple third function, $y = g + Cx^3$, and the parameter C is -10^{-5}. Then we found a histogram of $\theta_{\rm obs} - \theta_{\rm cal} = \Delta\theta$ clearly shows a peak around 0 degree. This explains the "S-character" structure well.

We connected outer magnetic fields (observed by optical polarization) to the deep inside of Mon R2. Furthermore, the close up view (see. Fig.1, right) is the close up polarization map of the central region containing IRS 1 and IRS 2. The small degrees of polarizations (<10%) are seen at the central region. Although the overall vector pattern is more or less center-symmetric around IRS 2, the vectors are aligned north-south at the center of the close up image. Such a structure of the central region could not be due to circumstellar structures of IRS 1 and IRS 2. We suggest that the aligned polarization patterns show dichroic polarization of the emission from the HII region, thus representing the magnetic field structure of the central region.

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