Magnetic Fields in Star-Forming Molecular Clouds: JCMT Polarimetry of OMC-3 in Orion A

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Using the new imaging polarimeter mounted on SCUBA at the JCMT, we have detected polarized thermal emission at 850 μm from dust along the $6'$ length of the dense filament known as OMC-3 in Orion A. The polarization pattern is highly ordered and is aligned with the long axis of the filament throughout most of the region, diverging only near the southern boundary by 30-60° (see Figures 1 and 2). This configuration indicates a plane-of-sky magnetic field, $B_\perp$, oriented normal to the filament along most of its length (if the polarization arises from thermal emission of dust grains aligned by the magnetic field via the Davis-Greenstein mechanism). The mean percentage polarization measured is 4.2% with a 1σ dispersion of 1%.

OMC-3 is part of the integral-shaped filament, first identified in ^{13}CO $J = 1 - 0$ by Bally *et al.* (1987). It is a region of active star formation, with only two of nine dust condensations in our field lacking evidence of outflow activity. The outflow directions do not appear to be correlated with the direction of $B_\perp$ or the filament itself. Thus, the field of the filament is unlikely to be the dominant factor in determining the configuration of the protostellar systems embedded within it. Depolarization toward regions of higher density, previously detected in many other star forming cores and protostars, is also evident in our data (see Figure 3).

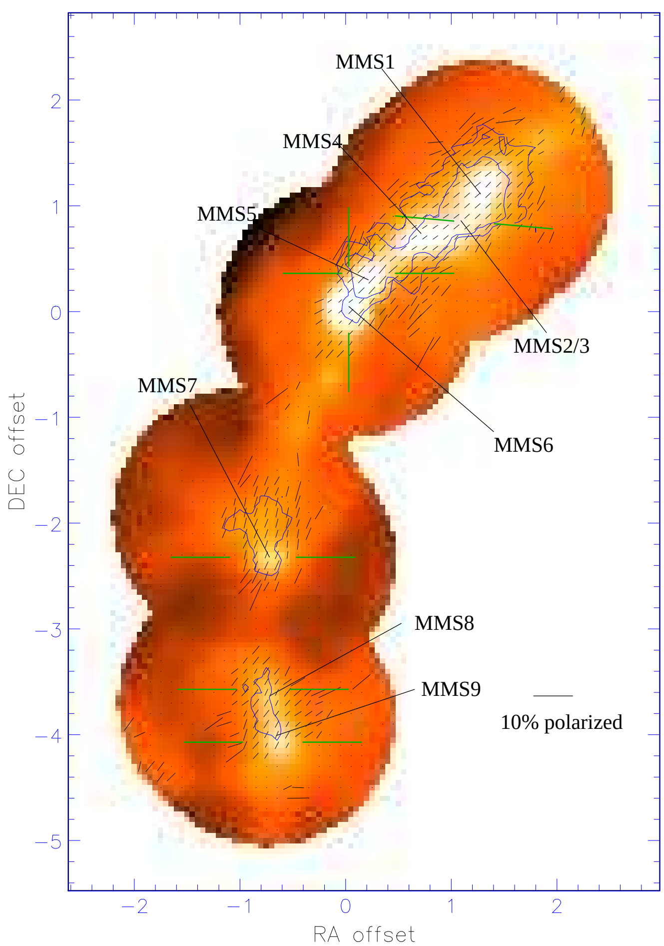

Figure 1. 850 μm polarization structure. The coloured greyscale indicates variations in uncalibrated I, ranging from -2 to 3σ; polarization vectors (up to a maximum of 20%) are overlain. The polarization structures are highly ordered and follow the filament's orientation along most of its length (see Figure 2). Therefore, the orientation of the $B_\perp$-field is predominantly orthogonal to the filament. Only vectors with $\sigma_p > 2.5$ are plotted, where σ_p is the signal-to-noise of the polarized flux. The accuracy of the position angle, θ, of each vector is related to σ_p, so no vector has $d\theta > 12°$. Blue contours indicate bounds of $\sigma_p = 6$ ($d\theta < 5°$) and $\sigma_p = 10$ ($d\theta < 3°$) respectively. These data contain $6\sigma_p$ detections on sources as weak as 0.5 Jy. The dust condensations MMS1-9 are those first identified at 1.3 mm by Chini *et al.* (1997). The orientations of known outflows have been labelled in green (see Yu *et al.* 1997; Chini *et al.* 1997; Castets & Langer 1995). The central coordinate is $\alpha_{B1950} = 5^h32^m55.6^s$, $\delta_{B1950} = -5°03'25''$.

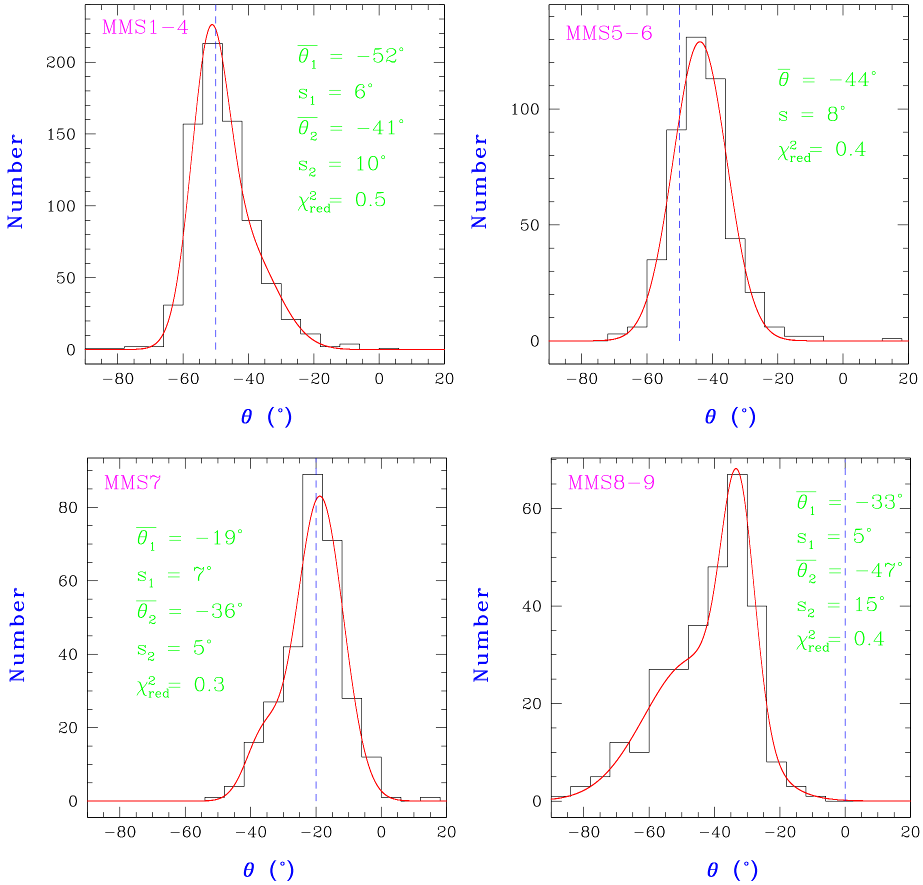

Figure 2. Variations in the Orientation of θ. On each histogram, the dashed line represents the position angle of the *filament*, while the polarization data have been binned to 6° widths and fit with 1 or 2 Gaussians (red) as appropriate by minimizing χ^2. The resultant values for the mean and dispersion of the position angle distributions are summarized in green for each region. The data reveal the changing orientation of the polarization pattern with respect to the filament.

From MMS1 to MMS7, it is clear that the polarization vectors lie predominantly along the filament to within ±10°. However, around MMS8 and MMS9, the filament runs roughly north-south, while the polarization vectors are offset by 30-60°. Since an evolutionary sequence has been suggested for the region, with source ages decreasing as one moves north, one might wonder whether the outflows were influencing the measured magnetic field direction where they are the most evolved. Reipurth *et al.* (1999) have identified MMS9 as the source of the most powerful outflow in OMC-3, yet Figure 1 reveals that the outflow direction is offset from $B_\perp$ by 30-60°.

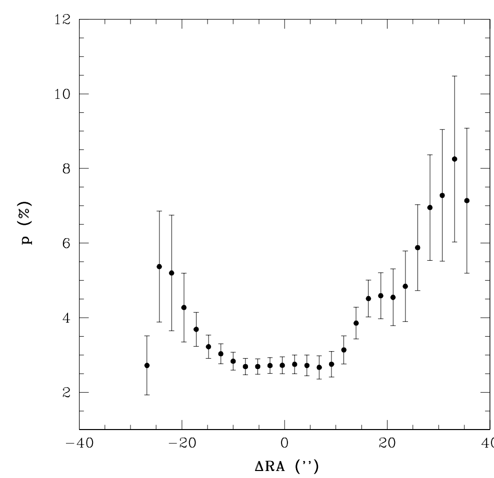

Figure 3. Depolarization across OMC-3. These data represent a perpendicular cut through the filament centered on $\alpha_{1950} = 5^{\rm h}32^{\rm m}46.9^{\rm s}$ and $\delta_{1950} = -5°01' \, 43.6''$ (the position of the MMS2/3 binary). The plot clearly shows a reduction in polarization toward the center of the filament. The error bars represent the uncertainty associated with each data point. Measurements of decreased p toward regions of high density could be due to changes in physical conditions or averaging of small scale variations in a large beam, but they are also suggested as an observable signature of helical fields (Fiege & Pudritz 1999). In OMC-1, Schleuning (1998) has measured a decreased polarization toward the core center at 350 μm and high-resolution data by Rao *et al.* (1998) with BIMA revealed substantial changes in polarization angle near the source which would tend to average to zero in a larger beam. Interpretation of the depolarization in OMC-3 will require modelling of field structures.

References
Bally, J. 1989, in Low Mass Star Formation and Pre-Main Sequence Objects, 1; Bally, J., *et al.* 1987, ApJ, 313, L45; Caslets, A., & Langer, W.D. 1995, A&A, 294, 835; Chini, R., *et al.* 1997, ApJ, 474, L135; Davis, L., & Greenstein, J. 1951, ApJ, 114, 206; Fiege, J., & Pudritz, R. 1999, MNRAS, in press; Goodman, A.A., *et al.* 1995, ApJ, 448, 748; Johnstone, D., & Bally, J. 1999, ApJ, 510. L49; Rao, R., *et al.* 1998, 502, L75; Reipurth, B., *et al.* 1999, submitted to ApJ; Schleuning, D.A. 1998, ApJ, 493, 811; Yu, K.C., *et al.* 1997, ApJ, 485, L45