Near-Infrared Imaging Polarimetry toward Serpens South: Revealing the Importance of the Magnetic Field

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It is now widely accepted that stars form predominantly within clusters inside dense clumps of molecular clouds (MCs) that are turbulent and magnetized. However, how clusters form in such dense clumps remains poorly understood. Recent numerical simulations suggest that a moderately strong magnetic field (MF) is needed to impede star formation in MCs for the simulated star formation rates to match observed values (e.g., [1]). In contrast, weak MF (a few μG) is claimed in MCs where turbulent compression largely controls the structural formation of MCs on scales of a few to several parsecs [2]. In the later case, the MFs associated with cluster-forming clumps are expected to be distorted significantly by supersonic turbulent flows.

To characterize the MF structure of cluster-forming clumps, it is important to uncover the global MF structures associated with cluster-forming clumps. So we carried out near-infrared polarization observations of filamentary clouds in the Serpens South embedded cluster [3], which is believed to be in a very early stage of cluster formation. Although some small deviation is seen, the MF is roughly perpendicular to the main filament elongated toward the NW and SE direction (Fig. 1, here the polarization vectors are assumed to be the directions of the local MF). This ordered MF configuration suggests that the MF is strong enough to regulate the entire structure of the main filament and, therefore, that the formation of the main filament has proceeded under the influence of the MF.

In contrast to the main filament, sub-filaments that converge on the central part of the cluster or intersect the main filament, appears to be nearly parallel to the MF direction. They could be outflows from the cluster or inflow toward the main filament. Recent CO observations toward Serpens South suggest that CO outflow lobes are anti-correlated with the sub-filaments [4], reinforcing the inflow view of the sub-filaments.

In addition, the global MF appears to be curved in the southern part of the observed region. This curved morphology suggests that the global MF is distorted by gravitational contraction along the main filament toward the northern part, where the mass of the cloud seems to be mostly concentrated. Using the Chandrasekhar-Fermi method, the MF strength is roughly estimated to be a few $\times 100\,\mu$G in two zones along the main filament.

All the above results show that the MF appears to significantly influence the dynamics of the Serpens South cloud. This does not appear to support the weak MF models of MC evolution/cluster formation, at least not for the Serpens South cloud

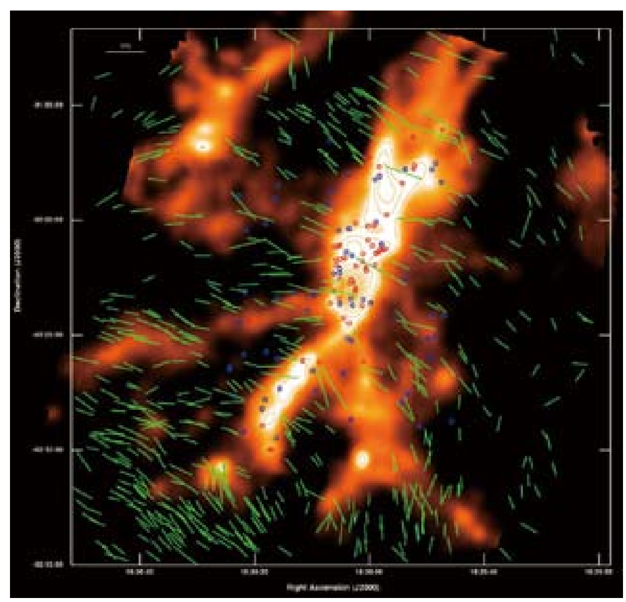

Figure 1: *H*-band polarization vector map toward Serpens South for point sources, superposed on the 1.1-mm dust-continuum image. YSOs are indicated by red (class 0/I) and blue (class II) open circles.

References

[1] Li, Z.-Y., Nakamura, F.: 2006, *ApJ*, **640**, L187.
[2] Padoan, P., et al.: 2001, *ApJ*, **553**, 227.
[3] Sugitani, K., et al.: 2011, *ApJ*, **734**, 63.
[4] Nakamura, F., et al.: 2011, *ApJ*, **737**, 56.