Discovery of Toroidal Magnetic Fields around Protostars in NGC1333 IRAS 4A from Dust Polarization Measurements

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Understanding how a sun-like star form and how subsequently planets form around it is one of the most fundamental problems in astrophysics. In the past decade, whether magnetic fields play an essential role during the star and planet formation is one of the hottest debated topic. It is therefore critically important to measuring the magnetic fields in star-forming region for testing the star formation theories. In spite of its importance, the magnetic field is the most poorly measured parameter in the star formation process due to the high sensitivity requirements. In recent years, measuring the polarization from dust continuum at millimeter or submillimeter wavelengths has become the most effective way to map the magnetic field geometry. However, since the measured polarized emission is an integrated quantity along the line of sight, it is difficult to properly show the true complexity of the field structure from the dust polarization map. Here we demonstrate a powerful technique to explore the internal structure of the magnetic fields with interferometric observations. Using this technique, we are able to reveal the toroidal field component in a protostellar circumbinary disk. Our results suggest that the magnetic braking is in action during the embedded stage of a star-forming core, which is in agreement with the expectation of the standard star formation model with dominate magnetic fields.

Keywords: star formation; dust polarization; magnetic fields