P140a Unveiling the role of the magnetic field at the smallest scales of star formation

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New polarization data from ALMA are both expanding and confounding our understanding of the role of magnetic fields in low-mass star formation. Here I will show some of the highest resolution and highest sensitivity polarization images ever made of two Class 0 protostellar sources. These new ALMA observations achieve $\sim$140 AU resolution, allowing us to observe the magnetic field orientation in the innermost regions surrounding the protostars. The collapse of strongly magnetized dense gas is predicted to pinch the magnetic field into an hourglass shape that persists down to scales <100 AU. However, in contrast with more than 50 years of theory, the ALMA data toward one source—known as Ser-emb 8—definitively rule out an hourglass morphology and instead reveal a chaotic magnetic field that has not been inherited from the field in the interstellar medium surrounding the source. We compare these data with cutting-edge, moving-mesh AREPO simulations that we performed, and conclude that that Ser-emb 8 formed in a weakly magnetized environment where large-scale turbulent motions dictate the magnetic field morphology even on $\sim$100 AU scales. However, in the second source—known as Serpens SMM1—the magnetic field has clearly been shaped by the bipolar outflow emanating from the central source, in contrast to the turbulence-dominated morphology of Ser-emb 8. Two sources, two stories: with the sensitivity and resolution of ALMA, we are embarking on an entirely new chapter in our journey to understand the role of the magnetic field in the earliest stages of star formation.