Measuring Magnetic Fields from Water Masers in the Synchrotron Protostellar Jet in W3(H2O)

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Magnetic fields are invoked to launch, drive, and shape jets in both low- and high-mass protostars, but observational data on the spatial scales required to assess their role in the protostellar mass-loss process is still scarce.

We report full polarimetric VLBA observations of water masers towards the Turner-Welch Object in the W3(OH) high-mass star forming complex. This object drives a synchrotron jet, which is quite exceptional for a high-mass protostar, and is associated with a strongly polarized water maser source, W3(H2O), making it an optimal target to investigate the role of magnetic fields on the innermost scales of protostellar disk-jet systems.

The linearly polarized emission from water masers provides clues on the orientation of the local magnetic field, while the measurement of the Zeeman splitting from circular polarization provides its strength. The water masers trace a bipolar, biconical outflow at the center of the synchrotron jet. Although on scales of a few thousand AU the magnetic field inferred from the masers is on average orientated along the flow axis, on smaller scales (10s to 100s of AU), we have revealed a misalignment between the magnetic field and the velocity vectors, which arises from the compression of the field component along the shock front.

Our measurements support a scenario where the magnetic field would evolve from having a dominant component parallel to the outflow velocity in the pre-shock gas, with field strengths of the order of a few tens of mG (at densities of 10^7 cm^-3), to being mainly dominated by the perpendicular component of order of a few hundred of mG in the post-shock gas where the water masers are excited (at densities of 10^9 cm^-3).

The general implication is that in the undisturbed (i.e. not-shocked) circumstellar gas, the flow velocities would follow closely the magnetic field lines, while in the gas shocked by the prostostellar jet the magnetic field would be re-configured to be parallel to the shock front.