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Signatures of magnetic braking in Class 0 protostars: Exploring the gas kinematics in magnetized models of low-mass star formation

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Only indirect evidence of the role of magnetic braking in regulating gravitational collapse and the formation of circumstellar disks, such as compact disk sizes and the launching of high-velocity collimated protostellar jets, has been found from observational work.

More direct tests of the magnetic braking shaping the angular momentum of the gas in Class 0 protostars are crucially needed to confirm and make progress on the magnetically regulated disk formation scenario.

In the present work we used nonideal magnetohydrodynamic models of protostellar collapse and synthetic observations of molecular gas spectral emission, from the radiative transfer post-processing of these models. We analyzed the synthetic observations to test whether possible kinematic signatures of the magnetic braking in the gas velocity field can be captured from maps of the molecular gas emission in protostellar envelopes.

By comparing the 3D specific angular momentum of models with varying turbulent energy and magnetization, we show that, in the numerical models of protostellar evolution explored, the increase in magnetization and its consequences on the spatial redistribution of angular momentum modifies the shapes of the radial profiles of specific angular momentum probed along the equatorial plane. However, various analysis of gas kinematics from the synthetic observations of molecular line emission mostly fail to capture the magnitude and differences in radial profiles of specific angular momentum due to different magnetization. Finally, we compare our synthetic observations to observational datasets from the literature to discuss possible magnetic braking signatures in protostellar envelopes.

Our analysis suggests that the detection of symmetric patterns and organized velocity fields in the moment 1 maps of the molecular line emission, and monotonous radial profiles of the specific angular momentum showing a power law decline, should be suggestive of a less magnetized scenario. Protostellar cores where efficient magnetic braking is at work are more likely to present a highly asymmetric velocity field, and more prone to show complex radial profiles of their specific angular momentum measured in the equatorial plane.

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