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3D MHD simulation of Magnetospheric Accretion onto a Protostar

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Protostars evolve via the interaction with the surrounding accretion disk. In particular, it is believed that the stellar spin evolution is controlled by the angular momentum exchange between the protostar and the disk through the stellar magnetic fields.

Observations suggest that the stellar spin velocity decreases to ~10% of their breakup speed within ~1Myr after the birth. However, there is no established models to explain the stellar spin evolution. Many theoretical estimations have been performed before, but the results depend on the assumptions, such as the spatial distribution of the turbulent diffusivity and viscosity which are difficult to predict. Previous 2D MHD simulations pointed out the importance of coronal mass ejections for the angular momentum loss of the stars (Zanni & Ferreira 2013. See also Hayashi et al. 1996). However, it is unclear if this argument holds even in 3D simulations. Therefore, to advance our understanding of the protostellar evolution, we need detailed 3D modeling of the interaction between the protostar and the turbulent accretion disk.

We have been performing 3D MHD simulations of the star-disk interaction where the central star has a dipole magnetosphere. We found that when the accretion rate is moderate (~10^{-8} Msun/yr), the magnetospheric accretion tends to be asymmetric about the equatorial plane. This asymmetric accretion is maintained in the simulation because of the angular momentum exchange process. The asymmetric magnetosphere drives an outflow, which carries away the angular momentum from the protostar. Some coronal mass ejection-like events are observed, but they are not as powerful as seen in the previous 2D simulations. We will discuss the 3D effects on the magnetospheric accretion process.

References

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