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Formation and structure of magnetized protoplanetary disks

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Protoplanetary disks are thought to form through the gravitational collapse of magnetized, rotating dense cores. In this talk, I will review work conducted during an enjoyable and fruitful collaboration with Daniele Galli on the gravitational collapse phase and the structure of magnetized protoplanetary disks.
To enable the formation of rotationally supported disks, the magnetic flux from the natal cloud must be lost to prevent catastrophic magnetic braking. During this process, accretion disks threaded by a poloidal magnetic field and irradiated by the central star are expected to emerge. The poloidal field induces sub-Keplerian gas rotation in the disk, which can accelerate planet migration and enhance disk stability against gravitational perturbations. Additionally, magnetic compression reduces the disk scale height compared to nonmagnetic disks. The mass-to-flux ratio, λ, is the key parameter governing these effects. Models of magnetized disks around young YSOs such as HL Tau and TW Hya suggest λ~ 20 −30, significantly higher than the values of the natal cloud, indicating substantial flux loss during disk formation. Determining λ observationally is crucial for understanding this process. Polarized dust emission from protoplanetary disks is primarily dominated by dust scattering rather than emission from grains aligned with the magnetic field. Consequently, measuring disk magnetization requires Zeeman splitting observations with ALMA and the VLA. These measurements are essential for advancing our understanding of protoplanetary disk formation and evolution.

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