EXPLORING PROTOPLANETARY DISK EVOLUTION VIA MHD WINDS

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We performed population synthesis of protoplanetary disks with MHD winds. We found that, for low viscosities, high torque values and strong disk winds best reproduce the accretion rates observed. We also found outward migration at ∼1au for masses $< 1M_\oplus$.

Recent results suggest that low viscosities could be the norm in protoplanetary disks, meaning that viscosity alone may not be the reason for their rapid dispersal. MHD winds act in disks threaded by a magnetic field, extracting mass and angular momentum, inducing accretion and reducing their lifetimes.

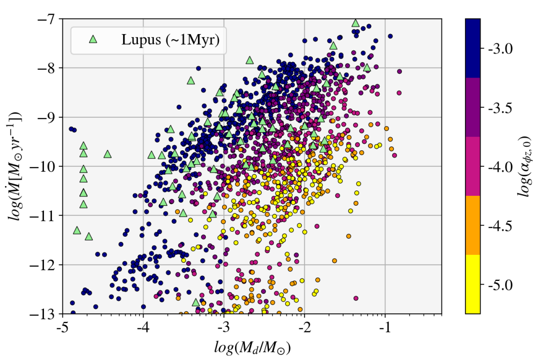

Fig. 1. Accretion rates for the synthesis and Lupus cluster. Values for the DW torque strength are in colors.

Figure 1 shows accretion rates vs disk mass for our population synthesis, in comparison to observational data for the Lupus cluster. The synthesis consists of 5000 disks following empirical initial conditions for the disk and star parameters (Gómez 2023), with $\alpha_{\phi z}$ between 10^{-5} and $10^{-3} M_\star/M_\odot$, in the Strong DW regime (Suzuki et al. 2016). We found that both viscosity and magnetic torque parameters need to be proportional to the stellar mass to account for the observed relation $\dot{M}_{acc} \propto M_\star^2$. We also implemented a star formation rate (Coleman & Haworth 2022) and found it to be fundamental to reproduce the observed high accretion rates, especially in populations of ages >2Myr. MHD winds can also reproduce the observed dissipation time scales, resulting in characteristic lifetimes of ∼7Myr.

MHD winds affect the gas surface density profile, impacting the dynamical evolution of protoplanets. Outward migration is observed for protoplanets of masses $\lesssim 1M_\oplus$, at $r \sim 1$au (figure 2). As proposed by Ogihara et al. (2018), this could explain the insitu formation of close-in super-earths.

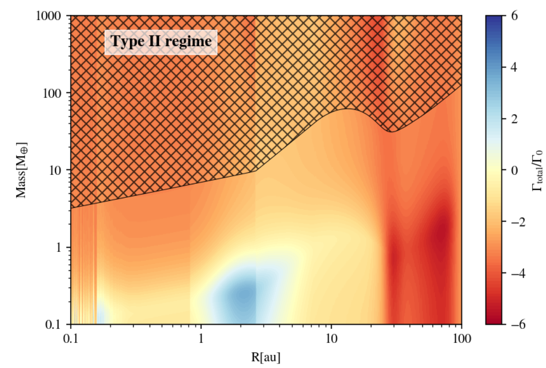

Fig. 2. Migration map at 1Myr for a protoplanetary disk evolving via strong MHD winds with low $\alpha_{\phi z}$. Torque prescriptions are from Jiménez & Masset (2017) and type II regime zones from Crida et al. (2006).

Our results contrast with a recent study by Weder et al. (2023), who concluded that weak DW and strong torques are needed to reproduce the accretion rates, while strong DW cannot due to the rapid dispersal of the disk. The discrepancies could be due to our implementation of a star formation rate, and to the introduction of a proportionality of the magnetic torque parameter with the stellar mass.

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