NUMERICAL MODELLING OF MAGNETIC STAR-DISK INTERACTION.

C. Zanni, N. Bessolaz, J. Ferreira, *Laboratoire d'Astrophysique de Grenoble, 414 Rue de la Piscine, 38041, Grenoble, France, (Claudio.Zanni@obs.ujf-grenoble.fr)*.

Nowadays there is a general consensus on the fact that accretion onto classical TTauri stars (CTTS) is controlled by the interaction between the stellar magnetosphere and the surrounding accretion disk. According to this this picture, the accretion disk is truncated at a few stellar radii by the interaction with the stellar magnetic field and is subsequently channeled into funnel flows terminating with a shock on the stellar surface. This idea is strongly supported by the detection of dynamically relevant surface magnetic fields, by the observation of material accreting at free-fall speed and by the spectral and colour variability which can be associated with hot-spot activity. One of the puzzling aspects emerging from the observations of CTTS is that they exhibit rotation periods of the order of 3-10 days despite the fact that they are still actively accreting and contracting. An efficient mechanism to remove angular momentum from the star is therefore needed. One of the possible solutions to the problem is given by the star-disk interaction. On one hand, the disk is accreting and therefore is increasing the angular momentum of the star; on the other hand, the disk can brake the stellar rotation at the same time, provided that the disk and the star are magnetically connected beyond the corotation radius, which is the position where the period of rotation of the disk is equal to that of the star.

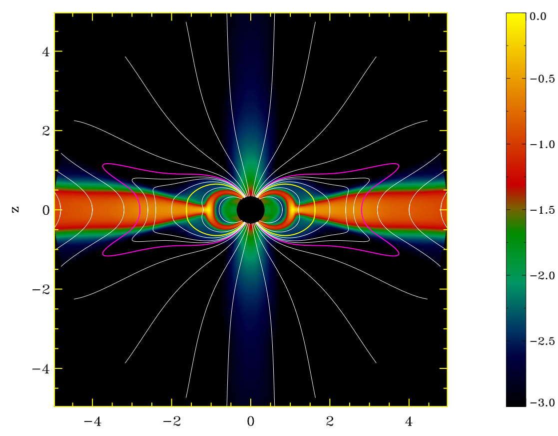

Figure 1: Density map of a typical simulation. The yellow line represents the magnetic surface anchored at the corotation radius, while the purple line marks the last magnetic surface connecting the star and the disk.

Along this lines, we present the results of numerical MHD simulations of the interaction of an accretion disk with the magnetosphere of a young star. The axisymmetric simulations are performed with the PLUTO code (*http://plutocode.to.astro.it*), developed at the University and at the Astronomical Observatory of Torino. The star is modelled as a perfect conductor with a fixed period of rotation while its magnetic field is a purely dipolar field aligned with the rotation axis of the star. The Keplerian accretion disk includes both resistive and viscous effects. By performing a parameter space analysis, including the transport coefficients describing the disk diffusivity and viscosity, we first elucidate the mechanism which leads to the truncation of the disk and to the formation of accretion columns on the surface of the star.

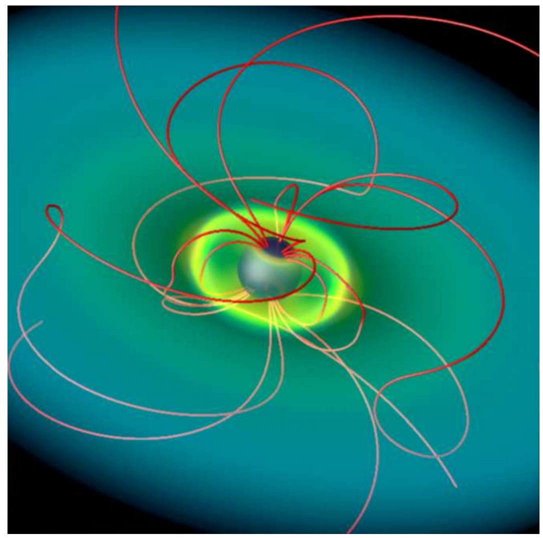

Figure 2: 3D rendering of one of the runs. The opening of the outer field lines due to the differential rotation is clearly visible.

We then consider the torque exerted by the accretion disk on the magnetized star. On one hand, due to the differential rotation between the star and the disk, the field lines open beyond the corotation radius, thus reducing the braking torque. Moreover, when part of the disk remains connected to the star beyond the corotation radius, the disk viscosity must be efficient enough in this region in order to remove radially both the disk and the stellar angular momentum. Finally, the simulations show clearly that most of the braking torque is associated with the open field lines anchored onto the star surface: therefore, a disk-locked configuration does not seem to be efficient enough to explain the stellar spin-down. We conclude that additional mechanisms, namely reconnection X-winds or accretion powered stellar winds, must be taken into account to explain the removal of stellar angular momentum.