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Angular momentum evolution during star and planetary system formation

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Abstract. We focused on analysing the role played by protoplanetary disks in the evolution of angular momentum during star formation. If all the angular momentum contained within collapsing pre-stellar cores was conserved during their formation, proto-stars would reach rotation rates exceeding their break-up velocities before they reached the main sequence (Bodenheimer 1995). In order to avoid this occuring, methods by which proto-stars can lose angular momentum must exist. Angular momentum can be transferred from star to disk via stellar magnetic field lines through a process called magnetic braking (Camenzind 1990; Königl 1991). Alternatively, the stellar angular momentum can be lost from the star-disk system entirely via stellar- or disk-winds (e.g. Pelletier & Pudritz 1992; Matt & Pudritz 2005).

The proportion of lost stellar angular momentum retained within the protoplanetary disk is important to studies of planetary system formation. If the bulk motion within the disk remains Keplerian, any increase of angular momentum in the disk causes an outward migration of disk material and an expansion of the disk. Therefore, an increase in disk angular momentum may cause a reduction in the disk surface density, often used to indicate the disk's ability to form planets.

We made use of multi-wavelength data available in the literature to directly calculate the stellar and disk angular momenta for two nearby regions of star formation. Namely, these were the densely populated and highly irradiated Orion Nebula Cluster (ONC) and the comparitively sparse Taurus-Auriga region. Due to the limited size of the ONC dataset, we produced an average surface density profile for the region. We modelled the stars as solid body rotators due to their fully convective nature (Krishnamurthi *et al.* 1997) and assumed the disks are flat and undergo Keplerian rotation about the same rotation axis as the star.

We observed the older disks within each of the two star forming regions to be preferentially larger and less massive, consistent with viscous accretion theories and disk dispersal. However, when drawing comparisons between the two regions, the ONC sample appeared to have less massive disks than the Taurus-Auriga sample, even though the population of Taurus-Auriga is older. This may suggest an influence of the birth cloud environment on protoplanetary disk evolution.

Finally, the older stars within the ONC were observed to harbour disks that contained more angular momentum than their younger counterparts whereas, in the Taurus-Auriga sample, the amount of angular momentum contained in the older and younger samples was consistent. We suggest that the missing disk angular momentum in the older Taurus-Auriga disks may be contained within yet-undetected planets.

Keywords. stars: formation, planetary systems: formation, planetary systems: protoplanetary disks, stars: rotation

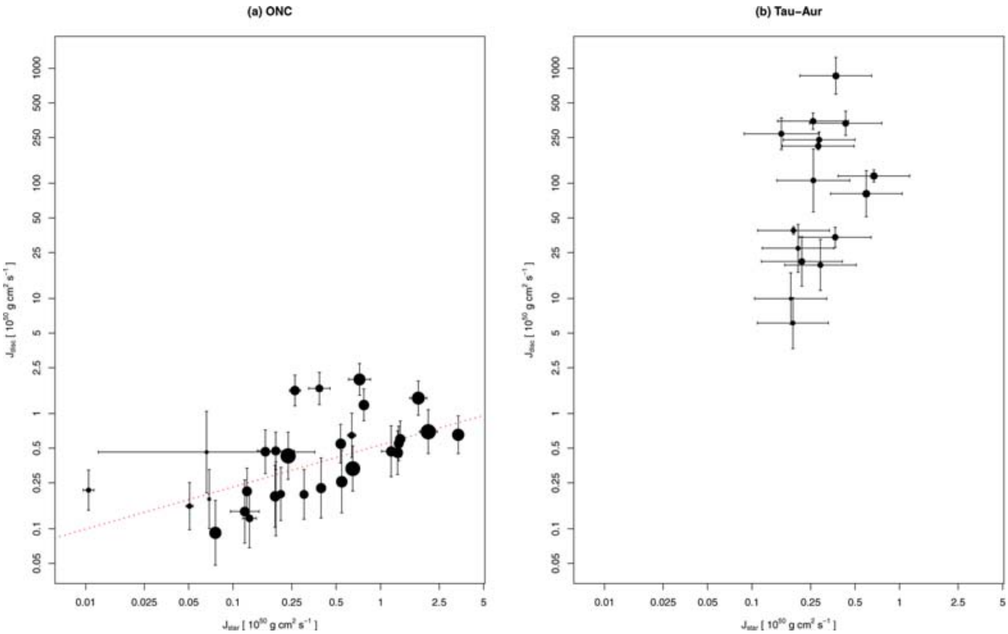

Figure 1. Comparison of stellar and disk angular momenta in (a) ONC and (b) Taurus-Auriga. The data points are scaled according to their stellar radii. The result of a χ^2 fitting procedure is shown by the dashed line for the ONC but no such correlation was found in the case of the Taurus-Auriga. Within the ONC sample, the older stars appear to harbour disks containing higher angular momentum. However, the disk angular momenta of the older and younger samples within Taurus-Auriga remains consistent. The missing angular momentum in the older Taurus-Auriga disks may have formed as yet-undetected planets.

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