Cosmic Magnetic Fields:
From Planets, to Stars and Galaxies
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The surface magnetic fields of T Tauri stars

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Abstract. We present surface magnetic field maps of the two accreting T Tauri stars, CV Cha and CR Cha. Our magnetic field maps show evidence for strong, complex multi-polar fields similar to those obtained on young rapidly rotating main sequence stars. Both CV Cha and CR Cha show magnetic field patterns that are more complex than those recovered for the lower mass, fully convective T Tauri star, BP Tau.

By comparing our maps with previously published maps of classical T Tauri stars, we infer that magnetic field patterns on T Tauris, and their underlying magnetic field generation mechanisms evolve quickly as they develop radiative cores. This may have implications for the efficiency with which T Tauri stars can effectively lock onto their surrounding disks under the magnetospheric accretion model scenario. This, in turn, has implications for the angular momentum evolution of T Tauri stars as they evolve towards the main sequence.

Keywords. Stars: magnetic fields – stars: imaging – stars: accretion – stars: formation – techniques: spectro-polarimetry

1. Background

The main properties of classical T Tauri stars (CTTS) can be explained using the "magnetospheric accretion scenario" (e.g., Camenzind 1990). In this scenario, the magnetosphere of the central star is responsible for truncating the inner edge of its circumstellar disk; material is channelled along magnetic field lines onto the stellar surface, causing accretion shocks at the site of impact on the stellar surface.

We present the first surface magnetic field maps of the accreting pre-main sequence (PMS) stars, CV Cha and CR Cha, using the technique of Zeeman Doppler imaging. Only two other similar systems have been imaged before using this technique: V2129 Oph and BP Tau (Donati *et al.* 2007, 2008a). Our results suggest that PMS stars with radiative cores have more complex field distributions than fully convective stars. These results have implications for magnetospheric accretion and for the evolution of magnetic fields in intermediate mass stars as they evolve onto and along the main sequence.

2. Summary

- CV Cha and CR Cha are the first intermediate-mass T Tauri stars to be imaged using the technique of Zeeman Doppler imaging.
- Our maps show that T Tauri stars with radiative cores have more complex magnetic field distributions than the fully convective T Tauri, BP Tau (Donati *et al.* 2008a).

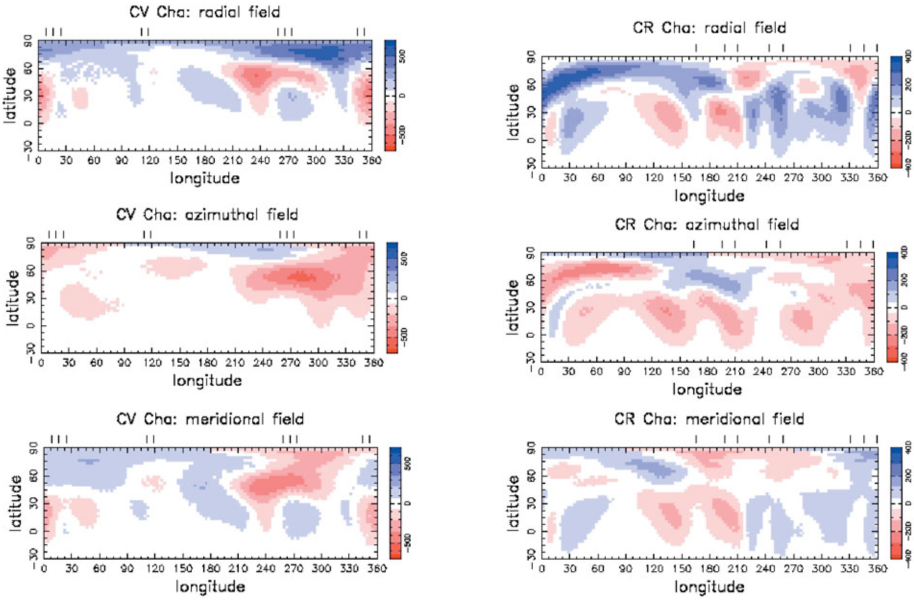

Figure 1. Magnetic field maps of the classical T Tauri stars, CV Cha and CR Cha. Our maps suggest magnetic fields in higher mass stars are more complex than those in the lower mass star, BP Tau (Donati *et al.* 2008a). These maps were obtained using the technique of Zeeman Doppler imaging and circularly polarised data that were acquired using the UCLES/SemelPol instrument configuration on the Anglo-Australian Telescope (AAT). The phases of observations are represented by the tick marks above each plot.

• This may be analogous to the behaviour observed across the fully convective boundary in main sequence M-type stars. Morin *et al.* (2008) find that M4 stars, i.e. stars that are nearly fully convective, have simpler axisymmetric large-scale poloidal fields. In contrast, higher mass cool stars, show significant toroidal field (Donati *et al.* 2008b).

• CV Cha and CR Cha are progenitors of A-type stars. They will take under 9 Myr to become fully radiative. Only 10% of A-type stars are found to be magnetic (Ap stars). Over the next 5-6 Myr, this magnetic field will either dissipate or be frozen in. Further details are discussed in Hussain *et al.* (2009).

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