

New Measurements of Magnetic Fields on T Tauri Stars

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1. Introduction

Magnetospheric accretion theories predict strong (up to 10 kG) magnetic fields on specific classical (accreting) T Tauri stars (CTTS) (Johns-Krull et al. 1999a, ApJ, 516, 900). Measurement of the true magnetic field strengths on these stars offers a unique opportunity to test the current models. While different detailed theories of magnetospheric accretion all have unknown factors involved, they all predict the same variation of the magnetic field strength from star to star (Johns-Krull et al. 1999a). Since the Zeeman effect varies as λ^2 and Doppler broadening varies as λ^1 , detection of Zeeman broadening of spectral lines is easier in the infrared relative to the optical. Therefore, we have begun a program to systematically measure the magnetic field properties of a large sample of CTTS. In December 1997, we observed several TTS at the NASA IRTF, obtaining spectra in 4 different K band settings, 3 of which are analyzed here.

2. Analysis

For each TTS, we analyze 4 magnetically sensitive Ti I lines in the K band as well as 9 magnetically insensitive CO lines at $2.3 \mu\text{m}$. For each star, we take literature values of key atmospheric parameters (T_{eff} , gravity, $v \sin i$) and an assumed solar metallicity and calculate synthetic line profiles using Hauschildt et al. (1999, ApJ, 512, 377) model atmospheres. For each star, a single magnetic component of some strength, B , and filling factor, f , added to a non-magnetic component with filling factor $(1-f)$ is inadequate to model the data. Therefore, we fit a distribution of magnetic components with B ranging from 0 - 6 kG in 2 kG steps. An example fit is shown for the CTTS TW Hya in Figure 1. Note the obvious broadening of the 4 Ti I lines in the upper two panels of the figure and the lack of broadening seen in the CO lines of the lower panel. In the Table below we list the total magnetic flux, ΣBf (equal to the mean magnetic field), for each star.

3. Discussion

We have measured 2 - 3 kilogauss mean magnetic fields on 6 T Tauri stars (5 CTTS plus 1 naked or non-accreting TTS - NTTs). Johns-Krull et al. (1999a) and Safier (1999, ApJ, 510, L127) have pointed out that these fields are too strong to be confined by the local gas pressure in the atmospheres of these low gravity stars. One possibility is that the filling factor of magnetic field regions is really 1.0: there is no quiet photosphere on a TTS. The mean field strengths reported

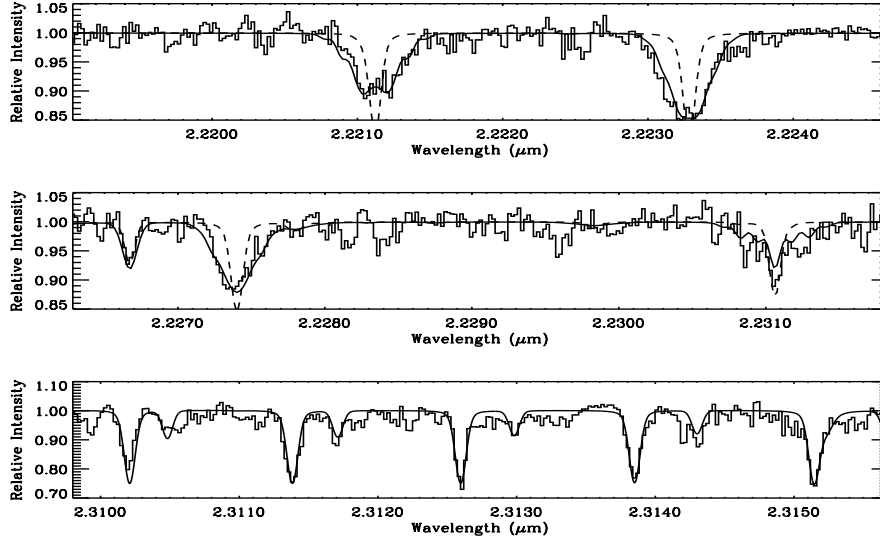


Figure 1: The solid histogram shows three K band spectra of the CTTS TW Hya. The dashed line is a synthetic spectrum with no magnetic field and the smooth solid line is the best fitting magnetic model with $\Sigma Bf = 2.6$ kG.

Star	Spectral Type	ΣBf (kG)
Hubble 4	K7 NTTS	2.4
T Tau	K0 CTTS	2.5
BP Tau	K7 CTTS	2.1
TW Hya	K7 CTTS	2.6
DK Tau	M0 CTTS	2.7
DF Tau	M2 CTTS	2.3

Table 1: Derived mean field strengths.

above are similar to those found in sunspots where the strong local fields suppress convection. It may also be the case that convection is suppressed throughout the photosphere of a TTS. As a result, the atmospheric structure will change which may affect various derived quantities on TTS. Johns-Krull et al. (1999a) evaluate the predicted magnetic field strength in the context of 3 detailed magnetospheric accretion theories. From Table 1, T Tau, BP Tau, DK Tau, and DF Tau all have predicted field strengths which do not correlate with the mean fields reported above, independent of the specific magnetospheric accretion theory used. However, Johns-Krull et al. (1999b, ApJ, 510, L41) showed how to use high resolution circular spectropolarimetry to measure the magnetic field in the accretion shock on CTTS. Johns-Krull and Valenti (1999, *Stellar Clusters and Associations: Convection, Rotation, and Dynamos*, eds. R. Pallavicini, G. Micela, & S.Sciortino, in press) measured these accretion shock magnetic fields on 4 CTTS and the resulting fields do correlate with those predicted by theory. Therefore, even given the small number of stars examined so far, it appears that the magnetic field participating in the accretion flows on TTS are well predicted by current theories, even if the mean field is not.