THE STAR–DISK CONNECTION

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ABSTRACT We find that stars and accretion disks both have emission-line surface brightnesses that scale roughly linearly with the local rotation rate. This suggests that a dynamo mechanism is responsible for powering chromospheres in accretion disks as well as in stars. If this unification of stars and disks is correct, then dynamo models can be tested over a greatly expanded range of rotation rates, and the importance of secondary dynamo parameters may become evident. The idea needs to be tested by searching for further empirical connections between magnetic activity in stars and disks.

Keywords: chromospheres; accretion disks; stars; dynamos

Cataclysmic variables are short-period interacting binary stars containing an accretion disk around a white dwarf that is fed by Roche lobe overflow from a late-type companion star. Its strong Keplerian shear makes the disk a likely site for dynamo action. Although magnetic field strengths in disks have not been directly detected by Zeeman effects, many possible indicators of magnetic activity are observed including H I, He I, Ca II, Fe II, Mg II, Si IV, C IV, N V emission lines, rapid photometric variations, winds, and x-ray emission.

The disk's emission lines exhibit striking double-peaked velocity profiles. The Keplerian velocities are highly supersonic, thus different parts of the velocity profile arise from distinct regions of the disk. The two peaks correspond to opposite rims of the disk, while the far wings of the line profile arise from regions close to the center of the disk. The detailed shape of the velocity profile can be used to reconstruct the radial distribution of the line emission.

We are using doppler tomography techniques (Marsh and Horne 1988) to map the disk's emission-line regions. Results so far published include maps of Balmer emission lines in two dwarf novae, IP Peg (Marsh and Horne 1990) and U Gem (Marsh et al. 1990). The doppler mapping studies confirm and strengthen the general finding from earlier line profile fitting that disks have emission-line surface brightnesses decreasing with radius as $R^{-3/2}$.
Fig. 1: A roughly linear dependence of emission-line surface brightness on rotation rate is found for Ca II H+K emission in rotating stars and for Hβ emission in two dwarf nova accretion disks.

Figure 1 compares the activity-rotation relationship observed for stars and disks. For a sample of stars taken mainly from Rütten (1987), we plot the Ca II H+K surface brightness vs the rotation rate. For two dwarf nova accretion disks, we plot lines giving the Hβ surface brightness as a function of the Keplerian rotation rate. Remarkably, the Ca II emission on stellar surfaces and the Hβ emission on disk surfaces both scale roughly linear with rotation rate.

Stars and disks exhibit the same power-law slope in Figure 1. We therefore suggest that a dynamo mechanism analogous to that which powers stellar chromospheres is also generating the emission lines in quiescent accretion disks. If this unification of stars and disks proves to be correct, then we have an excellent opportunity to test dynamo theories over a large range of rotation.
rates. The stellar sample spans rotation periods of 1–500 days, while in each
disk the Kepler period ranges from 10 to 500 seconds.

Rotation rate appears to be the primary parameter in both stars and disks,
but the geometry and other details of the dynamo must be very different in the
two cases. Disks may help to establish what parameters besides rotation are
important for dynamos, a program which has been difficult using stars alone
because the stellar parameters tend to be correlated along the main sequence
(e.g. Basri 1987).

Further studies should aim to test our proposed unification of stellar
and accretion disk dynamos. In stars there appear to be simple power-
law relationships among the various magnetic activity indicators. Do similar
relationships hold in disks? The photometric flickering activity seen in accretion
disks may represent a superposition of flare-like events occurring at each radius
at a rate proportional to the local Kepler frequency. How do the flare rates
in disks compare with those in stars? These and similar questions remain as
directions for future work.

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