GI890 - THE MAGNETIC BRAKE?

P.B. BYRNE, J.G. DOYLE and M. MATHIOUDAKIS
Armagh Observatory, Armagh BT61 9DG, N. Ireland

ABSTRACT  Very high resolution Hα spectra of the 10.35 hr period
BY Dra/flare star, FK Aqr (= GI890) provide evidence of AB Dor-like
circumstellar material.

Keywords: Late-type stars; rotational modulation; circumstellar matter

1. INTRODUCTION

Cameron and Robinson (1986, 1989a,b) discovered a rapidly rotating, K0 star,
AB Dor, undergoing mass-loss in the presence of closed loops. They suggest
that mass-loss occurs in condensations at the apexes of coronal loops near the
corotation radius. The cool material decouples from the magnetic field and
removes angular momentum, providing a ”magnetic brake”.

Young et al. (1990; Y90) have discovered a rapidly rotating (P = 10.35 hr;
v\sin i = 70 km/sec) M2Ve star, HK Aqr (= GI890). They saw shifts in the
centroid of the Hα emission line over a small range of phase, with a correlated
reduction in the line flux, which were attributed to non-uniform distribution of
Hα-emitting plages. Byrne and McKay (1990; BMcK90) suggested that,
due to HK Aqr’s large rotational velocity, a partial chromospheric eclipse would
cause the same effect. A coincident drop in MgII h and k flux supported
this interpretation. Doyle and Cameron (1990) proposed AB Dor-like coronal
condensations as the eclipsing material.

In this paper we describe two observing campaigns on HK Aqr which throw
further light on this phenomenon.

2. OBSERVATIONS

We have obtained two datasets, spaced by about 2½ weeks. The first comprises
simultaneous low-resolution (R ~ 10 000) blue (∼ 3600 - 4200 Å) spectra (exposure
5 min) taken with the South African Astronomical Observatory’s (SAAO) 1.9 m
telescope, and UBV(RI)Kc photometry (20 sec/cycle), taken with SAAO’s 1.0 m
telescope. The second comprises 16 Hα spectra (R ~ 50 000; exposure 5 min),
taken using the Anglo-Australian 3.9 m telescope (AAT).

Fig. 1 is the V band lightcurve for HK Aqr excluding flares. There is a small
amplitude spot modulation (ΔV ~ 0.07) with minimum at ϕ ~ 0.6. Fig 2 shows
the variation of CaIIK with phase on the night with best phase coverage. We
note the following.

[ 1.] There is a weak modulation in the sense that the flux near ϕ ~ 0.6 (V
light minimum) is higher than at ϕ = 0.0 – 0.4.
There is no drop in Ca K flux like that observed in Mg II h&k in 1984.

There is evidence for short-lived flaring on a time scale $\sim 20$ min (filled point).

Fig. 3 shows the Hα spectra. The top profiles show the mean of the first 3 spectra, contrasted with the final spectrum of the series. Note the dramatic change in the blue wing and line centre while the red wing hardly changes. Fig. 3 also shows differences between the mean of the first 3 spectra and the individual spectra. We note the following.

1. The profile is essentially constant over the first 4 spectra.
2. Then the line develops a small emission feature to the blue of line centre and, possibly, a very weak absorption at line centre.
3. In the last 5 spectra, the absorption at line centre deepens and develops an extended blue wing, and weak emission is seen to the red of line centre.

3. DISCUSSION

From Fig. 2 we conclude that there is no equivalent in Ca II K to the 40% Mg II dip in flux seen by BMcK90 and by Y90. The same conclusion is reached by considering the Ca II H/He and Hδ. Therefore it is improbable that the absorption is due to feature which are constant in time.

The variation in Hα is, however, similar to that seen by Y90. They see the Hα centroid shift, first to the red, accompanied by decreasing line intensity, and then to the blue. The red shift occurs over $\Delta \varphi \sim 0.15$, with maximum at $\sim \varphi \sim 0.65$. Our data show a blue wing absorption over $\Delta \varphi \geq 0.035$ at $\varphi > 0.7$, as the cause of the red shift of the Hα centroid. The maximum depression of the Hα intensity is $\sim 40\%$ of the excess above the local continuum compared with $\sim 40\%$ in Y90. Thus we have confirmed the Hα phenomenon in Y90 after $\sim 5$ yr. The decrease in Hα intensity is consistent with the 1984 results as is its occurrence just after maximum spottedness ($\Delta \varphi_{94} \sim 0.05$, $\Delta \varphi_{89} \sim 0.15$) is qualitatively similar.

Our spectra, however, show much more detail than those of Y90. The flux decrease and centroid velocity shift are shown to be due to an absorption at line centre with a blue wing out to $\sim 120$ km s$^{-1}$, considerably more than the rotational $v \sin i$ for HK Aqr ($\sim 70$ km s$^{-1}$).

We propose a cloud of neutral hydrogen, similar perhaps to a prominence, condensing from the stellar corona close to the corotation radius, and qualitatively similar those of AB Dor, as the cause. To account for the blue wing, however, we also require that there be a substantial upflow of the material.

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REFERENCES
Fig. 1. The mean V light curve for HK Aqr in mid-October 1989.

Fig. 2. 20 min averages of CaII K flux for 15 Oct 1989.

Fig. 3. The Hα line profile on 4 Oct 1989 over 80 min at φ ~ 0.7 (see text).