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Surface differential rotation of IL Hya from time-series Doppler images

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Abstract. We present a time-series Doppler imaging study of the K-subgiant component in the RS CVn-type binary system IL Hya ($P_{\rm orb} = 12.905$ d). From re-processing the unique long-term spectroscopic dataset of 70 days taken in 1996/97, we perform a thorough cross-correlation analysis to derive surface differential rotation. As a result we get solar-type differential rotation with a shear value α of 0.05, in agreement with preliminary suggestions from previous attempts. A possible surface pattern of meridional circulation is also detected.

Keywords. stars: activity, stars: imaging, stars: individual (IL Hya), stars: spots, stars: late-type

1. Time-series Doppler images of IL Hya

IL Hya is a double-lined binary star (K0IV + G8V), a typical RS CVn-type system orbiting with a period of 12.905 days. Our time-series spectroscopic dataset were obtained during a 70-night long observing run at NSO in 1996/97. From that we reconstruct 30 time-series Doppler images for two favoured mapping lines (Fe I-6430 and Ca I-6439) using our image reconstruction code TempMap (Rice *et al.* 1989). Adopted astrophysical parameters are listed in Table 1. As samples from the reconstructions, combined (Fe+Ca) maps are shown in Fig. 1, indicating significant changes of the spotted surface over a few rotation cycles.

2. Surface differential rotation and meridional flow

To measure surface DR we employ our method called 'ACCORD' (acronym from Average Cross-CORrelation of consecutive Doppler images), based on averaging cross-correlation function (ccf) maps of subsequent Doppler images. This way the surface differential rotation (hereafter DR) pattern in the ccf-maps could be enhanced, while

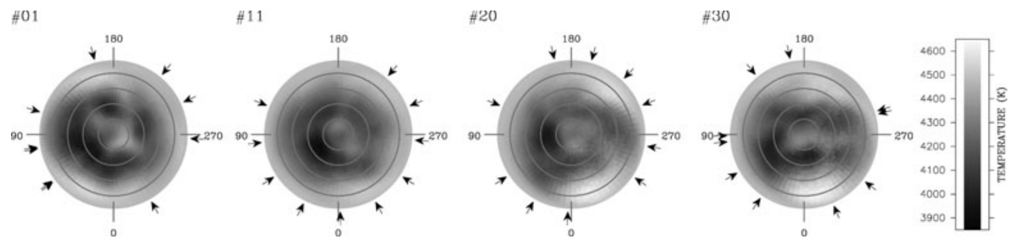

Figure 1. Time evolution of the spotted surface of IL Hya from time-series Doppler imaging.

Table 1. Astrophysical chart of IL Hya based on Weber & Strassmeier (1998)

Spectral type	K0IV (+G8V)
$\log g$	2.5±0.5
$T_{\rm eff}$ [K]	4500±250
$B-V$ [mag]	1.012±0.010
$V-I$ [mag]	0.99±0.01
Distance[a] [pc]	105.9±5.6
$v\sin i$ [km s^{-1}]	26.5±1.0
Inclination [deg]	55±5
$P_{\rm orb}$ [days]	12.905±0.004
Radius[a] [R$_\odot$]	8.1±0.9
Microturbulence [km s^{-1}]	2.0
Macroturbulence [km s^{-1}]	4.0
Chemical abundances	0.9 dex below solar
Mass [M$_\odot$]	≈2.2

[a] based on Hipparcos data

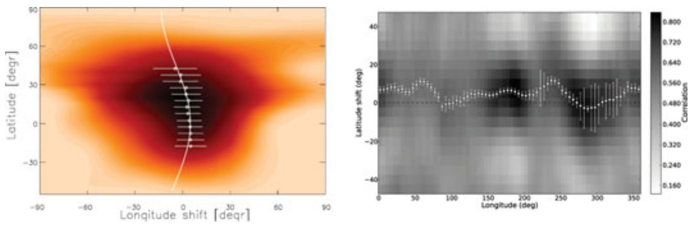

Figure 2. Averaged cross-correlations clearly reveal solar-type DR pattern (left) and common poleward drifting of spots (right).

the unwanted effect of stochastic spot changes are supressed (see Kővári *et al.* 2004, 2007 for details). Applying ACCORD yields solar-type rotation law in the form of $\Omega(\beta) = \Omega_{\rm eq} - \Delta\Omega\sin^2\beta$ with an equatorial angular velocity $\Omega_{\rm eq}$ of 28.28 ± 0.03 deg/day and $\Delta\Omega = \Omega_{\rm eq} - \Omega_{\rm pole}$ of -1.43 ± 0.15 deg/day, corresponding with a surface shear $\alpha = \Delta\Omega/\Omega_{\rm eq}$ of 0.05 ± 0.01 (see the fitted average ccf-map in the left panel of Fig. 1). This shear is consistent with the value of $\alpha = 0.03\pm0.02$ derived by using a different method for a different dataset taken in 1988 (Kővári & Weber 2004). Regarding the reliability of the results read the other paper by Kővári *et al.* in this proceedings.

Latitudinal motion of spots can also be quantified by ACCORD. For this we use only the hemisphere of the visible pole. For a detailed description of the method see Kővári *et al.* (2007). The resulting latitudinal correlation pattern (right panel in Fig. 2) can be converted into an average poleward surface velocity field of 0.5 ± 0.1 km/s, that could be interpreted as the surface pattern of a single-cell meridional circulation.

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