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FIRST SIMULTANEOUS PHOTOMETRIC AND SPECTROSCOPIC ANALYSIS OF THE ACTIVE STAR IT Com

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IT Comae Berenicis (HD 118234) was discovered to be a single-lined spectroscopic binary by Griffin (1988), who determined the orbital period $P_{\rm orb} = 59\overset{\rm d}{.}054$ and eccentricity $e = 0.59$. From existing multicolor photometry, he deduced the primary to be a K0 or K1 giant and suggested the secondary might be of earlier spectral class. Strassmeier (1994) observed CaII H&K emission lines well above the nearby stellar continuum, demonstrating a very high level of chromospheric activity. From time series photometry with an automated photometric telescope (APT), Henry et al. (1995) discovered brightness variability in HD 118234 with an amplitude of about $0\overset{\rm m}{.}20$ caused by rotational modulation in the visibility of photospheric spots. They determined the star's rotation period to be $P_{\rm rot} = 64 \pm 1$ days and noted two unequal minima per rotation cycle, indicating that HD 118234 had large spotted regions on opposite hemispheres of the star. Moreover, by combining their $v \sin i$ measurement with the rotation period, Henry et al. (1995) found a minimum radius of 7.0 $R_\odot$, confirming the giant classification. They also noted that, while the star's orbital and photometric periods are similar, rotation in IT Com is far from the pseudosynchronous rotation period of $15\overset{\rm d}{.}1$ days predicted from the orbital eccentricity.

In this brief paper, we present the results of a coordinated photometric and spectroscopic observing campaign conducted during 2004 April–June at the Fairborn Observatory (FO), Çanakkale Onsekiz Mart University Observatory (ÇOMÜ), and Catania Astrophysical Observatory (OACt). The photometric observations were made with the T3 0.4-m APT at FO and with the 0.4-m Schmidt–Cassegrain telescope at ÇOMÜ and the reduction was performed correcting for atmospheric extinction with nightly extinction coefficients and transformed to the Johnson system with yearly mean transformation coefficients. The spectroscopic observations were made with the FRESCO spectrograph at OACt at a resolution $R = 22\,000$ and the reduction was performed following the standard steps of background subtraction, division by a flat field spectrum, wavelength calibration, and normalization to the continuum through a polynominal fit. The main goal of these observations was to study active regions at photospheric and chromospheric levels, as we have done previously for other RS CVn binaries and single active stars (Frasca et al., 2000; Frasca et al., 2002; Biazzo et al., 2006a; Biazzo et al., 2006b).

For photospheric diagnostics, we used the Johnson V and B light curves and the hemisphere-averaged effective temperature curve derived from line-depth ratios (LDRs) of metal weak lines (Gray & Johanson, 1991; Catalano et al., 2002). We converted seven specific combinations of LDRs to temperatures with LDR–$T_{\rm eff}$ calibrations that we have previously developed (Catalano et al., 2002). The V and B light curves and the resulting $T_{\rm eff}$ values are plotted in the first three panels of Figure 1 as a function of rotational phase computed from the ephemeris

$$\mathrm{HJD}_{\varphi=0} = 2\,453\,063.0 + 64\overset{\rm d}{.}0 \times E, \tag{1}$$

where the initial epoch is arbitrary (2004 February 27) and the rotational period of $64\overset{\rm d}{.}0$ is adopted from Henry et al. (1995). Both the light curves and the temperature plot exhibit a maximum around $\varphi = 0\overset{\rm p}{.}30$ and a subsequent minimum near $\varphi = 0\overset{\rm p}{.}60$. The V and B light curves also show a second maximum, not visible in the $\langle T_{\rm eff}\rangle$ curve due to a phase gap, and a further minimum at $\varphi \simeq 0\overset{\rm p}{.}05$, perhaps present also in the temperature modulation but not clearly visible due to the scarce phase coverage. This double-wave behaviour, found earlier by Henry et al. (1995) in their 1993 photometry, is thus in our 2004 data, indicating again the presence of spots on opposite hemispheres. The peak-to-peak amplitudes of the top three panels in Figure 1 are $\Delta V = 0\overset{\rm m}{.}077$, $\Delta B = 0\overset{\rm m}{.}075$, and $\Delta\langle T_{\rm eff}\rangle = 77$ K.

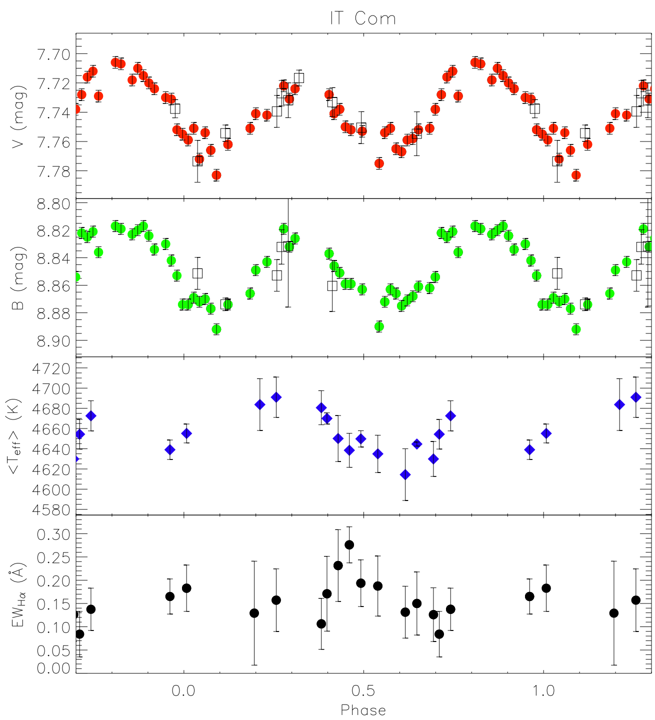

Figure 1. *From top to bottom.* V and B magnitudes, averaged $T_{\rm eff}$ and $EW_{\rm H\alpha}$ as a function of rotational phase. In the light curves, the filled circles are FO data, while the empty squares are ÇOMÜ photometry. For the photometric observations, HD 117816 ($V = 8\overset{\rm m}{.}48$, $B = 10\overset{\rm m}{.}05$) was used as comparison star, while HD 119126 ($V = 5\overset{\rm m}{.}58$, $B = 6\overset{\rm m}{.}59$) was chosen as check star (Yoss & Griffin, 1997). A shift has been applied to the few ÇOMÜ data in order to adequately match those ones from FO

For a chromospheric diagnostic, we used the net Hα emission as derived from the *spectral synthesis method* (e.g., Barden, 1985; Frasca & Catalano, 1994). With this technique, the difference between the observed spectrum and a "non-active" template gives, as residuals, the net Hα chromospheric emission. We have used a well-exposed spectrum of β Gem (K0IIIb, $B-V=1\overset{\text{m}}{.}00$) as our H$\alpha$ template. This spectrum has not been rotationally broadened since IT Com has a $v\sin i = 6.5$ km s^{-1} (Fekel, 1997), i.e. lower than the resolution of the spectrograph. The Hα equivalent widths ($EW_{\rm H\alpha}$) integrated across the residuals in the observed-minus-template spectra suggests only marginal modulation with rotational phase (Figure 1, bottom). The most evident feature in the Hα plot is an increase in equivalent width around phase $0\overset{\text{p}}{.}5$ (the second minimum in the light curve) of a factor ≈ 2 just over the 3σ level.

The values of the averaged temperature and the net equivalent width $EW_{\rm H\alpha}$ of IT Com are listed in the Table 1, while the photometric data are reported in Tables 2 and 3, which are available electronically through the IBVS website as files 5740-t2.txt and 5740-t3.txt. The typical precision of the T3 observations, about $0\overset{\text{m}}{.}004$, has not been reported in Table 2.

Table 1. Temperature and net Hα equivalent width of IT Com

HJD (+2 400 000)	Phase	$\langle T_{\rm eff}\rangle$ (K)	$EW_{\rm H\alpha}$ (Å)
53 108.438	0.710	4654±15	0.08±0.05
53 110.457	0.742	4673±15	0.14±0.05
53 124.512	0.961	4639±10	0.17±0.04
53 127.477	0.007	4655± 9	0.18±0.05
53 139.520	0.196	4684±26	0.13±0.11
53 143.430	0.257	4691±20	0.16±0.07
53 151.453	0.382	4681±17	0.11±0.05
53 152.457	0.398	4670± 6	0.17±0.08
53 154.441	0.429	4650±23	0.23±0.08
53 156.438	0.460	4638±17	0.28±0.04
53 158.488	0.492	4650± 8	0.19±0.05
53 161.508	0.539	4635±18	0.19±0.06
53 166.391	0.616	4614±26	0.13±0.06
53 168.457	0.648	4645± 2	0.15±0.07
53 171.402	0.694	4630±17	0.13±0.06

The results presented here are part of a project devoted to obtain both spectroscopic and photometric observations of a sample of magnetically active stars with different spectral types, ages, masses, rotational periods and activity levels. The ultimate goal is to investigate possible dependences of active region parameters (i.e. temperature and filling factor) on global parameters (such as mass and radius).

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