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Research Note

On the nature of V 589 Sagittarii

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Abstract. We present optical and near infrared spectroscopy of the symbiotic star candidate V 589 Sgr. The presence of TiO and VO absorption bands, along with strong H I and He I emissions, confirm the symbiotic star classification, although the primary is clearly rather cooler than is common in symbiotics. Following standard spectroscopic methods, a spectral type of M4 III is derived for the cool component, along with a distance of 8 kpc.

Key words. stars: binaries: general – stars: binaries: symbiotic – stars: evolution – stars: fundamental parameters – stars: V 589 Sgr

1. Introduction

V 589 Sgr was noted as an irregular variable with the comment "RCB type ?" in a study of Milky Way area 187 by Swope (1936). This author gives a magnitude range of 14.2 mag to fainter than 16.5 mag ($m_{\rm pg} = 17.6$ mag according to Milone (1990) and *Simbad*), but no light curve is shown in her paper. The probable RCB classification was recently rejected by Kilkenny (1997) after the analysis of a spectrum showing Balmer lines of hydrogen in emission with a steep Balmer decrement. Instead, he proposed a classification as *symbiotic-like*, since the spectrum, spanning the wavelength range of 3400–5200 Å, shows marginal TiO bands but not the He I and He II emissions which are typical of symbiotic stars.

Another point noted by Kilkenny (1997) is the slightly different position of the object which he identified as the variable V 589 Sgr with respect to the GCVS's position. We add here that we measured the coordinates of V 589 Sgr as $\alpha_{2000} = 18^{\rm h}05^{\rm m}17\overset{\rm s}{.}1$, $\delta_{2000} = -34°44'47''$, thus improving those given in Milone (1990) and *Simbad*.

2. Observations and data reduction

We have obtained three spectra of V 589 Sgr at the Danish 1.54 m telescope on La Silla on May 29/30, 2000, with DFOSC grism #15 (HJD 2 451 694.6583), grism #5 (HJD 2 451 695.6228) and grism #7 (HJD 2 451 695.6422). These grisms have resolutions of 13, 7.5 and 4 Å, and yield a combined spectral range of 3800–9500 Å. Reductions were done in the usual manner using standard IRAF[1] routines. The spectra were flux-calibrated with the standard stars LTT 3864 and LTT 7987 (Hamuy et al. 1992; Hamuy et al. 1994). To minimize slit losses and improve flux calibration, a wide slit was used for standards stars (5″) while the slit for all objects was aligned along the paralactic angle. The wavelength calibration functions were constructed with ≈40 He-Ne lines and had typical rms of 0.1 Å.

3. Results

The low resolution spectrum, shown in Fig. 1, shows typical features of a symbiotic star, viz. Balmer emissions with steep decrement, which are signatures of the hot component, and TiO bands, probably originating in the cool atmosphere of a red star. In addition to the features

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⋆ Based on observations obtained at the European Southern Observatory, ESO proposal 65.H-0410(A).

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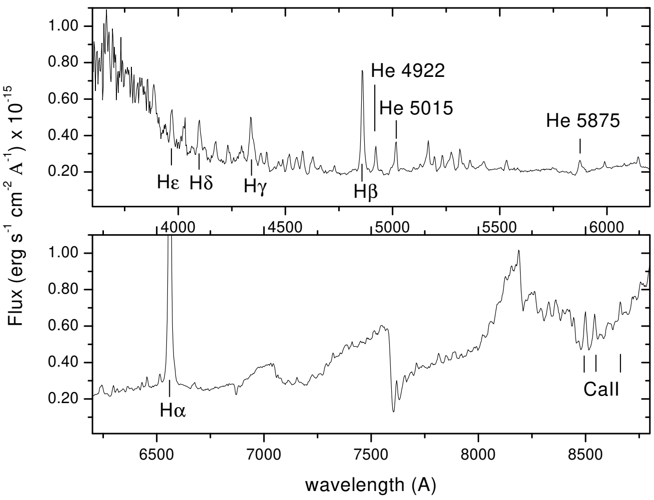

Fig. 1. Spectrum of V 589 Sgr obtained with DFOSC grism #15. Main emission lines are labeled. The Hα flux is truncated in the lower panel (the maximum is at 3.1 10^{-14} erg s^{-1} cm^{-2} A^{-1}) in order to better view all other features

seen by Kilkenny (1997), we find Fe I, He I and Fe II emissions, and most notably the Ca II 8498, 8542, 8662 triplet in emission. Based on the wavelengths, and the absence of Paschen 14, we suspect that these emissions are truly Ca II and not the Paschen P13, P15 and 16 lines. The emissions at λ 4730, 5197 and 6384 Å are tentatively identified as Mn I whereas λ 5991 and 6300 Å probably correspond to O I. The narrow absorption lines of the cool-star, often seen in symbiotics, do not appear in our spectrum. The Hα emission wings extend to velocities $\sim$1000 km s^{-1}. The spectral characteristics described above, especially the presence of the Ca II triplet in emission and the absence of He II emission, places V 589 Sgr as a special member in the class of symbiotic stars. The steep Balmer decrement, and the absence of He II 4686 emission, implies a temperature for the hot component lower than in other members of the class.

Table 1 lists the equivalent width and the radial velocity for the main spectral lines. Heliocentric radial velocities were measured by fitting Gaussian functions to the profiles whereas the equivalent width was obtained by integration of the flux between the points where the profile merges with the continuum. Since the spectrum shows strong gradients and severe line blending, it is not an elementary task to determine the continuum, so the errors associated to the equivalent widths can be of order of 30% for the weaker lines but certainly much lower for the stronger lines ($\sim$5% for Hα for instance). From Table 1 the mean radial velocities are: $v_{\rm H\,I} = 22 \pm 14$ km s^{-1} (3 lines), $v_{\rm He\,I} = 67 \pm 42$ km s^{-1} (3 lines), $v_{\rm Fe\,I} = 17 \pm 7$ km s^{-1} (4 lines), $v_{\rm Fe\,II} = 13 \pm 5$ km s^{-1} (5 lines) and $v_{\rm O\,I} = 7 \pm 12$ km s^{-1} (2 lines). The errors reflect the root mean square of the averages. Several lines cannot be identified. Possible causes are line blending or existence of lines of high excitation ions. The radial velocities here reported were measured on the grism #7 spectrum, since this spectrum provided the best set of radial velocities, compared with the spectra taken with lower resolution grisms. For this reason we do not give velocities of lines with $\lambda > 6900$ Å, since these measurements showed a great scatter. The above average of H I velocities does not consider the low velocity Hδ and Hϵ lines, since these lines are likely contaminated with Fe I and Fe II and might suffer of wavelength calibration biases on the CCD blue edge. The velocities reported

Table 1. Equivalent widths and radial velocities of the main emission lines

Line	W_λ (Å)	rv (km s^{-1})
Hα	−143	13
Hβ	−40	40
Hγ	−21	11
Hδ	−9	−46
Hϵ	−8	−162
He I 5875	−8	14
He I 5015	−10	105
He I 4922	−9	60
Ca II 8662	−1	
Ca II 8542	−4	
Ca II 8498	−7	
Mn I 4730	−5	4
Mn I 5197	−5	−2
Mn I 6384	−1	−3
Fe I 4384	−6	15
Fe I 4490	−6	8
Fe I 4602	−1	28
Fe I 5168	−6	17
Fe II 4628	−4	7
Fe II 5362	−2	18
Fe II 6433	−2	6
Fe II 6456	−2	8
Fe II 6516	−3	17
Fe I + Fe II 4232	−5	
Fe I + Fe II 4414	−10	
Fe I + Fe II 5316	−5	
Fe I + Fe II 6417	−1	
O I 5991	−2	−5
O I 6300	−3	19
unknown 4618	−2	
unknown 4666	−3	
unknown 5234	−4	
unknown 5275	−3	
unknown 5534	−2	
unknown 6147	−2	
unknown 6317	−2	
unknown 7633	−10	

here are different from those given by Kilkenny (1997), viz. $v_{\rm H\,I} = -6 \pm 10$ km s^{-1} and $v_{\rm Fe\,I} = -28 \pm 24$ km s^{-1}. A long-term study is necessary to confirm the radial velocity variability of this star.

4. Discussion

We intended a classification of the red component, based on the fact that the TiO bands are good indicators of the spectral type (Kenyon & Fernandez-Castro 1987). We measured the $[\mathrm{TiO}]_1$, $[\mathrm{TiO}]_2$ and [VO] indices defined by Kenyon & Fernandez-Castro (1987), obtaining 0.115(5), 0.37(0) and 0.22(0) respectively. These indices yield spectral types of M3, M5 and M4, using Eqs. (5–7) of Kenyon & Fernandez-Castro (1987). The spectral type ~M4 is close to the mean of a sample of 100 symbiotic stars (see Mürset & Schmid 1999).

The absence of Ca II absorption and other luminosity indicators (e.g. Na II and Fe I absorption lines, Zhu et al. 1999) makes any estimation of the luminosity class almost impossible. However, in the case where the secondary is a giant, like in most symbiotic stars, the calcium triplet in emission could not be understood as chromospheric activity, as sometimes occurs in dwarfs. An alternative explanation is an origin in the outer cool parts of an accretion disk as seen in some cataclysmic variables (e.g. Persson 1988).

We can use the emission line ratios to estimate the interstellar extinction. Assuming a theoretical ratio $F_{\mathrm{H}\alpha}/F_{\mathrm{H}\beta} = 2.8$ (nebulae case B, Osterbrock 1974), we derive, from the observed ratio of 4.13, a selective extinction $E(B-V) = 0.42$ (see Seaton 1979 for details of the method). This figure yields $A_V = 1.33$. This deduced extinction is similar to the total galactic extinction in the direction of V 589 Sgr ($N_{\rm H} = 1.8\ 10^{21}$ Dickey & Lockman 1990), when using the conversion according to Predehl & Schmitt (1995). This fact implies that V 589 Sgr is beyond all the galactic column. At a galactic latitude of $b_{\rm II} = -6.5$ deg this yields a distance larger than 1 kpc. Based on the intensity in the spectra we deduce a brightness of $m_V \approx 15.6$ mag, corresponding to a stage of intermediate brightness. The distance, inferred by assuming $M_V = -0.3$ for a M4 giant and the extinction above, is $d = 8$ kpc. On the contrary, when assuming a dwarf companion with $M_V \sim 11.3$ mag, the deduced distance would have to be of the order of 40 pc only, inconsistent with the deduced extinction of the Balmer lines.

A check of the ROSAT All-Sky survey archive reveals no X-ray source at the position of V 589 Sgr. This corresponds to an unabsorbed flux limit of $< 10^{-12}$ erg cm^{-2} s^{-1} in the 0.1–2.4 keV range. Given the above extinction, this is no surprise.

5. Conclusions

- We have confirmed that V 589 Sgr is a symbiotic star;
- A spectral type of M4 III was derived for the cool component;
- A distance of 8 kpc was found for the system.

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