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The Hα stellar and interstellar emission in the open cluster NGC 6910 *(Research Note)*

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ABSTRACT

Aims. We verify the nature of emission-line stars in the field of the open cluster NGC 6910.
Methods. Spectroscopy in the Hα region was obtained. Raw CCD frames of spectra of all stars fainter than $V = 9$ mag observed by us are significantly affected by nebular emission originating in the surrounding H II region IC 1318. After careful data reduction and subtraction of the nebular radiation we succeeded in obtaining reliable stellar spectra.
Results. We confirm that the star NGC 6910 37 is a Be star, and we have corrected the classification of V1973 Cyg from an Ae star to a normal A type star. Since the diffuse interstellar bands do not appear in the spectrum of this star while being present in the other stars we observed, we confirm that V1973 Cyg is a foreground object with respect to IC 1318 and NGC 6910. We also find that the Hα line in HD 194279 has a P Cygni profile and the Hα line profile is variable in HD 229196.

Key words. Galaxy: open clusters and associations: individual: NGC 6910 – stars: emission-line, Be – stars: individual: V1973 Cyg – ISM: individual objects: IC 1318

1. Introduction

The northern-sky open cluster NGC 6910, the core of the Cyg OB9 association, lies in the vicinity of the nebula IC 1318b, a part of IC 1318 – the γ Cygni Nebula. Arkhipova & Lozinskaya (1978) identified the star GSC 03156-00657 (indicated as No. 1 in their Fig. 1) as the excitation source of this nebula. According to Appenzeller & Wendker (1980), it is an O9 V type star. However, this star is not a member of NGC 6910, because it lies too far from the cluster centre. The IC 1318b nebula harbours a star-forming region SFR 2 Cyg, in which many emission line stars are known (Melikian & Shevchenko 1990; Shevchenko et al. 1991; Manchanda et al. 1996). In the field of the cluster, however, only a few stars with emission were found. Considering the same area as Kołaczkowski et al. (2004), i.e., $20' \times 20'$ centred at NGC 6910, seven stars with Hα emission were reported in the literature. However, only four of them are brighter than $V = 13$ mag. The brightest, HD 194279, was originally classified as a B0e star (MWC 634) by Merrill & Burwell (1943). Later, Morgan et al. (1955) classified this supergiant as B1.5 Ia (MCW 896). Following the discovery of its light variations by Hipparcos, the star was named V2118 Cyg (Kazarovets et al. 1999).

Schild & Romanishin (1976) did not find any Be stars in this cluster after checking stars brighter than 11.0 mag. A negative result was also obtained by Goderya & Schmidt (1994). On the other hand, Halbedel (1991) found weak central emission in the Hα line in the spectrum of the A3 star HD 229189 = BD +40°4145 (V1973 Cyg, Kazarovets et al. 1993) and classified this star as an Ae star. Usually only the hottest A-type stars are Ae stars, therefore this star seemed to be quite exceptional.

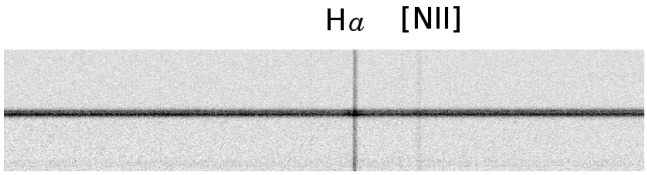

Fig. 1. CCD image of the slit spectrum of NGC 6910 37. Note the vertical lines corresponding to the emission from the nebula. The brighter line corresponds to the Hα line, the fainter to the [N II] 6583.45 Å line.

Recently, Kołaczkowski et al. (2004) searched NGC 6910 for variable B type stars. They also looked for emission-line objects in this cluster using Hα photometry. They find three stars that have Hα in emission. To the previously known emission line star V2118 Cyg, they added an O-type star HD 229196 (V2245 Cyg, Kazarovets et al. 2001) = MCW 895 (Morgan et al. 1955), which was previously known only from some peculiarities in the ultraviolet spectrum (Massa et al. 1983), and NGC 6910 37[1]. This research note aims to verify these findings spectroscopically.

2. Observations and data reduction

We observed four suspected Hα emission line stars brighter than 13 mag in V: V2118 Cyg, V2245 Cyg, V1973 Cyg, and NGC 6910 37. In addition, for comparison purposes we observed several other stars that are brighter than and near NGC 6910 37,

[1] See the WEBDA database (http://obswww.unige.ch/webda/) for the numbering system used in NGC 6910.

Table 1. List of Ondřejov coudé observations of stars in NGC 6910. Suspected emission objects are listed in the upper part of the table followed by the comparison stars. The *V* magnitudes are from Kołaczkowski et al. (2004).

WEBDA No.	Other star names	Spectral classification	*V* [mag]	HJD 2450000+	Spectral region [Å]	Exposure time [s]
2	V2118 Cyg (HD 194279)	B1.5 Ia[2], B2 Ia[4]	7.12	3985.3520	5952–7179	300
				3999.5324	5952–7179	600
4	V2245 Cyg (HD 229196)	O6 III[5]	8.61	3941.5973	5952–7179	678
				3985.3606	5952–7179	300
				3999.5208	5952–7179	900
6	V1973 Cyg (HD 229189)	A3 V[3], A3 Ve[6]	10.12	3941.5719	5952–7179	2700
37		Be[7]	12.44	3939.3843	5952–7179	2700
		(from Hα		3939.4182	5952–7179	2700
		photometry)		3939.4656	6160–6772	3600
5	BD +40°4146	B3[1]	9.74	3939.5126	6160–6772	3600
13	BD +40°4148	O9.5 V[3]	10.36	3941.5351	5952–7179	2700
14		B0.5 V[3]	10.46	3941.4782	5952–7179	2700
25		B3[1]	11.52	3950.4634	5952–7179	3600
				3950.5186	5952–7179	3261

Note: spectral types are as classified by: 1 – Becker & Stock (1949), 2 – Morgan et al. (1955), 3 – Hoag & Applequist (1965), 4 – Walborn (1971), 5 – Walborn (1973), 6 – Halbedel (1991), 7 – Kołaczkowski et al. (2004).

namely: BD +40°4146, BD +40°4148, NGC 6910 14, and NGC 6910 25.

Our spectroscopic observations were obtained in 2006 using the spectrograph in the coudé focus of the Ondřejov 2-m telescope; for a description see Šlechta & Škoda (2002). We observed the region around the Hα line, and the observations are summarised in Table 1. We obtained medium-resolution spectra ($R \sim 13\,000$) over the wavelength region 6160–6672 Å using the 700-mm spectrograph focus and low-resolution spectra ($R \sim 7400$) over the wavelength region 5952–7179 Å using the 400-mm spectrograph focus. In the 700-mm focus we used the SITe CCD 2030 × 800 chip having 15-μm pixels, while in the 400-mm focus we used the LORAL CCD 2688 × 512 chip with 15-μm pixels.

The data were reduced using the Image Reduction and Analysis Facility (IRAF[2]). The cluster NGC 6910 is in the same region of the sky as the γ Cygni Nebula, which is also a significant source of Hα radiation. Consequently, an Hα emission line can be found in the image of the CCD frame on both sides of the slit's stellar spectrum (see Fig. 1). This fact had to be taken into account in the data reduction process, at least for the faint stars, for which the contribution from the nebula becomes non-negligible in comparison with that of the star itself. After the overscan correction, bias subtraction, and flat field correction in IRAF, we cleaned the 2D FITS images from cosmics using the program `dcr` written by Pych (2004). Then, the contribution from the background emission was subtracted. The removal of cosmics mentioned above enabled us to use columns (perpendicular to the image of the stellar spectrum) that are only one pixel wide. Then, the background value in the given pixel was obtained using a second-order Chebyshev polynomial fit. The remaining steps, such as wavelength calibration, were done using IRAF.

[2] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

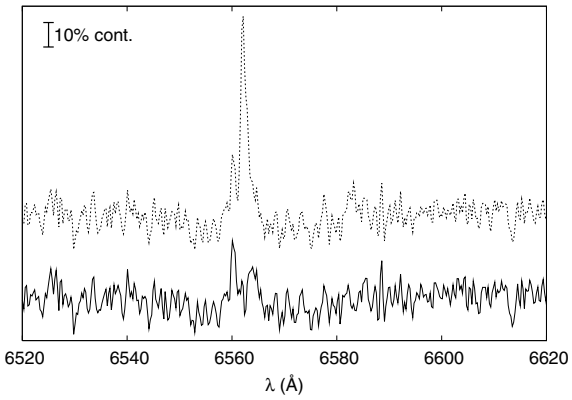

Fig. 2. The spectrum of NGC 6910 37 before (dotted line) and after (continuous line) subtraction of the contribution from the nebula. Note the presence of the two emission peaks in the first spectrum. The stronger peak corresponds to the Hα line, the weaker, to the nitrogen forbidden line [N II] 6583.45 Å. The spectra are normalised to the continuum and separated arbitrarily for clarity.

3. The emission line stars in NGC 6910

3.1. NGC 6910 37

Kołaczkowski et al. (2004) report that NGC 6910 37 is a new Be star, based on their Hα photometry observations. However, the spectrogram in Fig. 1 shows the presence of strong background Hα emission, evidently originating from the surrounding nebula. Figure 2 shows that, after background subtraction, emission in Hα is reduced albeit still present. A similar result was obtained using the low-dispersion spectrograms of this star (not shown here). This residual emission has to be intrinsic to NGC 6910 37 and indicates that the classification of this star as a Be star is likely to be correct.

In order to confirm the origin of the background emission, we observed four nearby stars: the star BD +40°4146 = NGC 6910 5, which lies very close to NGC 6910 37, the suspected binary BD +40°4148 = NGC 6910 13, and two recently discovered β Cephei-type variables NGC 6910 14 and NGC 6910 25 (see Pigulski et al. 2007). All these stars show a central emission peak in their

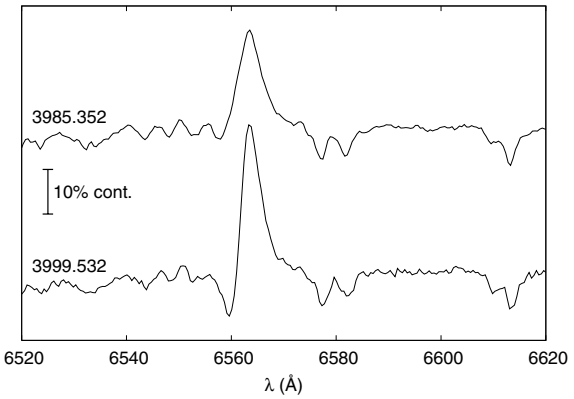

Fig. 3. Two spectra of the Hα line of V2118 Cyg. The spectra are labelled with the HJD−2 450 000.

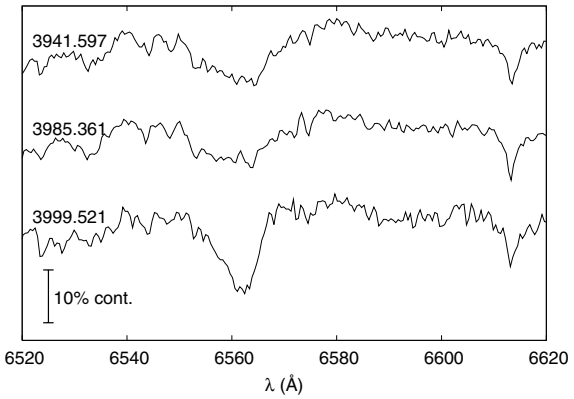

Fig. 4. Three spectra of the Hα line of V2245 Cyg. The spectra are labelled with the HJD−2 450 000.

spectra prior to background subtraction. The peak disappears once the background contribution is removed.

Since the procedure of background subtraction completely removes the Hα emission from the spectra of BD +40°4146, BD +40°4148, NGC 6910 14, and NGC 6910 25, it is clear that they are not Be stars. The emission in their uncorrected spectra comes from the surrounding nebula.

3.2. Bright stars from NGC 6910

To complete the survey of the known emission line stars in NGC 6910, we observed the brightest stars in the field of the cluster. Some of these were indicated to be in emission by Kołaczkowski et al. (2004). Moreover, they are often used for interstellar absorption studies (e.g. Pendleton et al. 1994; Imanishi et al. 1996; Galazutdinov et al. 2000, 2004; Clayton et al. 2003; Patriarchi et al. 2001, 2003; Herbig 1995, and references therein).

3.2.1. V2118 Cyg

The B1.5 Ia (or B2 Ia) supergiant HD 194279 (V2118 Cyg = NGC 6910 2) occasionally appears in radiatively driven wind studies. It shows P Cygni profiles for lower hydrogen lines (see Fig. 3 for Hα and Fig. 4 in Lenorzer et al. 2002 for Brα). However, other hydrogen infrared lines and also higher Balmer lines (Hβ to Hε) were found to be in absorption (Lennon et al. 1992).

Due to its brightness, the influence of the interstellar emission on the stellar spectrum of V2118 Cyg is negligible. Our observations indicate some variability in the P Cygni-type Hα line profile (Fig. 3).

3.2.2. V2245 Cyg

The O-type star HD 229196 (V2245 Cyg = NGC 6910 4) was listed as possibly in emission by Kołaczkowski et al. (2004). Apart from being listed in catalogues of Galactic O-type stars (e.g. Maíz-Apellániz et al. 2004), this star has not been studied in detail. We see no noticeable influence of the background interstellar emission on the stellar spectrum of V2245 Cyg, apparently due to its brightness. Moreover, there is no emission present in any of the three spectra (Fig. 4); however, changes in the Hα line profile are clearly seen. These changes and the presence of the extended blue wing in the Hα profile, together with the photometric variability make this star an interesting object for further study.

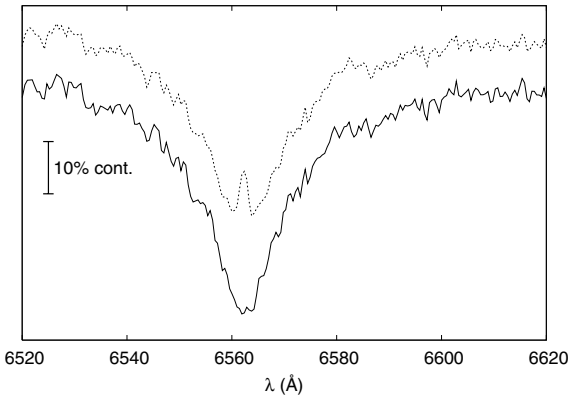

Fig. 5. The same as in Fig. 2, but for V1973 Cyg.

3.3. V1973 Cyg

The observations of NGC 6910 37 and nearby stars discussed in Sect. 3.1 lead us to suspect that the central Hα emission of V1973 Cyg (NGC 6910 6), which was reported by Halbedel (1991), may also have an interstellar origin. The result for this star was that again the central emission disappeared after the background was subtracted. Since without the subtraction of the background we obtained spectra similar to that presented by Halbedel (1991), we suspect that the spectrum she showed in this paper might be affected by the nebular emission. Thus, V1973 Cyg probably does not belong to the class of Ae stars. However, due to its peculiar variability found by Kałużny & Pojmański (1982), and confirmed by Halbedel (1991) and recently by Pigulski et al. (2007), this star remains a very interesting object for further study.

4. Radial velocities and cluster membership

To clarify their cluster membership, we measured the heliocentric radial velocities with an accuracy of $\sim$2 km s^{-1} of six of the observed stars in NGC 6910, as well as the heliocentric radial velocity of the IC 1318 nebula in the vicinity of each observed star (see Table 2). All measured stars except V1973 Cyg are cluster members. Cluster membership of V1973 Cyg has already been ruled out by Becker & Stock (1949). According to Hoag & Applequist (1965), it is a foreground object, and Shevchenko et al. (1991) came to the

Table 2. Heliocentric radial velocities of the observed stars ($RV_{\rm star}$) and surrounding nebula ($RV_{\rm neb}$) in NGC 6910 as measured using the Hα line.

Star	$RV_{\rm star}$ [km s^{-1}]	$RV_{\rm neb}$ [km s^{-1}]
BD +40°4146	−17.8	−28.3
V1973 Cyg	−6.9	−24.7
BD +40°4148	+11.4	−26.0
NGC 6910 14	−20.1	−29.7
NGC 6910 25	−7.3; −8.2	−26,5; −25.1
NGC 6910 37	−54.8; −46.5; −32.4	−27.9; −27.0; −26.0

same conclusion. Out of the five measured cluster members, only one is non-variable, while the remaining are either pulsating stars (NGC 6910 14 and NGC 6910 25) or suspected binaries (BD +40°4148, Kołaczkowski et al. 2004). Since only one or two spectra were obtained for each star, then the measured radial velocities are not representative of the centre-of-mass velocities. In consequence, we can only conclude that the radial velocities we measured do not contradict the cluster membership as proposed by the photometric data. The radial velocities of NGC 6910 37 display significant changes during the three hours of its observation (see Table 1) and suggest possible binarity of this Be star.

The measured radial velocities of the nebular Hα line (Table 2) are between −30 and −25 km s^{-1}, which is consistent with the results of Fountain et al. (1983, see their Fig. 5). Radio observations by Davies & Tovmassian (1963) found that an expanding shell of neutral hydrogen with a radial velocity of about −28.5 km s^{-1} surrounds the cluster and the H II region. The radial velocity of the cluster is −31 km s^{-1} (Hayford 1932), which is similar to the velocity of the neutral hydrogen shell. Also the radial velocity of the emission peak in the Hα line of V1973 Cyg, published by Halbedel (1991), is -29.6 ± 2.2 km s^{-1}, which supports the fact that the central emission in the Hα profile of this star has an interstellar origin.

Support for the cluster membership of stars comes from the presence of diffuse interstellar bands (DIBs) in the stellar spectra. DIBs at 6614 and 6284 Å (Galazutdinov et al. 2000, 2004) are observed in all stars except V1973 Cyg. The absence of the two DIBs in the spectrum of the latter star and its presence in the spectra of the other stars proves that V1973 Cyg is a foreground object that is much closer to us than NGC 6910. The presence of a DIB does not prove that the remaining seven stars are members of NGC 6910, but the similarity of their DIB profiles (once resolution is taken into account) in Fig. 6 suggests that these stars have very similar distances. If we adopt the measured values of the DIB wavelengths from Galazutdinov et al. (2000), 6613.56 and 6283.85 Å, their radial velocities have values around −9 km s^{-1}. However, since the nature of these DIBs is not known, the exact wavelengths are uncertain and, consequently, measured values of radial velocities may differ systematically from those of the nebular Hα lines.

The cluster itself becomes very interesting in view of the fact that it harbours at least seven β Cephei stars (Pigulski et al. 2007), which makes it one of the richest in this type of variable. Because the β Cephei stars constitute a relatively large fraction of early B-type cluster members, it was suggested (Kołaczkowski et al. 2004) that this can be explained by higher metallicity. The pulsations and Be phenomenon are not mutually exclusive, but the pulsations are enhanced in the high metallicity environment, while the effect is opposite for the Be phenomenon (Wisniewski & Bjorkman 2006; Martayan et al. 2006). Moreover, the fraction of Be stars

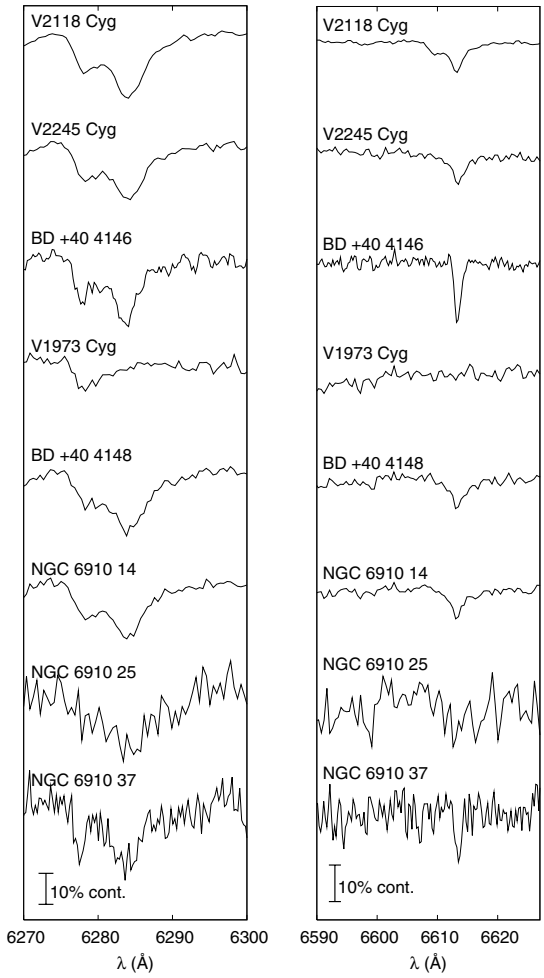

Fig. 6. Diffuse interstellar bands at 6284 Å and 6614 Å in the spectra of the observed stars. The absorption next to 6284 Å DIB, at about 6278 Å, is a telluric line. The spectrum of NGC 6910 25 is too noisy for the 6614 Å DIB to be visible. The spectra of BD +40°4146 and NGC 6910 37 were observed at a higher resolution; consequently, the DIB at 6614 Å is deeper and narrower for these two stars. Note the absence of both DIBs in the spectrum of V1973 Cyg.

may depend on the age of a cluster. Because of the small number statistics, no reliable conclusion as to the observational relation between the incidence of β Cephei and Be stars can be drawn at the moment.

5. Conclusions

Our spectroscopic observations of a sample of eight stars in NGC 6910 have confirmed the weak emission in the star NGC 6910 37 and, consequently, its classification as a Be star. There is, however, a significant contribution from the surrounding nebula to the observed spectra, which needs to be subtracted for stars observed in this region of the sky. We argue that this is probably the reason the variable star V1973 Cyg was thought to be an Ae star, while our observations show that it is a normal A-type star. The radiation from the nebula needs to be considered when observing stars in this region of the sky. Otherwise, as we have shown in the paper and, for example, as shown by Keller & Bessell (1998) for NGC 330, spurious emission can be detected.

We also confirm the weak emission in the supergiant HD 194279 and find P Cygni-type profiles of its Hα line. There is no emission in the Hα line of the other bright star in the cluster,

HD 229196, but its Hα profile is variable. It is therefore possible that at the epoch of the photometric observations, the Hα profile was partly filled in by emission that would be sufficient to get an agreement with the α index measured by Kołaczkowski et al. (2004).

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