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Two New LBV Candidates in the Galaxy IC342

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Two LBV candidates have been found in the galaxy IC342. Within the framework of the program of searching for LBV stars in galaxies outside the Local Group, spectral and photometric observations were carried out with the 6-m telescope of SAO RAS. These two objects revealed observed features characteristic of LBV stars. Their spectra show typical LBV emission lines: the broad and strong hydrogen lines and the HeI, FeII, and [FeII] emissions. We have obtained the estimates of the interstellar reddening and the photosphere temperatures. For one star, it was possible to build the spectral energy distribution (SED) and determine the temperature more accurately. We estimated the absolute magnitudes as $M_v \approx -9.3^m$ and -10.8^m, which allows us to classify the stars as LBV candidates.

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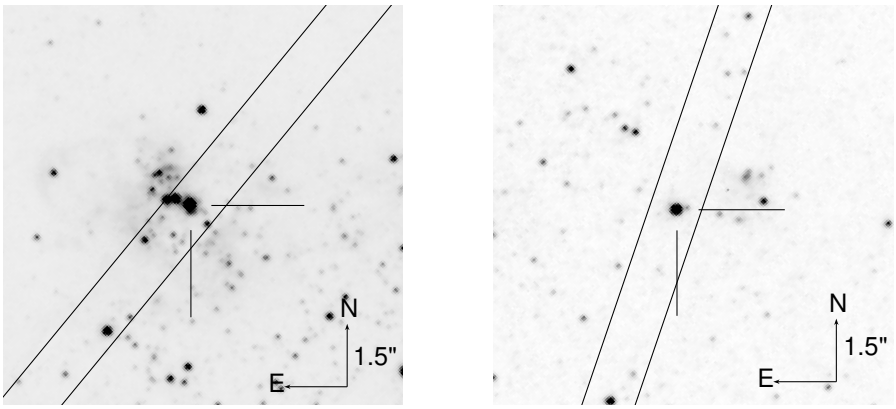

Figure 1: HST images of J034714.85+680857.2 (left) and J034612.42+680445.7 (right) obtained with the ACS/WFC camera in the F606W filter. The 1.2″ slit positions in the BTA/SCORPIO-1 spectroscopy are shown with solid lines.

1. Introduction

LBV stars, originally called Hubble–Sandage objects, were first discovered not in our galaxy but in M31 and M33 by their brightness variability as early as 1926 by Hubble and Sandage [1, 2]. Since then, the search for the objects of this type has not stopped. And despite the great progress in observational methods and instruments, the determining criterion for a star to belong to this class is the variability of its brightness and spectra. LBVs have spectral features that are also characteristic of other types of luminous massive stars, such as B[e] supergiants. Therefore, the detection of such objects, especially in other galaxies, provides a better understanding of the nature and relationships of all the subclasses of luminous stars.

2. Observations and results

The stars J034714.85+680857.2 and J034612.42+680445.7 were identified as massive star candidates using the method described by Tikhonov et al. [3]. Both objects are located near the star forming regions in the massive late-type (Scd) spiral galaxy IC342 beyond the Local Group at a distance of 3.93 Mpc [4]. In Figure 1 we present Hubble Space Telescope (HST) images showing both objects. Their spectral and photometric observations were carried out with the 6-m telescope of SAO RAS (BTA) equipped with the SCORPIO-1 and SCORPIO-2 reducers [5, 6].

The spectra of both stars are very similar (Figure 2) and show numerous FeII emissions (unmarked lines) and the [FeII] and hydrogen Balmer lines with wide wings. Some narrow components of the hydrogen and helium HeI lines as well as the forbidden lines [OIII], [NII], [SII], and some others belong to the nebula around the star forming region.

Several SiII and CrII lines in the **J034714.85+680857.2** spectrum indicate a possibly increased abundance of metals.

We performed aperture photometry of the stars using the HST/ACS archive data in the F435W and F606W filters for 2019/10/12. We converted the obtained values to the standard Johnson–Cousins system using the Pysynphot program: B = 19.90±0.02, V = 19.33±0.02.

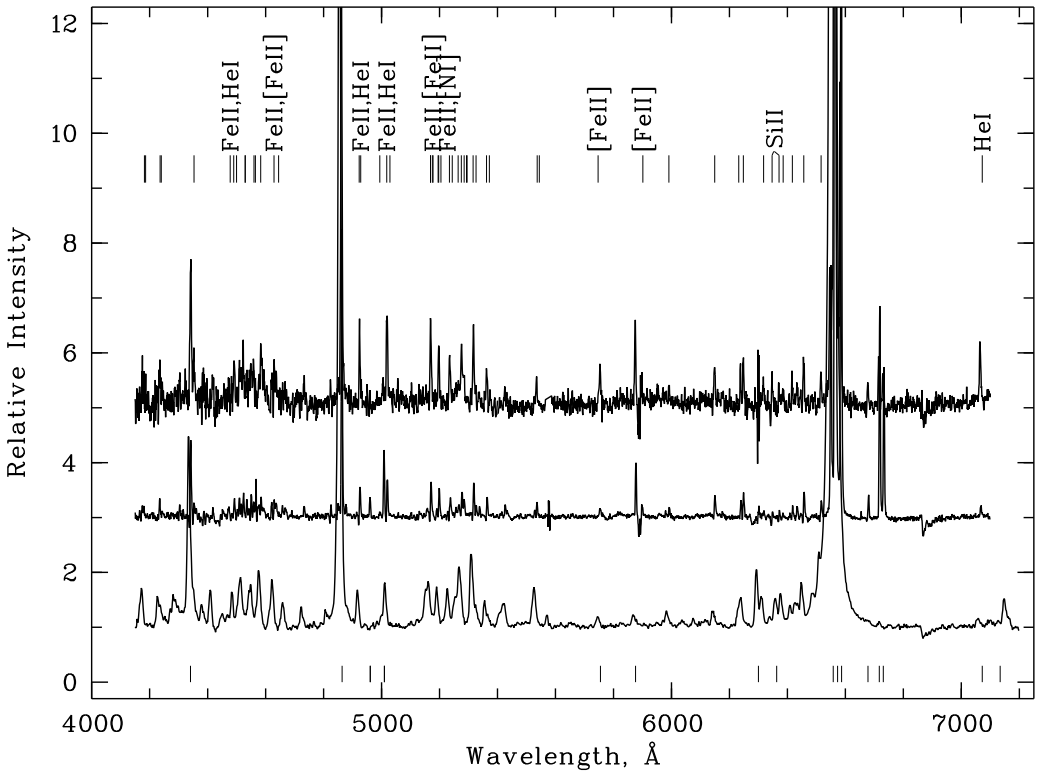

Figure 2: Optical spectra obtained with SCORPIO-2 on 2021/11/04 for J034714.85+680857.2 (top) and on 2021/10/14 for J034612.42+680445.7 (middle); J4415, a B[e] supergiant in the galaxy M31, is shown at the bottom. The narrow lines of the nebula are clearly visible (dashes at the bottom of the spectrum). A large number of the iron FeII (unlabeled lines), HeI, and [FeII] emission lines are also evident.

Using the observed ratios of the Balmer emissions in the spectrum of the nebula around the star, we have estimated the reddening value $A_V = 2.19 \pm 0.15^m$. The reddening-corrected absolute magnitude of the star is $M_V = -9.32 \pm 0.15^m$, the intrinsic color $(B-V)_0 = -0.15 \pm 0.05^m$ corresponds to the spectral class B1–B5 and temperatures of 14000–23000 K.

The HST/ACS photometry (2005/12/18) of **J034612.42+680445.7** was carried out in four filters: F435W = 21.921±0.02, F555W = 21.21±0.02, F658N = 18.65±0.02, and F814W = 19.92±0.015. The magnitudes converted to the Johnson–Cousins system are B = 21.90±0.03, V = 21.14±0.03; A_V measured from the nebula below the object is about 3.5^m.

A large A_V value gives a very blue color (≈-0.5^m), which corresponds to a very high temperature above 40000 K, but the observed spectrum with many FeII lines indicates a lower photosphere temperature. This means that A_V is closer to 2.1 ± 0.1^m (obtained from the nebula above the target). At A_v=2.1±0.1^m the intrinsic color $(B-V)_0 = 0.08 \pm 0.03^m$ corresponds to the spectral class A2–A7 and a photosphere temperature below 9000 K. However, the observed spectrum contains HeI lines with P Cyg profiles, which indicates their formation in the stellar wind of the object. Thus, the temperature cannot be lower than 12000 K (spectral class B7). For a B7 star the unreddened color is $(B-V)_0 = -0.04^m$. From here we get a minimum A_V estimate of about 2.5^m. We plotted the spectral energy distribution based on the spectrum and HST photometry. As a result of the SED

fitting by the blackbody model, the following parameters of the star were obtained: $A_v \approx 2.5^m$, a photosphere temperature of 12000 K, $M_V \approx 10.8$.

3. Discussion

The spectral and photometric variability of J034714.85+680857.2 and J034612.42+680445.7 have not been detected, which does not allow them to be classified as LBVs. In Figure 2 we compare the spectra of both stars with the B[e] supergiant J4415 in the galaxy M31, studied earlier [7]. The spectra are very similar. The estimates of $M_v \approx -9.3^m$ and 10.82 ± 0.15 allows us to classify the stars as LBVs or B[e] supergiants. Based on their spectral features, absolute magnitudes, and temperatures, we can assume that these two objects in IC342 are B[e] supergiants. Unfortunately, we do not have infrared photometry for these stars that would help classify them unambiguously, so for now we leave their status as LBV candidates.

4. Acknowledgements

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