Search for Massive Stars in NGC 4449

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Abstract. We present a study of three new LBV candidates from the NGC 4449 galaxy. Their absolute magnitudes are brighter than -8^m . Preliminary estimates of the photosphere temperatures and bolometric luminosities were obtained for all three objects.

Keywords: stars: emission lines, Be; stars: variables: S Doradus; stars: massive; galaxies: individual: NGC 4449 DOI:10.26119/978-5-6045062-0-2_2020_100

Luminous blue variables (LBVs) are the brightest $(> 10^5 L_{\odot})$ massive $(M \ge 25 M_{\odot})$, Humphreys et al. (2016)) stars, characterized by noticeable spectral and photometric variability. We present a study of new LBV candidates J122810.94+ 440540.6 $(V = 19.43 \pm 0.03^m)$, J122811.70+440550.9 $(V = 20.26 \pm 0.03^m)$ and J122809.72+440514.8 $(V = 17.94 \pm 0.03^m)$ from NGC 4449 (D = 4.27 Mpc), Tully et al. (2013)).

The spectra of the objects were obtained with 6-m Russian telescope in 2014-2020 (Fig. 1). The observed spectral lines of candidates are typical for confirmed LBVs. The notable features in the spectra are the numerous emission lines Fe II and [Fe II], He I and also broad components of hydrogen lines, which indicate the range of the photosphere temperatures of about $T_{phot} = 10000 - 20000$ K. A more accurate estimate of the photosphere temperatures will be obtained from the analysis of the spectral energy distributions of the studied objects.

The emission lines He I and Fe II, in 122809.72+440514.8 spectrum have P Cyg-type profiles. This object demonstrated some spectral variability from 2015 to 2020 (Fig. 1, left). The wings of the hydrogen lines H β , H γ broadened noticeably, while the [Fe II] (λ 5157) and Fe II (λ 5169) lines became brighter in

the spectrum obtained in 2020. However, the emission lines of iron Fe II and [Fe II] $\lambda\lambda$ 4500 - 4700 and $\lambda\lambda$ 5200 - 5400 weakened in the spectrum of 2020 relative to the spectra obtained in 2015 and 2018.



Fig. 1. Left: Spectra of J122810.94+440540.6 (top), J122811.70+440550.9 (bottom). Right: Blue spectra of J122809.72+440514.8 obtained in 2015 (top), 2018 (middle) and 2020 (bottom). Short and long unlabelled ticks designate the [Fe II] and Fe II lines, respectively. Blue ticks designate $H\delta$, $H\gamma$, and $H\beta$ lines.

J122809.72+440514.8 showed a photometric variability $\Delta V = 0.54 \pm 0.09^m$ from 2005 (Hubble Space Telescope) to 2020 (2.5-m telescope SAI MSU). The other two objects did not reveal significant variability. We estimated the interstellar absorption as $A_V = 0.2 \pm 0.2^m$ (J122810.94+440540.6), 0.3 ± 0.2^m (J122811.70+440550.9) and 0.8 ± 0.2^m (J122809.72+440514.8) using the hydrogen lines of the surrounding nebulae. The estimates of absolute and bolometric magnitudes were obtained, as well as estimates of bolometric luminosities.

Star	A_V, m	M_V, m	$M_{\rm bol}, ^m$	$\log(L_{\rm bol}/L_{\odot})$
J122810.94+440540.6	0.2 ± 0.2	-8.9 ± 0.2	-10.0 ± 0.9	$5.9^{+0.4}_{-0.3}$
J122811.70+440550.9	0.3 ± 0.2	-8.0 ± 0.2	-9.2 ± 0.9	$5.6^{+0.4}_{-0.3}$
J122809.72+440514.8	0.8 ± 0.2	-11.0 ± 0.2	-12.0 ± 0.9	$6.7^{+0.4}_{-0.3}$

Table 1. Parameters of the studied stars.

Acknowledgements. The reported study was funded by RFBR according to the research project N 19-52-18007.

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