Hot stars toward the Galactic Bulge – photometric study from UV to IR

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As a part of optical multiband study of stellar populations toward the Galactic Bulge we selected hot objects in the extremely crowded fields. In this work, we present a search for white dwarfs and hot subdwarfs. The results base on our observations (using CTIO-1m telescope) and publicly available databases of projects such as OGLE-III, VPHAS+ and VVV. Parameters of stars were estimated using extinction-corrected multicolor photometry and proper motions.

1 Introduction

A study of the inner part of the Galaxy encounters several significant limitations caused by complex nature of this region. Inside the observed field we can see a mixture of stellar populations located in: solar neighborhood, Galactic disk, halo and Galactic Bulge. Furthermore, for very crowded fields we can expect some technical problems, e.g.: severe contamination of unresolved sources, significant but unknown effects of variability on colours when measured at different time. Reliable estimation of physical properties of particular object requires distance and interstellar extinction measurements.

In this part of the Galaxy relatively large and spatially variable extinction is highly correlated with distance. At least, in some cases, an independent estimation of extinction is possible when many photometric colours and corresponding reddening relations are available. Our research is focused on hot objects, therefore reasonable measurements of U-band magnitudes are crucial.

2 The data

In the first attempt we performed a pilot project with the aim to observe at CTIO-1m telescope equipped with the 4K $\times$ 4K CCD ($20' \times 20'$ field-of-view, 1 of 4 converters was damaged) that has the enhanced blue sensitivity, especially at U-band, and the set of standard Johnson-Cousins filters. During 10 nights we observed 20 fields in four bands: U (exposure time: 1500 s), B (400 s), V (250 s) and I (150 s). In addition to detections of 45 hot objects we obtained standard photometry for most of our fields based on their observations along with the nearest standard field (Paczyński et al., 1999) made during selected photometric nights.

A precise multi-colour photometry of extremely crowded fields toward the Galactic Bulge is now available due to modern wide-field surveys. They cover the whole optical, VPHAS+ (Drew et al., 2014), OGLE-III (Szymański et al., 2011), and near-infrared VVV (Minniti et al., 2010) wavelenghts with wide range of magnitudes and high angular resolution. Combination of all measurements allowed us to detect

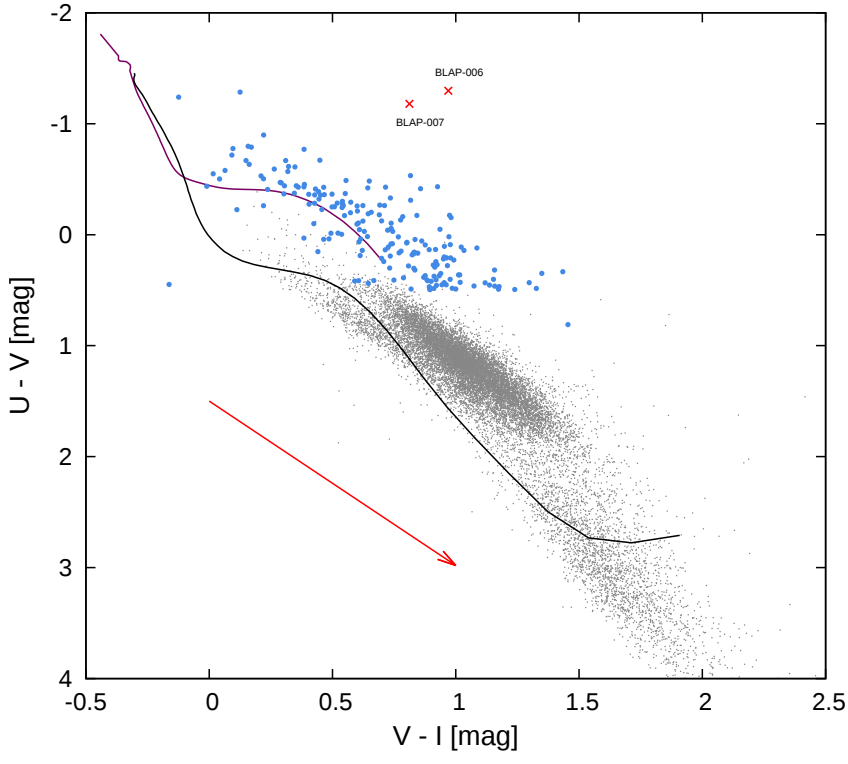

Fig. 1: Color-color diagram toward the Galactic Bulge. Above 16 000 small gray points (error for each color is $U-B/B-V/V-I < 0^{\mathrm{m}}.02$) indicate stars observed by the CTIO-1m telescope in 2007. The blue dots (error for each color is $U-V/V-I < 0^{\mathrm{m}}.08$) mark 190 candidates for hot objects. They have been found in combined databases of VPHAS+ ($u_{\mathrm{SDSS}} \rightarrow U$) and OGLE-III ($V$, I). Two red crosses present positions of BLAPs. The black line represents the unreddened main sequence. The violet curve shows the unreddened sequence of white dwarfs with $\log g = 8.00$ (Koester, 2010). The red arrow indicates reddening $E(U-V)/E(V-I) = 1.48$ calculated using $E(U-B)/E(B-V) = 0.85$ (Bruś & Kołaczkowski, 2014) and $E(V-I)/E(B-V) = 1.25$ (Udalski, 2003).

and characterize some of the rare objects: white dwarfs, hot subdwarfs and very rare, e.g.: blue large-amplitude pulsators (BLAPs) (Pietrukowicz et al., 2017), blue stragglers and extremely metal-poor stars.

3 Analysis and results

After careful selection of the hot stars and the reddening/extinction estimation (see Fig. 1) we performed analysis of their spectral energy distribution (SED) with VOSA web application (Bayo et al., 2008). In some interesting cases, SEDs indicated very high temperatures and the compact nature of the sources.

An independent approach can be useful in our study, because we can expect larger proper motions for nearby objects. In this way we can distinguish between white dwarfs and more luminous objects. We estimated proper motions for stars

with positions measured in the Gaia-DR1 catalogue and OGLE-III survey. As the result, we selected good candidates for hot white dwarfs. More precise measurements from Gaia mission in the near future will help to determine what is the nature of stars selected in this work.

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