New LBV stars in the Andromeda galaxy

S. Fabrika[1], O. Sholukhova[1], A. Sarkisian[1], D. Bizyaev[2]

[1] Special Astrophysical Observatory, Nizhnij Arkhyz, Russia,
[2] Apache Point Observatory and New Mexico State University, USA

We performed near-infrared and optical spectroscopy of five Luminous Blue Variable (LBV) candidates and two known LBV stars in M31. We use a new approach to the LBV parameters estimation based on the inherent property of LBVs to change their spectral type at constant bolometric luminosity. Two LBV candidates have to be classified as new LBV stars. Two more candidates are, apparently, B[e]-supergiants. Using spectral energy distributions and variability of the stars we estimate their temperatures, reddening, radii, and luminosities.

LBV stars are crucial clue for massive stars evolution. It is especially important to select such stars in nearby (Local Group) galaxies, because we may study the whole massive star population with known metallicity and distance. There are four established LBVs in the Andromeda galaxy (Humphreys, Davidson, 1994), however, one may expect at least dozens of such stars in this galaxy. In fundamental papers by P. Massey with colleagues a survey was presented for selection of new LBV candidates. The number of known and suspected LBVs was 24 in M31 (Massey et al., 2007).

Using this list we have performed the same-epoch near-infrared and optical spectroscopy (Sholukhova et al., 2015) of five LBV candidates and two known LBV stars in M31. Using these spectra we develop a new method of SED fitting applicable for LBV stars. It breaks a well-known reddening - temperature degeneracy by an assumption that the bolometric luminosity stays constant while the optical V-brightness may vary significantly. This is an inherent property of LBVs to change their spectral type keeping its bolometric luminosity constant. Using the known V-magnitudes, the preliminary estimates of the reddening (from surrounding nebulae), and the stellar temperatures (from spectra) we may more precisely calculate the reddening and the temperatures for different states of LBVs. Our approach is successfully verified with two known LBVs in M31: Var A-1 and AE And (Fig. 1). However three out of seven stars did not show the LBV-like variability. The table shows stellar parameters derived from the SEDs.

Stellar parameters estimated from our SEDs. The photosphere temperature range were preliminary estimated from spectra. The best-fit temperature, the reddening, the stellar radius in the solar units, the V-band and bolometric absolute magnitudes are presented.

Object	Name	T_{sp}, K	T, K	A_v	M_v	M_{bol}	R(Ro)
J004302.52+414912.4	AE And	15000... 20000	18000	0.96±0.2	-8.9	-10.7	100
J004450.54+413037.7	VarA-1	20000... 27000	25000	1.7±0.15	-9.3	-11.5	90
J004051.59+403303.0		18000 24000	22000	1.5±0.1	-9.0	-10.9	90
J004526.62+415006.3		10000... 15000	12000	1.3±0.1	-9.4	-10.0	200
J004350.50+414611.4		10000... 15000	13000	2.0±0.2	-8.7	-9.4	130
J004417.10+411928.0		15000... 20000	18000	0.9±0.2	-8.1	-9.6	70
J004444.52+412804.0		18000. 22000	20000	3.8±0.1	-10.0	-11.7	150

We find that two stars, J004051.59 and J004526.62 do show the typical LBV variability, 0.5 and 1.0 mag respectively. In the JHK diagram (Fig. 2) they are located in the LBV region. The star J004350.50 has shown a small variability (0.16 mag), however it is also located in the LBV region. Its nature is unclear yet. Two more stars J004417.10 and J004444.5 we classify as B[e]-supergiants. They have a typical for such stars excess in the JHK bands (Fig. 1 and 2). Nevertheless, the both stars indicated variability (0.15 and 0.30 mag respectively), and J004417.10 has even shown a spectral variability (Sholukhova et al., 2015).

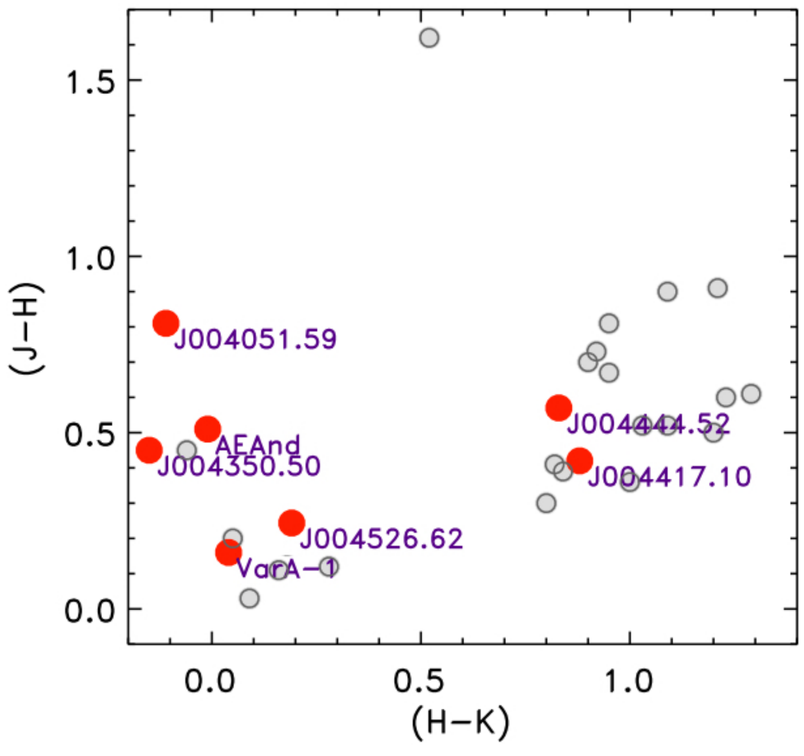

Fig. 2. The JHK diagram taken from (Kraus et al., 2014) with our stars indicated by red circles. We confirm that the LBV and B[e]-supergiant stars are disposed separately in the diagram which indicates a stronger dust emission surrounding B[e]-supergiants.

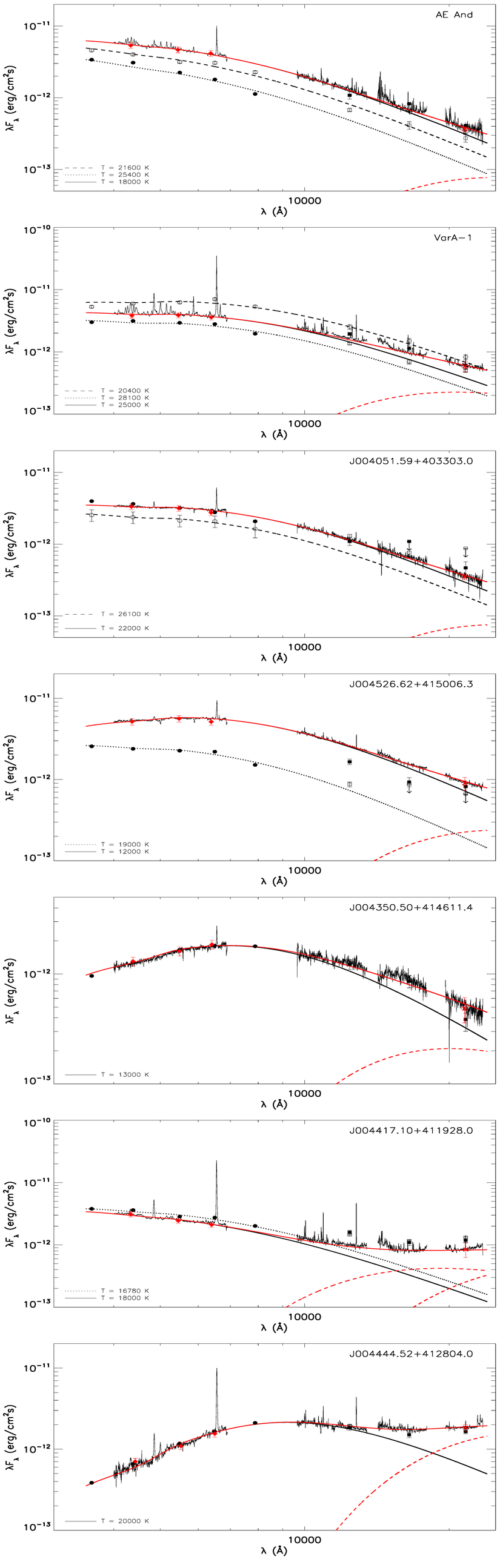

Fig. 1.The spectral energy distributions with models. The optical and near-infrared spectra are shown with corresponding photometry (red diamonds). Filled symbols are the optical data by (Massey et al., 2006) and the JHK data from 2MASS. Open symbols are the data from (Humphreys et al., 1984) and (Berkhuijsen, 1988). The curves show the black body approximation with reddening applied. The red dashed curves mark the dust approximation. The best-fit temperatures are indicated.

References:

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