Peculiar Early-Type Supergiants and LBVs: Resemblance and Difference

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Miroshnichenko, A.S., 1997. Proc. of the Conference ``Luminous Blue Variables: Massive Stars in Transition", A. Nota & H. Lamers (eds.) ASP Conf. Ser. 120, 202. Peculiar early-type supergiants and LBVs: resemblance and difference

Article:

Peculiar early-type supergiants (hereafter PETS) have been distinguished from normal ones because of stronger emission lines in their spectra. This is a result of different stellar wing kinematics: PETS have slower winds with low terminal velocities – nearly 10 times smaller than those of normal supergiants. All of them are massive stars and undergo different episodes of post-main-sequence evolution probably related to an evolutionary sequence – Of, Ofpe/WN(, LBVs B[e]. There is a certain lack of well-studied objects and absence of a list of targets belonging to the types mentioned above. New PETS candidates can be found in a catalog by Wackerling (1970) containing the majority of emission-line early-type stars in the Galaxy, lists containing galactic PETS and related sources by Allen & Swings (1976), Carlson & Henize (1979), Miroshnichenko et al. (1995) Similar objects from the Magellanic Clouds have been studied by Zickgraf et al. (1986), Nota et al. (1996), etc. A catalog of Herbig Ae/Be stellar group objects compiled by Thé et al. (1994) contains galactic stars displaying observational properties of pre-main-sequence intermediate- and high-mass stars. Certainly not all of them are related to the evolutionary sequence from Of to B[e] stars. It has been suggested that some objects are planetary nebulae (like HD 51585), probable binary systems with a cool companion (e.g., MWC 84, HDE 327083), or young Herbig Ae/Be stars (He3-40, HD 45677). Our experience shows that extended observations by different techniques even obtained in short time interval allow us to put reasonable constraints on an object's parameters. Here we show an example with MWC 314, an object from the Allen & Swings (1976) list.

MWC 314 = BD +14°3887 = IRAS 19192 + 1447 – is a 10^m star with strong emission-line spectrum of low ionized species (H I, He I, Fe II) on top of very red continuum (B – V ~ $1^m.6$). Its dereddned SED and Balmer emission line strengths are very close to those of P Cyg. In 1990-1996 we obtained nearly 50 U BV RI and U BV RI J H K photometric observations of MWC 314 with 1-meter telescopes near Almaty (Kazakhstan) as well as several medium-resolution optical spectra with the 6-meter Russian telescope at Northern Caucasus. Interpretation of the Balmer line profiles with a non-LTE radiative transfer code and the SED between 0.25 and 25 μm led to a conclusion that the star is a high-luminosity early-B supergiant with a mass loss rate of about 3 10^{-5} M⊙ yr^{-1} and a terminal velocity of v_∞ = 500 km s^{-1}. We estimate stellar parameters as follows: log L/L⊙ = 6.2, T_* = 30000 K, R_* = 50R⊙ , which yield an initial mass of about 80 M⊙ (Miroshnichenko 1996). Its position in the evolutionary tracks (Maeder & Meynet 1988) is very close to the LBV phase, and we suggest that the object can be considered as an LBV candidate.

Analysis of the PETS emission-line profiles shows that velocity laws in their slow winds are different (Pauldrach & Puls 1990, Rivinius et al. 1966, Zickgraf et al. 1996). Usually the well-known "β-velocity law" is used to model them. Despite a few objects have been modeled so far one can mention that for the stars without circumstellar dust or having only cool dust β values are less than 2, while for the stars containing both hot and cool dust β is about 4. In other words, winds with slower acceleration can give rise to dust formation. An analogy with this process in classical Novae can be found: only slow Novae (i.e. with slow brightness decline after maximum) exhibit deep minima in their light-curves identified with dust shell formation.

Modeling of the IR-excess has been done for a few PETS without circumstellar dust (P Cyg, MWC 314) and shows an agreement with results of line profile modeling. Dusty envelopes of B[e] stars have not been modeled yet. Mid-IR spectra of the brightest objects (MWC 300, MWC 349, CPD -42°11721, CPD -52°9243) do not show presence of the silicate features at 10 and 18 μm. It can be a result of either moderate optical depth of the envelope or silicate depletion in the ejected matter. The main problem for the galactic ones is to disentangle interstellar and circumstellar extinction. Recently Miroshnichenko, Ivezić & Elitzur (1997) showed how to distinguish between these two components by SED modeling in the range of 0.3-100 μm for some Herbig Ae/Be stars. We plan to apply this procedure to galactic B[e] stars in the nearest future.

From the above analysis we are able to give some recommendations to search for new LBV candidates. They should have strong and narrow Balmer emission lines, other emission lines of only low-ionized species, near-IR excess connected with free-free radiation only. Far-IR excess can be observed if a star has already experienced LBV-type outbursts. We would suggest to search for the latters among stars with strong Hα emission in the lists of northern and southern luminous stars (LS and LSS).

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