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Galactic B[e] Stars: A Review of 30 Years of Investigation

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Abstract. I will review major studies of B[e] stars as a group as well as those of individual members. I will discuss observational properties of different subgroups of B[e] stars and update membership in them. Comparison with other groups of emission-line stars will be made, and sources for enlarging the group will be discussed. Current problems in analysis of the observational data will be suggested. The list of the most unstudied B[e] stars will be presented. I will try to highlight the role of B[e] stars in studies of the stellar evolution.

1. Introduction

B[e] stars (also known as peculiar Be stars) were selected as emission-line B-type stars with large IR excesses due to hot CS dust and optical spectra that contain forbidden emission lines (e.g., [O I], [N II], and sometimes [O III]) in addition to the Balmer and Fe II lines (Allen & Swings 1976). The discoverers found that the group defining features are characteristic of a broad range of object from Be stars to Planetary Nebulae (PNe). They suggested three mechanisms to explain the circumstellar (CS) shell formation: "formation of PNe as a single event, interaction of an OB star with a late-type companion and direct ejection from a particularly massive Be or Oe star".

It has been confirmed that all the proposed mechanisms work: 13 PNe, 6 symbiotic binaries, and 7 supergiants (including 1 Luminous Blue Variable, LBV, η Car) are among the group objects. Pre-main-sequence Herbig Ae/Be (HAeBe) stars were not supposed to be part of the group, but later it was found that 7 B[e] stars were at that stage of evolution. The remaining half of the group has not been associated with certain stellar groups or evolutionary stages until recently. B[e] stars were mostly studied as individual objects and not as a group, most likely due to the initially suggested heterogeneity. Summarizing the first 20 years of research, Lamers et al. (1998) recognized 5 subgroups of B[e] objects: pre-main-sequence HAeB[e], symbiotic binaries (a cool giant and a white dwarf or a neutron star, symbB[e]), compact Proto-Planetary Nebulae (PPNe)/Planetary Nebulae (cPNB[e]), supergiant (sgB[e]), and unclassified (unclB[e]). These authors concluded that the B[e] phenomenon is associated with objects at very different evolutionary stages, but with similar conditions in their extended gaseous and dusty envelopes. However, the nature and evolutionary state of the unclB[e] stars has not been revealed.

Relative faintness of the group members (most of them have visual brightnesses below V=10 mag), sparseness of the observational data, their variable behavior and complex properties are among the main reasons for the slow progress in understanding B[e] stars. The situation has changed when the IR properties of B[e] stars were analyzed (see Miroshnichenko et al. 2002a, for a brief review). Below I will review the major milestones in investigation of B[e] stars over the 30 years since their discovery.

2. Observational Studies

The discovery of B[e] stars occurred a few years after detecting IR excesses in hot stars (Geisel 1970). It was shown that the strongest excesses are due to CS dust that existed near mostly emission-line stars (e.g., HAeBe and Wolf-Rayet stars). Weaker excesses, such as those of Be stars, were attributed to CS gas, also responsible for the line emission. These findings were based on a number of near-IR surveys that were conducted during the 1970's (e.g., Allen, Swings, & Harvey 1972; Cohen 1973; Gehrz, Hackwell, & Jones 1974). The survey by Allen & Swings (1976) was among these pioneering studies. It resulted in finding of a distinct group of objects (B[e] stars), in which forbidden emission lines co-existed with clear signatures of hot dust, but the group has not received as much attention as the other mentioned emission-line hot stars most likely because of its heterogeneity. During the first decade after their discovery, B[e] stars were mostly studied by the Liège group (e.g., Swings 1981; Gosset et al. 1985) or as members of other lists of objects. Moreover, only the brightest or those with the most noticeable features, such as a very strong line emission or a very high IR brightness (e.g., HD 45677 and MWC 349) were observed.

The IR all-sky survey accomplished by the IRAS satellite in 1983 brought us a completely new view of the CS dust. Many objects were found to have dusty envelopes, including the discovery of Vega-type stars (Aumann 1985) and a large number of optically-bright PPNe (e.g., van der Veen, Habing, & Geballe 1989). Although IRAS detected all B[e] stars (44 out of the 65 objects were detected even at 60 μm), these data have not inspired their further studies. Even the discovery of the B[e] supergiants in the Magellanic Clouds (Zickgraf et al. 1985) have not triggered more interest to B[e] stars in the community.

A color-color diagram with the IRAS data for B[e] stars is shown in Fig. 1. A striking feature of this diagram is that a number of unclB[e] stars (within the dash-lined box) with no evidence for cool companions are characterized by a steep flux decrease toward longer wavelengths that corresponds to a lack of dust with temperatures above 150–200 K. Such an IR spectral energy distribution (SED) is unusual for hot stars that emit enough UV photons to warm even distant CS dust and indicate that the dusty envelopes are compact. These feature was noticed only over a decade after the IRAS mission by Sheikina, Miroshnichenko, & Corporon (2000).

In 1996 the MSX satellite, which made a survey of the galactic plane ($|b| \leq 5^{\circ}$) in 6 IR bands, centered at wavelengths between 4 and 21 μm, and a sensitivity, similar to that of IRAS, detected 52 original B[e] stars (Egan et al. 2003). The MSX fluxes turned out to be very similar to those of IRAS at close wavelengths, thus indicating no significant changes in the dusty component parameters over the 13 years between the surveys. The MSX color-color diagrams are not that impressive as that of the IRAS colors because of a narrower range of the MSX

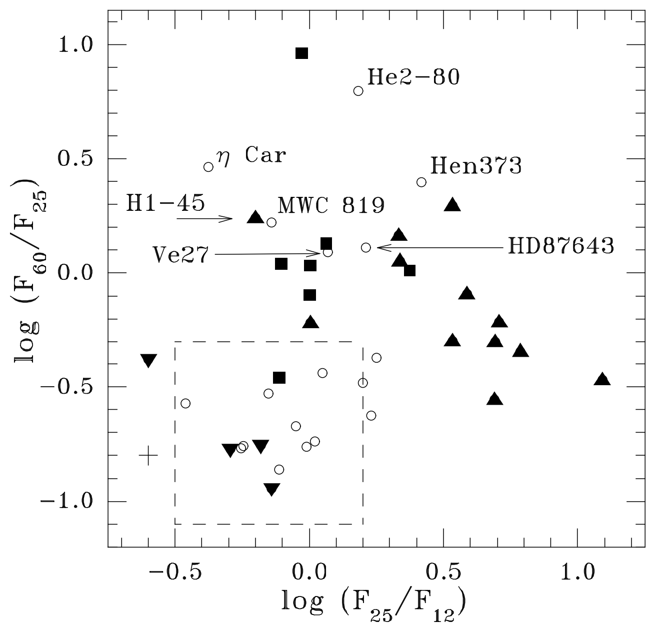

Figure 1. The IRAS color–color diagram for B[e] stars. Symbols: symbB[e] – downward triangles, HAeB[e] – squares, cPNB[e] – upward triangles, sgB[e] and unclB[e] – open circles. The large cross indicates the photospheric locus. The dash-lined box marks the most probable location of the B[e] stars with warm dust (from Miroshnichenko et al. 2002a). A few unusually located objects are marked.

wavelength coverage, which also coincide with the flat part of the SED of most B[e] stars.

I would like to mention several studies, focused on unclB[e] stars, that were important in my opinion. Zickgraf & Schulte-Ladbeck (1989) obtained broad-band optical polarization measurements of 8 objects, found the intrinsic component in 5 of them, and concluded that the CS geometry is most likely non-spherical and the dominating polarizing mechanism can be scattering on either CS gas (in MWC 645 and MWC 939) or dust (in MWC 342 and MWC 623). On the other hand, their data showed that polarization in systems with CS dusty disks, such as MWC 300 and MWC 922, followed the interstellar (IS) law. Zickgraf & Stahl (1989) obtained high-resolution optical spectroscopy of MWC 623 and revealed the presence of a K-type secondary. Later, with more observations, Zickgraf (2001) confirmed that the binary consists of a B4 III and a K2 Ib–II star and showed no radial velocity variations. The latter is probably an indication of a pole-on orientation of the system with respect to the line of sight.

During the 1990's, C. and M. Jaschek with Y. Andrillat published the results of a medium-resolution optical spectroscopy of 8 unclB[e] stars (HD 51585, HD 45677, HD 50138, CI Cam, MWC 17, MWC 342, MWC 349 A, and MWC 645 in separate papers). They identified hundreds of spectral lines in the spectrum of each object and tried to determine the stellar parameters and distances toward them. In most cases photospheric lines were not detected that emphasized the importance of high-resolution observations. Oudmaijer & Drew (1999) obtained spectropolarimetric observations in the Hα line of a sample of HAeBe and B[e] stars and found that all the B[e] stars showed polarization changes across the line that is indicative of dense equatorial CS disks. Cidale, Zorec, & Tringaniello (2001) observed 10 unclB[e] stars spectrophotometrically in the blue region and determined the objects' fundamental parameters (temperatures, luminosities, and surface gravities) from analysis of their Balmer jumps. Zickgraf (2003) presented high-resolution spectroscopy of 18 B[e] stars near a few permitted (e.g., Hα) and forbidden (e.g., [O I] 6300 and 6363 Å) emission lines as well as near the Na D-lines and modeled the forbidden line profiles, thus developing a diagnostics of the parameters and geometry of the CS gaseous and dusty envelopes.

The author of this review has been involved in studies of specifically unclB[e] stars since mid-1980's. Our group at Pulkovo Observatory obtained simultaneous multicolor ($UBVRIJHK$) photometric observations of 10 such objects in 1986–1994 and published a catalog of 228 observations (Bergner et al. 1995). Combined photometric and spectroscopic data were analyzed for a few objects (e.g., Miroshnichenko & Corporon 1999). These studies always showed signs of binarity, such as quasi-periodic photometric or radial velocity variations. Finally, the unusual grouping of some unclB[e] stars in the IRAS color-color diagram (see Fig. 1) was noticed, and our later investigation had been devoted to a deeper analysis of these objects, which were tentatively called B[e] stars with warm dust (B[e]WD). Ten papers on B[e]WD were published in 2000–2005, including a series of 5 papers on galactic sgB[e] that are considered a part of the B[e]WD group. The new B[e] binary systems have been discovered as a result of these efforts. A more detailed discussion of the properties of B[e]WD is given in Miroshnichenko et al. (2006).

Since most B[e] stars are relatively faint (only a few are brighter than V=10 mag), their high-resolution observations require large telescopes and sensitive detectors. This is still difficult to get observing time at such facilities to monitor the objects frequently. Recently three papers that reported low-resolution spectroscopy of early-type emission-line stars, including some B[e] objects have been published. Pereira, Franco, & Araújo (2003) observed 33 objects from the list of Sanduleak & Stephenson (1973) with 8 B[e] stars among others; Pereira, Landaberry, & Araújo (2003) obtained spectra of Hen 1191 and Hen 2–79; and Gauba et al. (2003) obtained a spectrum of MWC 939. These are interesting and important surveys that record snapshots of generally variable B[e] stars and may add some faint new candidates to the group. On the other hand, since such spectra detect only the strongest emission lines and absorption features (e.g., diffuse interstellar bands and the Na D-lines) and a fraction of the spectra have low signal-to-noise ratios, conclusions on the objects' nature and evolutionary state are weakly supported.

In summary, the observational studies showed that B[e] stars are complicated objects, whose understanding could be achieved through obtaining multitechnique high-quality data. The group is one of only 8 groups of stars with a hot stellar companion that have CS dust. These include HAeBe and Vega-type stars with protostellar dust, symbiotic and VV Cep binaries with the cool companion that dominates the spectrum at optical/IR wavelengths and is responsible for dust formation, PPNe/PNe with dust formed at the previous, AGB evolutionary stage, WR stars and LBVs with powerful winds that seem to be dense enough to allow dust formation, and unclB[e] stars. The latter seems to be the only group with no understanding of both the mass loss and dust formation mechanisms.

3. Other Sources of Galactic B[e] Stars

Obviously, Allen & Swings (1976) caught only the tip of the iceberg. They surveyed the brightest objects or those with the strongest line emission. Additionally, the near-IR brightness threshold ($K \sim 8$ mag) was good at the time, but not deep enough for a more complete search. Nevertheless, there were no direct attempts to expand the list of galactic B[e] stars and only a few papers turned out to contain new candidates to the group.

Carlson & Henize (1979) presented a list of 20 southern stars with strong line emission in the optical region. It partially overlapped with the original list of B[e] stars (2 common objects, CPD$-52°$9243 and GG Car). Also, one object (HDE 327083) was later shown to be a binary sgB[e] (Miroshnichenko et al. 2003). An important list was published by Dong & Hu (1991), who positionally cross-correlated the catalog of galactic early-type emission-line stars by Wackerling (1970) and the IRAS Point Source Catalog (PSC, IPAC 1986). These authors found nearly 200 objects with strong IR excesses ($V - [25] \geq 8$ mag, where [25] is the magnitude in the IRAS band centered at 25 μm). The list included 12 original B[e] stars (η Car, RY Sct, CI Cam, HD 45677, HD 50138, HD 87643, MWC 342, MWC 623, MWC 645, MWC 922, AS 222, and AS 225); 5 objects, which were later identified as B[e]WD (AS 78, AS 381, Hen 3–298, Hen 3–303, and MWC 657, Miroshnichenko et al. 2002a); and 2 objects I consider B[e]WD (Hen 3–847 and AS 119). On the other hand, a large number of optical sources ($\sim$30%) were identified incorrectly due to a low positional accuracy of the IRAS PSC ($\sim$10–30 arcsec). It can easily be shown using recently released all-sky data catalogs (e.g., USNO–B1.0 and 2MASS) with a much higher astrometric accuracy ($\sim$1–2 arcsec).

In any case, these studies showed that the B[e] group is larger than just the original list by Allen & Swings (1976). The objects found in these papers as well as the original unclB[e] stars were included in the catalog of the Herbig Ae/Be stellar group by Thé, de Winter, & Peréz (1994), whose analysis of available observations resulted in a conclusion that no set of observational data could separate young and evolved objects with CS dust. This conclusion has not yet been proven wrong. Since most unclB[e] stars have been shown to be relatively evolved (at least not at the pre-main-sequence evolutionary stage), they are good candidates for a careful comparison with HAeBe to search for such separation criteria.

4. Theoretical Studies

There have not been many attempts to study B[e] stars theoretically. Partially it was due to the fact that half of the group belonged to already studied types of object (see Sect. 6.). Also, most of the published theoretical or modeling papers were devoted to sgB[e], which are better understood.

I will quote just 4 papers specifically devoted to interpretation of the properties of luminous B[e] stars. For the first conference on B[e] stars, Bjorkman (1998) modeled the SED of the LMC sgB[e] R 126 and showed that its wind can be dense enough to produce dust. Stee (1998) studied the behavior of CS disks and concluded that photospheric lines cannot be detected in the optical spectra of sgB[e] with mass loss rates above 10^{-5} M$_\odot$ yr^{-1} due to the CS continuum veiling. Kraus & Lamers (2003) studied the ionization structure of dense CS disks and suggested that neutral gas can be close to the stellar surface, therefore making dust formation possible as the matter density is high in the inner parts of the disk. Finally, Porter (2003) investigated 2 different models of the sgB[e] disks (an equatorial wind model produced by wind bi-stability, and a Keplerian viscous disk model). He found that both models could account for dust formation, but they both significantly underestimate the dust continuum. The problem can be reconciled by making the radial density profiles less steep than in the original physical models.

This brief review shows that our understanding of even the most luminous B[e] stars, which may naturally develop strong winds, is still far from satisfactory. Lower luminosity unclB[e] stars have not been approached from the theoretical end. However, the discussions at this conference show that binaries may play an important role in future exploration of their nature and evolutionary state.

5. Important Recent Discoveries

New technology and sometimes the nature itself give us opportunities to unveil mysteries that we are trying to investigate. Two important results on B[e] stars have been obtained since the first conference in 1997.

On the night of April 1st, 1998, the unclB[e] star CI Cam exhibited an all-wavelength outburst that was interpreted as an explosion in a binary system with a degenerate companion (e.g., Frontera et al. 1998). The nature of the secondary is still under debate. Due to the detection of a strong γ-ray flux, it was suggested to be a neutron star or even a black hole (Robinson, Ivans, & Welsh 2002). However, recently Barsukova et al. (2006) found periodical radial velocity variations of the emission line of He II 4686 Å with a period of 19.4 days and suggested that the secondary is rather a white dwarf. The distance toward the object is not known well. Robinson, Ivans, & Welsh (2002) suggested that it is larger than 5 kpc, while Miroshnichenko et al. (2002b) argued for less than 3 kpc. Despite these uncertainties, it is clear that the nature of the object was well hidden and would not be revealed if not the detected outburst. This justifies the importance of monitoring programs for B[e] stars.

The second important result obtained for a B[e] object was Keck observations of the dusty envelope of RY Sct (Gehrz et al. 2001). RY Sct is a β Lyr type eclipsing binary with an orbital period of 11.1 days that is located at a distance of 1.8 kpc. Its dusty disk was resolved for the first time at 6 IR wavelengths from 3.8 to 18.7 μm. A careful modeling of these data was done by (Men'shchikov & Miroshnichenko 2005, see also this volume for a brief description of this work). It was shown that the dust formation rate is not very high ($\sim 10^{-7}$ M$_\odot$ yr^{-1}) that implies an accumulation of dust in the circumbinary area. More importantly, since the IR excess of RY Sct is among the smallest of those in B[e] stars, this suggests that the CS dust could be formed at higher rates near the low-luminosity objects. Also, the successful detection of the disk around such a distant object suggests that dusty structures around closer ones (e.g., HD 45677 and HD 50138) could be resolved as well.

6. Subgroups of B[e] Stars

Lamers et al. (1998) separated B[e] stars into 5 subgroups, whose content will be reviewed here taking into account new results and my own opinion.

HAeB[e]. Allen & Swings (1976) did not intend to include young stars in their list, because it was realized that they had extended protostellar envelopes, in which both forbidden line emission and pre-existing dust could naturally coexist. However, it was found later that pre-main-sequence stars might show weak nebulae, which were not discovered before the search for B[e] stars. Some objects with easily recognizable nebulae were classified as young stars later. Currently, with some uncertainty, we can classify 6 objects from the original B[e] list as HAeB[e]: HD 31648, HD 163296, HD 190073, LkHα 101, MWC 137, Hen 3–938. Studies of forbidden emission lines in pre-main-sequence stars (e.g., Böhm & Catala 1994; Acke, van den Ancker, & Dullemond 2005) showed that over 50% of them display the lines of [O I]. On the other hand, I still consider the HAeBe classification of LkHα 101, MWC 137, and Hen 3–938 uncertain because of their extremely strong line emission (especially rich Fe II spectra that are not that common in genuine young stars) and uncertain distances.

SymbB[e]. There are 6 symbiotic binaries among the original B[e] stars: RX Pup, He 2–34, AS 269, Hen 3–782, He 2–442, and H 1–25. They all are definitely D-type symbiotics (dusty, according to Allen 1984). In these objects, the dust seems to form in the circumbinary area due to mass loss from the cool primary, while the emission-line spectrum is excited by the hot companion. In principle, more known symbiotic objects exhibit forbidden lines of [Fe II], [O I], and [O III] (e.g., AS 360 and HM Sge) and could be considered B[e] stars. Thus, it is also natural for symbiotic systems to have the B[e] phenomenon.

cPNB[e]. Compact PNe are the most abundant among B[e] stars with understood nature. This subgroup also includes PPNe and contains 13 objects: M 1–11, M 1–91, M 1–92, M 2–9, M 2–56, Mz 3, Vy 2–2, Hb 12, H 1–45, He 2–90, He 2–101, HD 167362, and HD 316248. The CS dust in these objects was formed during the previous, AGB, evolutionary phase. Their dense and extended envelopes are due to the AGB and post-AGB wind. Thus, many PNe and PPNe should show the B[e] phenomenon.

sgB[e]. These are galactic analogs of the Magellanic Clouds sgB[e] stars. There are 7 members of this subgroup from the original list of B[e] stars (η Car, MWC 349, CPD$-52°$9243, MWC 300, RY Sct, and 3 Pup). Two of them (RY Sct and 3 Pup) are recognized binaries, while the other ones are suspected binaries. Recently 3 more galactic sgB[e] were found: HDE 327083 (see Sect. 3.), AS 381 (Miroshnichenko et al. 2002c), Hen 3–1398 (Miroshnichenko et al. 2001). Two of the latter (HDE 327083 and AS 381) were found to show direct evidence of binarity (absorption lines of the secondary companion), which could be a general property of galactic sgB[e]. If we do not consider the LBV η Car and still uncertainly classified MWC 349, it turns out that the maximum luminosity of the galactic sgB[e] is log $L/L_{\odot} = 5.1\pm0.2$ (see Miroshnichenko et al. 2001, 2003, 2004), while that of the Magellanic Clouds sgB[e] is nearly 0.5 dex higher. I think that this effect deserves a further careful study.

unclB[e]. This is the largest subgroup of the original list (33 of the 65 objects). Neither their nature nor evolutionary state is known. Some of them are still considered members of other groups. For example, HD 45677 and HD 50138 are thought to be HAeBe (e.g., van den Ancker, de Winter, & Tjin A Dje 1998). However, they do not belong to known star forming regions and have very different SEDs from those of young stars. Most of the unclB[e] stars have mid-IR flux ratios within the dash-lined box shown in Fig. 1 (see Sect. 2.). This feature prompted Miroshnichenko et al. (2002a) to suggest the new type of stars, B[e]WD, that seems to currently form CS dust. It includes the original B[e] stars, such as CI Cam, MWC 300, MWC 342, MWC 623, HD 45677, HD 50138, and CD−24°5721. My later analysis led me to add a number of other original B[e] stars to this type (MWC 17, MWC 645, MWC 1055, Hen 230, AS 222, AS 225, GG Car, and SS 170). Our recent positional cross-correlation of the USNO–B1.0, 2MASS, and IRAS PSC added another ∼30 objects, making B[e]WD the largest family of hot dust-forming stars (see Miroshnichenko et al. 2006, for details). There are also a few unclB[e] stars with flatter IR SEDs, indicating a wider temperature range of the CS dust, than those of B[e]WD. These include HD 87643, Ve 2–27, MWC 819, and MWC 922. Only Ve 2–27 seems to belong to the Vela star forming cloud (Liseau et al. 1992) and might be a HAeB[e], while the evolutionary state of the others is uncertain.

7. Current Problems

We still have many problems which are needed to be solved on the way toward revealing the nature of B[e] stars. In addition to those of the unknown mass loss and dust formation mechanisms, there is a number of those pertaining to analysis of the observational data. They include the following.

• Unknown contribution of the CS/IS reddening. Many B[e] stars are isolated and located near the galactic plane, and the determination of the IS reddening is complicated due to a patchy distribution of the IS matter.

• The CS contribution to the optical continuum in B[e] stars with strong emission-line spectra should be important. Even in Be stars with Hα lines not stronger than ∼50–70 Å in the equivalent width, the free-free and bound-free CS continuum may contribute up to ∼70% of the observed V–band flux (Bjorkman et al. 2002). Such a CS veiling may also alter the photospheric line strengths or even wash them out. However, this effect is still not taken into account in current studies. This leads to overestimating of the objects' luminosities, provided the extinction and distance are known correctly.

• Ambiguity of kinematical distances. Many studies of distant galactic objects rely on distances from the galactic rotational curve. In addition to photospheric lines that seem to represent the systemic velocity, sometimes emission lines are used for this purpose (Humphreys et al. 1989). However, due to the orbital motion in binary systems, the presence of possible peculiar radial velocities, and perhaps effect of the CS density distribution on the emission-line profiles, direct use of the mean radial velocities as distance indicators may lead to erroneous distances. It seems to be important to compare the structure and parameters of the interstellar bands and lines in the spectra of B[e] stars and various distance indicators in the same direction to constrain kinematical distances toward the objects in question (e.g., Miroshnichenko et al. 2002b).

Finally, I list the most unstudied or puzzling, in my opinion, unclB[e] stars. MWC 17 has been considered a symbB[e] (Ciatti, D'Odorico, & Mammano 1974; Martel & Gravina 1985a), but Jaschek & Andrillat (1999) have not confirmed previously reported late-type star features, such as the CH band at λ4300 Å. Even its optical brightness is not accurately known, as only a few measurements have been obtained so far (V=11.6 and 13.2 mag, Martel & Gravina 1985b; Bergner et al. 1995, respectively). MWC 137 was classified a HAeBe (Finkenzeller & Mundt 1984) or a sgB[e] (Esteban & Fernandez 1998). The lack of detected photospheric lines and an uncertainty in distance are the reasons for such an ambiguity. An extremely well-observed B[e] star MWC 349, showing very strong emission-line spectrum along with maser and laser radio emission, was discussed in many papers. However, there is still a controversy concerning its evolutionary state that has been considered to be either an sgB[e] (Hofmann et al. 2002) or a pre-main-sequence HAeB[e] object (Meyer, Nordsieck, & Hoffman 2002). It is worth mentioning that no good high-resolution optical spectrum of MWC 349 has been published. A few objects from the northern hemisphere, such as MWC 645 and MWC 819, and even more from the southern hemisphere, such as He 2–79, He 2–80, He 2–91, He 2–139, AS 222, and AS 225, received almost no attention since the introduction of B[e] stars.

8. Conclusions

Although our knowledge about the B[e] phenomenon is still vague, especially when it comes to the dust producing objects (sgB[e] and unclB[e]), I would like to summarize the previous studies and the current state of research as follows.

- It has been recognized that among other objects, in which the B[e] phenomenon is understood (e.g., HAeB[e], cPNB[e], and symbB[e]), there is a large and distinct group of dust-forming hot stars with still unclear nature and evolutionary state. Thus, the B[e] phenomenon turned out to be very important for understanding the stellar evolution and dust formation (ultimately life), however its role has been underestimated.
- B-type stars of a large luminosity range (3 orders of magnitude) can produce dust (see Miroshnichenko et al. 2006). Here I refer to sgB[e] and unclB[e] stars. This should be taken into account in studies of the galactic dust balance, which never considered B-type stars as dust producers (e.g., Gehrz 1989).
- There is a growing population of binary B[e] objects. Thus, binarity might be the key property for their follow-up studies.
- B[e] objects seem to be much more common in the Milky Way. Numerous candidates have been and will be found in the IRAS, MSX, 2MASS, DENIS, and SDSS data bases.
- Outcome of the investigation of B[e] stars: new ideas for evolutionary theories of single/binary stars, refinement of our understanding of dust formation, important implications for the evolution of the Universe.

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