The B[e] Phenomenon: Forty Years of Studies
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Long-Term Photometric Monitoring of Objects with the B[e] Phenomenon

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1. Introduction

One of the defining features of the B[e] phenomenon is a large IR excesses due to hot CS dust (Allen & Swings 1976). Most B[e] objects show a pronounced near-IR excess that allows to distinguish them from other objects with circumstellar material, such as Be stars, or cool stars. While B[e] objects from the original list by Allen & Swings (1976) were observed with near-IR photometry (although not extensively), most objects that have been discovered later were typically only observed in the all-sky surveys, such as 2MASS and DENIS. Here we report the results of our JHK photometric observations of a number of B[e] objects and highlight the most variable ones.

2. Observations

Photometric observations in the JHK bands were taken at the following telescopes: 1.1 m AZT–24 at Campo Imperatore (Italy) in 2008–2015 with an imager/spectrometer SWIRCAM (D'Alessio et al. 2000). Several comparison stars were used in the vicinity of each object, photometry was taken from the 2MASS catalog (Skrutskie et al. 2006). 2.12 m (in 2008) and 0.84 m (in 2009 and 2010) at the Observatorio Astronómico Nacional San Pedro Martir (OAN SPM, Mexico) with an IR camera/spectrograph Camila (Cruz-González et al. 1994). Several comparison stars were observed during each observing night, photometry was taken from (Hunt et al. 1998).

3. Results

We took near-IR photometric observations of over 50 objects with the B[e] phenomenon from the lists of Allen & Swings (1976); Miroshnichenko et al. (2007, 2011). The majority of them have been classified FS CMa type objects (Miroshnichenko 2007). Eight of the objects have been observed over 25 times (MWC 17, MWC 645, IRAS 17449+2320, IRAS 06071+2925, MWC 790, MWC 1055, V669 Cep, and [KW97] 12–39). Another eight objects have been observed 8–18 times (IRAS 21095+4726, IRAS 07080+0605, IRAS 06341+0159, AS 386, AS 119, SS 170, IRAS 06148+3054, IRAS 01571+6018).

The strongest variations were found for MWC 645 (ΔK = 0.8 mag), [KW97] 12–39 (ΔK = 0.7 mag), MWC 17 (ΔK = 0.6 mag), and IRAS 06071+2925 (ΔK = 0.5 mag). The following objects observed over 15 times exhibited a smaller variability amplitude ($\Delta K = 0.2 - 0.3$ mag): IRAS 17449+2320, AS 386, MWC 1055, MWC 790, IRAS 07080+0605, IRAS 06341+0159, and V669 Cep.

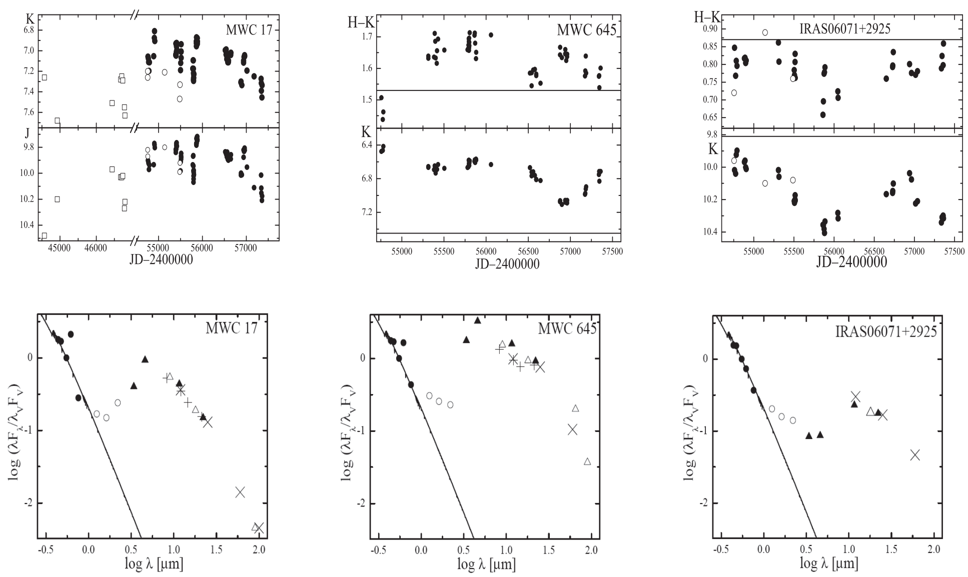

Figure 1. **Upper panels:** *JHK* variations of some program objects. Common symbols: open circles – OAN SPM, filled circles – Campo Imperatore. Solid lines show the 2MASS brightness level. **Left:** MWC 17. Open squares show data from Strafella et al. (1987). **Center:** MWC 645. **Right:** IRAS 06071+2925. **Lower panels:** Spectral energy distributions of the same objects. Symbols: filled squares – ground-based optical data, open squares – 2MASS data, filled triangles – WISE data, crosses – IRAS data, pluses – MSX data, open triangles – AKARI data. The photometric data were dereddened using observed $B - V$ color-indices and $T_{\rm eff}$ estimates (25000 K for MWC 17 and MWC 645, 12000 K for IRAS 06071+2925) based on the spectral line content. Solid lines represent theoretical stellar atmosphere models from Kurucz (1993).

Two strongly variable objects (MWC 17 and MWC 645) still have an uncertain nature and evolutionary status and show extremely strong emission-line spectra. Circumstellar emission in both completely veils intrinsic stellar spectra. Another object with noticeable brightness variations, IRAS 06071+2925 has been classified a pre-main-sequence star (PDS 211, Vieira et al. 2003) and an FS CMa object candidate (Miroshnichenko et al. 2007). Our spectra show that the underlying late B-type star is a fast rotator. The near-IR brightness variations may contain a periodic component (P ∼ 5 years). Examples of the detected brightness variations for these three is shown in Fig. 1 (upper panels). Their spectral energy distributions (see lower panels of Fig. 1) demonstrate a fast drop toward longer wavelengths at $\lambda \geq 10\mu$m that is typical of FS CMa objects and some B[e] supergiants (Miroshnichenko 2007). Our spectroscopic data for MWC 645 show a weak emission line of [Ca II] 7291 Å which has been proposed a diagnostics for B[e] supergiants (Aret et al. 2012). The other two objects do not exhibit this line and are most likely FS CMa type objects.

Properties of several other program objects are briefly described here. [KW97] 12–39 is a poorly studied object located in the star-forming complex IC 1805 (Wolff et al. 2011) and is most likely a pre-main-sequence star. AS 386 (Merrill & Burwell 1949) has not been studied in detail. Its IR excess was discovered independently by Clarke et al. (2005) and our group. It has a composite optical spectrum that includes lines from a hot and a cool star. IRAS 17449+2320 is an early A–type emission-line star has been classified as an FS CMa type object (Miroshnichenko et al. 2007) and further studied by Sestito et al. (this volume).

Our near-IR photometry program continues at both observatories. It is accompanied by optical high-resolution spectroscopy at OAN SPM, McDonald Observatory, Ondřejov Observatory, and CFHT as well as by optical photometry at the Tien-Shan Astronomical Observatory (Kazakhstan). Some results from the latter sites are presented in Zharikov & Miroshnichenko, Korčáková, and Manset et al. (this volume).

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