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Unraveling the nature of B[e] star candidates[1]

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Abstract. B[e] stars are amongst the least understood group of massive stars because their spectra often reflect the physical conditions of their circumstellar environment which veil the real nature of the central object. These stars exhibit emission lines of forbidden and permitted transitions and the presence of a dusty disk causing the observable strong infrared excess emission. In this work we describe IR spectroscopic observations of 3 B[e] candidates aiming to discuss on their classification.

Resumen. Las estrellas B[e] son un grupo de estrellas masivas difíciles de comprender, dado que sus espectros reflejan las condiciones físicas del material circunestelar que enmascaran la verdadera naturaleza del objeto subyacente. Estas estrellas exhiben líneas permitidas y prohibidas en emisión y poseen un disco de polvo que produce el fuerte exceso infrarrojo observado. En este trabajo describimos observaciones espectroscópicas infrarrojas de 3 candidatos a objetos B[e] con el objetivo de discutir acerca de su clasificación.

1. Introduction

The B[e] phenomenon is defined by the appearance of strong Balmer emission lines, low excitation permitted emission lines and forbidden emission lines in the optical spectrum, as well as a strong infrared excess due to the presence of a dusty disk. In most cases, the circumstellar gas and dust surrounding these objects mask the photospheric features, making it extremely difficult to assign spectral type and evolutionary stage to the underlying star.

Among B[e] stars we can find pre-main sequence objects (HAeB[e]), evolved stars such as B[e] supergiants (sgB[e]) or compact planetary nebulae (cPNB[e]) and symbiotic stars (SymB[e]) (Lamers et al. 1998). Many B[e] stars still have

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an unclear classification (unclB[e]), since they satisfy the classification criteria for more than one of the above classes.

In the last few years, many stars were suggested as B[e] candidates. Their few observations, however, hamper proper identification. As these objects are typically very faint, the infrared region provides spectral features that might help to identify these candidates as B[e] stars, and eventually to classify them. For example, stars with shocks such as cPNs and Herbig stars typically display H_2 in emission and sometimes ^{12}CO in emission. Also, many B[e] supergiants share common properties with the pre-main sequence Herbig Ae/Be stars. Both show infrared excess and the presence of ^{12}CO and H_2 emission. The luminous B[e] stars also display emission in the higher members of Pfund series while the less luminous ones have only emission from the lower transitions. To distinguish between pre and post main sequence stages, Kraus (2009) proposed a useful criterion based on the detection of the ^{13}CO molecule in emission, which is a clear indicator of the evolved nature of the star.

In the present work, we propose to study the K- and L-band spectra of a group of new B[e] star candidates. We aim to comfirm their B[e] nature by looking for the presence of the characteristic emission in the H lines, CO bands and H_2 molecular lines. In addition, where possible, we will use the infrared features to classify these stars.

2. Observations

Medium resolution IR spectroscopic observations of some B[e] star candidates were performed in december 2012, with GNIRS spectrograph mounted on GEMINI North (Program ID GN-2012BQ-101) using longslit mode. K-band spectra (2.02-2.38 μ) were taken with the short camera (0.15"/pix), a 110 l/mm grating and a 0.3 arcsec slit and L-band spectra (3.56-4.08 μ) were obtained with the long camera (0.05"/pix), a 31.7 l/mm grating and a 0.1 arcsec slit.

3. Results

IRAS 07080+0605 ($\alpha = 07^h\,10^m\,44^s$, $\delta = +06^\circ\,00'\,07''$; 2 000, $m_V = 13.60$)

Kohoutek & Wehmeyer (1999) detected the optical counterpart in their survey of Hα emitting stars.

Miroshnichenko et al. (2007) reported an optical spectrum with broad H absorptions and double-peaked emissions in Hα, Hβ and O I lines and classified the underlying star as an A spectral type. They also suggested that this star may be a binary in a rapid mass transfer, according to the strong infrared excess and the H emission observed.

Our K-band spectrum shows an inverse PCygni line profile in Brγ with a weak emission. We also observe an unusual CO molecular absorption band (Fig.1 *left*) probably related with a 100 K molecular cloud. The L-band spectrum (not shown) only shows a barely detectable Brα emission.

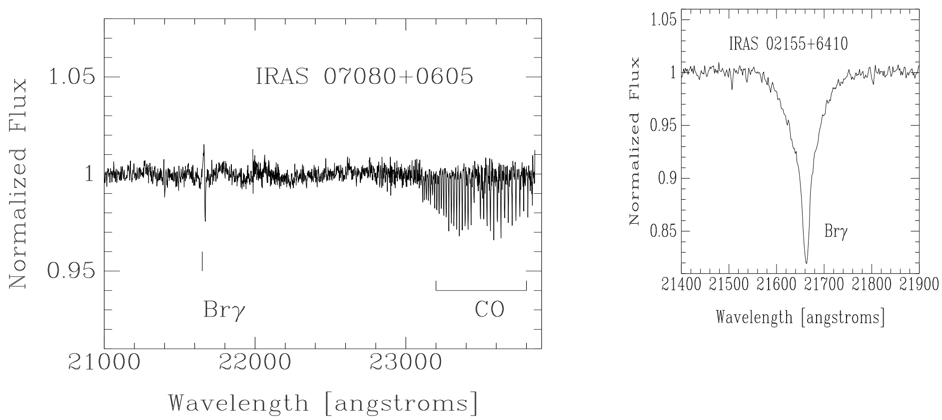

Figure 1. K-band spectrum of IRAS 07080+0605 (*left*) and Brγ line of IRAS 02155+6410 (*right*)

IRAS 02155+6410 ($\alpha = 02^h\,19^m\,22.8^s$, $\delta = +64^\circ\,24\,'\,41.23''$; 2000, $m_V = 11.11$)

This star was reported to have a SED similar to those of the objects with the B[e] phenomenon in the IRAS wavelength range. This star was examined for the presence of the SiO maser emission (Jiang et al. 1999) and that of the ^{12}CO emission (Kerton & Brunt 2003), but none was detected. Its optical counterpart was classified as a mildly reddened A3-type dwarf with no line emission, except for a slight asymmetry of the Hα profile (Miroshnichenko et al. 2007).

Our K-band spectrum shows a strong Brγ line in absorption (Fig.1 *right*) and the absence of CO molecular bands. The star also exhibits a featureless L-band spectrum, with no presence of hydrogen lines. This is not a B[e] star. Our observations would be consistent with an A spectral type star.

MWC728 ($\alpha = 03^h\,45^m\,14^s$, $\delta = +29^\circ\,45\,'\,03''$; 2000, $m_V = 9.8$)

This star was first detected in the Mount Wilson survey for galactic early-type emission line sources (Merrill & Burwell 1949). The optical spectrum reported by Miroshnichenko et al. (2007) shows double-peaked Balmer and [O I] lines in emission. These authors suggested a B6/B7 spectral type based on the He I 4471/Mg II 4481 line equivalent width ratio and detected the weak Li I 6708 and Ca I 6717 lines that are indicative of a late-type companion.

Our K-band spectrum shows the Brγ line in emission, and the CO band heads of the 2-0, 3-0 and 4-2 molecular transitions in weak absorption (Fig.2 *top*). We also identified Ca I and Na I lines and possible H_2 lines. In the L-band we observe Pfγ and Brα lines in emission (Fig.2 *bottom*). As there is no Pfund line emission from the higher Pfund series and the other H lines are in weak emission we can discard a supergiant nature of the B-type star. Thus, our observed IR spectra are consistent with a binary scenario consisting of a B-type star and a non-supergiant G-type companion. The absence of CO band and H_2 molecular emission means that this star is probably neither a pre nor a post main sequence object. Instead, it might be a main sequence star similar to HD50138 (Borges Fernandes et al. 2009).

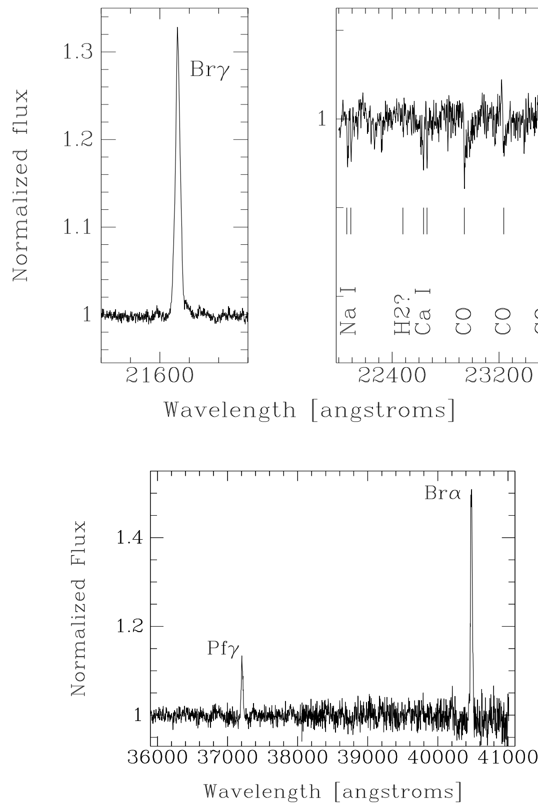

Figure 2. K-band (*top*) and L-band (*bottom*) spectra of MWC728

4. Conclusions

We have studied the near IR spectra of three B[e] star candidates. We found that two of the stars are definitely no B[e] stars. Both have an A spectral type and their infrared excesses are of an unclear origin. The third star, MWC728, is probably a B-type emission line star, non-supergiant, with a G-type companion.

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