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Properties of the circumstellar dust in galactic FS CMa objects

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Abstract. FS CMa objects are a group of hot stars that exhibit the B[e] phenomenon. The group was defined a few years ago on the basis of the formerly known unclassified B[e] stars and newly discovered objects. One of their main features is the presence of hot circumstellar dust whose properties were unknown. We present IR spectra of nearly 20 FS CMa objects obtained with the Spitzer Space Telescope. Dusty features, such as broad silicate bands in emission and narrow bands that are usually explained by PAHs, are detected. The IR fluxes are compared to those detected by IRAS and MSX. Main results of the data analysis are briefly discussed.

Keywords. stars: early-type, infrared: stars, circumstellar matter

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1. Introduction

The B[e] phenomenon is the simultaneous presence of line emission (forbidden: [O I], [Fe II], [N II], sometimes [O III] and permitted: H, He, and Fe II) and large IR excesses due to hot circumstellar (CS) dust in the spectra of B-type stars (Allen & Swings 1976). It is found in five groups of stars (Lamers *et al.* 1998): pre-main-sequence stars, symbiotic binaries (a cool giant and a white dwarf or a neutron star), proto-planetary/planetary nebulae, supergiants, and FS CMa objects (formerly known as unclassified B[e] stars, Miroshnichenko 2007). The presence of CS dust near hot stars may be due to various reasons. In pre-main-sequence stars, it is inherited from protostellar clouds. In proto-planetary nebulae, it is left from the previous, asymptotic giant branch (AGB) evolutionary stage. In symbiotic binaries, CS dust is formed in ejecta of cool giants, as in AGB stars. In B[e] supergiants with very dense radiation-driven winds, dust can be formed due to self-shielding of parts of the winds (e.g., due to clumping) from dust-destroying UV radiation. Only B[e] supergiants and FS CMa objects seem to form dust, when they have a B-type star in their content. FS CMa objects are the least studied. Our Spitzer program was aimed at taking IR spectra of a sample of 25 Galactic FS CMa objects with IRS in the range 5–37 μm for the first time.

2. The Galactic FS CMa group

The group comprises ∼50 members and ∼20 candidates (Miroshnichenko *et al.* 2010), ∼30% of which are detected binary systems. The main defining features of FS CMa objects include: 1) A B to early-A type star with an extremely strong emission-line spectrum; 2) A sharp decrease of the IR flux at $\lambda > 10\mu$m indicating that the dusty

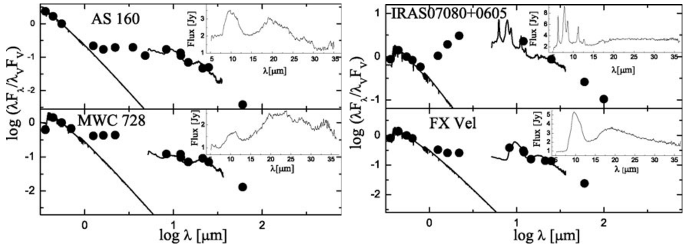

Figure 1. Spectral energy distributions (SED) of some program objects (various photometric data are shown by the dots) and their Spitzer spectra (shown by the solid lines in logarithmic units on the main plots and in flux units on the insets). Solid lines through the dereddened optical parts of the SEDs are model atmospheres (Kurucz 1994) for $T_{\rm eff}$ = 10,000 K (FX Vel and IRAS 07080+0605), 12,000 K (MWC 728), and 19,000 K (AS 160).

envelopes are compact and either stable for a long time or recently created; 3) Luminosity ($\log L/L_\odot = 2.5$–4.5) is typical for a 3–10 $M_\odot$ single star; 4) The Balmer line emission is ~10 times stronger than that in supergiants, Be, and Herbig Ae/Be stars. It is too strong to be explained by the evolutionary mass loss from a single star of similar luminosity.

3. Spitzer data

All 25 objects were observed, most spectra have good quality, data problems were found in the spectra of four objects, two objects were not detected. Silicate emission features were detected in all observed objects except for IRAS 07080+0605 (Fig. 1). The structure of the 10–μm feature and presence of forsterite bands at 23.3, 27.8, and 33.7 μm suggest that the dust was formed some time ago and already processed by stellar radiation. Objects with late-B/early-A spectral type stars also exhibit emission features which are attributed to Polycyclic Aromatic Hydrocarbons (Leger & Puget 1984) or to Small Carbonaceous Molecules (Bernstein & Lynch 2009). The IR flux level of all the objects is comparable with that of earlier observations (MSX, IRAS).

4. Conclusions

The Spitzer IRS spectra revealed the chemical composition of the Galactic FS CMa objects for the first time. The data constrain the amount of CS dust. This will allow us to estimate their role in the Galactic dust production. Previously B-type stars of intermediate and low luminosity were not considered as dust producers. Simultaneous modeling of the gaseous and dusty envelopes in FS CMa objects together with their orbital parameters will enable us to understand what kind of binary systems can pass through this evolutionary stage and solve the long-standing problem of the existence of the B[e] phenomenon in objects whose evolutionary state was unknown for over 30 years.

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