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PROPERTIES OF GALACTIC FS CMA TYPE OBJECTS, A NEW GROUP OF DUST-FORMING SYSTEMS

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RESUMEN

El recientemente definido grupo galáctico de FS CMa abarca $\sim$ 40 objetos no muy luminosos que amplían significativamente el rango de luminosidades de formación de estrellas de polvo caliente. Estos objetos exhiben espectros de emisión de línea extremadamente fuertes y excesos IR, que son indicativos de envolturas compactas de polvo. Estos son muy probablemente sistemas binarios que experimentan actualmente, o han experimentado recientemente, una fase de rápido intercambio de masa, asociado con la formación de polvo. La compleja estructura del ambiente circunestelar vela significativamente las estrellas subyacentes y requiere la investigación de múltiples técnicas, en la cual la interferometría debe desempeñar un papel importante.

ABSTRACT

The recently defined Galactic FS CMa group comprises $\sim$40 not very luminous objects that significantly expand the luminosity range of hot dust-forming stars. These objects exhibit extremely strong emission-line spectra and IR excesses, which are indicative of compact dust envelopes. They are most likely binary systems that currently undergo or have recently undergone a phase of a rapid mass exchange, associated with dust formation. Complex structure of the circumstellar environments significantly veils the underlying stars and requires multitechnique investigation, in which interferometry should play an important role.

Key Words: circumstellar matter — stars: early-type — stars: emission-line, Be

This is the fourth and the last talk on objects with the B[e] phenomenon. Since basic information about it has already been presented (see papers by M. Borges Fernandes and M. Kraus in this proceedings), I will directly focus on the new subgroup of FS CMa stars, previously known as unclassified B[e] stars. It consists of $\sim$ 40 Galactic objects that exhibit very strong emission-line spectra and a steep decrease of the IR flux at $\lambda \geq 10-30$ μm (Miroshnichenko 2007; Miroshnichenko et al. 2007). Until recently, the nature and evolutionary state of the majority of these objects were considered controversial. Their luminosity range ($2.5 \leq \log L/L_{\odot} \leq 4.5$) indicates that the stars are not very massive, while the location on the Hertzsprung-Russell diagram (typically within the main sequence) suggests that they are not extremely evolved. The shape of the IR spectral energy distribution in combination with a lack of a visible nebulosity suggest that circumstellar (CS) dust is compactly distributed. It has probably been formed only recently or is being formed now.

Our initial results, presented in the group defining papers (see above), show that a noticeable fraction of the objects ($\sim$ 30%) are either recognized or suspected binary systems. Binarity is usually manifested by the presence of absorption lines, typical of late-type stars (e.g., Li I 6708 Å and Ca I 6717 Å). In some cases, individual emission lines exhibit a different behavior compared to the rest of them. For example, a traveling He II 4686 Å emission line in the spectrum of CI Cam (Barsukova et al. 2006) indicates the presence of a degenerate secondary. Recently we found a similar phenomenon, exhibited by He I lines, in the spectrum of IRAS 00470+6429 (Miroshnichenko et al. 2009). It is hard to detect the secondaries, because they are typically 2–3 mag fainter than the primary B–type stars. Nevertheless, we believe that long-term monitoring of FS CMa objects will reveal more binaries in the nearest future.

Apart from the fact that the FS CMa objects are interesting as a still poorly studied group of emission-line stars, two important reasons to further investigate them can be highlighted here. The first one is to reveal mechanisms responsible for the very strong emission-line spectra. The second one is to reveal the origin and location of the CS dust.

The strong emission-line spectra of FS CMa objects are not expected from single stars, because the current theory of stellar evolution predicts relatively weak stellar winds for main-sequence stars in the mentioned luminosity range. Their Hα line equiva-

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lent widths are typically over an order of magnitude larger than those of other intermediate-luminosity hot stars (e.g., Be stars, Herbig Ae/Be stars, Miroshnichenko 2008). The emission-line strength is more likely due to accumulation of the gas in the primary's Roche lobe rather than to a strong mass loss rate. It is known that many well-studied Be stars with strong line emission are binaries (e.g., Harmanec et al. 2000; Bjorkman et al. 2002). Just like FS CMa binaries, most binary Be stars have much fainter (and probably less massive) secondaries. However, it is unclear why FS CMa objects retain more CS material than Be stars. Currently we have no direct evidence of a Roche lobe overflow in any of the known FS CMa type binaries, but mass exchange through the disks cannot be ruled out. Perhaps, these disks live longer than transient disks of Be stars.

The location of the CS dust around FS CMa objects is unknown. It might be confined around either stellar companion, but the orbital separation in this case would be very large, making their mutual influence negligible. The dust might also be located in the circumbinary space, where the abundant CS material could escape during times of mass exchange between the companions. Most of the twenty group objects observed spectroscopically with the Spitzer Space Telescope (Miroshnichenko et al. 2008) show weak silicate emission features at 10 and 18 μm, suggesting that the dust is optically-thin. Interferometry is very important in constraining the dust properties in the FS CMa objects, but only a few group members have been observed so far. Some good candidates for future interferometry located at distances of less then $\sim$ 2 kpc include HD 85567 and Hen 3–140 in the southern sky as well as IRAS 00470+6429, MWC 342, and MWC 657 in the northern sky.

We currently have over 300 high-resolution optical spectra of most group members north of $-25°$ declination. Analysis of the line profiles and radial velocity variations is in progress. Observations of more southern objects are needed to complete it for the entire group.

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DISCUSSION

M. Kraus: *I consider research of B[e] stars as a challenge to reveal their evolutionary phase. This should be true especially for the big group of unclassified stars. I wonder why you consider it necessary to pick one unclassified star, FS CMa, as the basis of another group of unclassified B[e] stars. This, in my opinion, does not help us to understand why these stars show the B[e] phenomenon.* — FS CMa, which has been suggested to be a prototype of the entire group of stars with the B[e] phenomenon by J.-P. Swings, has all the typical features of the new group. The unclassified objects were called so, because there has been no satisfactory explanation to their nature and evolutionary state. We have suggested a hypothesis about their nature (binary systems with periods of efficient mass transfer) and narrowed down the range of possible evolutionary stages. To me, they are not unclassified anymore.

R. Barbá: *The FS CMa systems with cool components look like a sort of symbiotic systems. Is the FS CMa group related to symbiotics?* — In symbiotic stars, the luminosity ratio of the hot and cool component is opposite to that in FS CMa stars. One can speculate that FS CMa objects might be an adjacent phase of evolution to symbiotic systems, separated by a mass exchange phase. However, we are not ready yet to compare these groups in detail.

R. Mennickent: *Do you find evidence of X-ray emission or UV excess that could support the hypothesis of a companion compact object?* — Only one FS CMa object, CI Cam, showed evidence of a degenerate companion by the presence of X-ray/γ-ray emission during its 1998 outburst. Another one, MWC 342, is located in the positional error box of an X-ray source detected by the UHURU satellite, but the association is still uncertain. We have plans to search ROSAT data to look for possible association of the group objects with X-ray sources.

M. Borges Fernandes: *What is the fraction of confirmed, not candidate, binary systems in your sample?* — The fraction of FS CMa objects that show signatures of an additional stellar component is currently nearly 30%.

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