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BE STARS IN THE MILKY WAY AND THE LMC

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RESUMEN

Se presenta un resumen de los resultados de tres estudios diferentes relacionados con estrellas Be. El primer resultado es acerca de una búsqueda de candidatas a estrellas Be en la LMC, el segundo estudio se relaciona con la primera búsqueda sistemática de estrellas candidatas a Be en la dirección del bulbo galáctico, y el tercer estudio es sobre de los resultados del análisis de espectros infrarrojos en la banda L de 13 estrellas Be galácticas eruptivas.

ABSTRACT

We present a resume of the results of three different studies of Be stars. The first study is about a search for Be star candidates in the LMC, the second study is related to the first systematic search for Be star candidates in the direction of the Galactic Bulge, and the third study is about the analysis of infrared L-band spectra of 13 outbursting Galactic Be stars.

Key Words: stars: emission-line, Be

1. INTRODUCTION

Be stars are non-supergiant fast rotator B stars, whose spectra show or have shown emission in Hα originated in a flattened circumstellar gaseous disk. The mechanisms producing the circumstellar disk and driving its dynamics and its structure are uncertain.

An useful tool to understand the physical conditions of these disks is to observe their infrared recombination lines, whose strengths are good indicators of the temperature and density distributions of their forming regions. Surveys of Be stars in the Magellanic Clouds (MC) and the Milky Way are important too in order to study the dependence of the Be-phenomenon on the metallicity.

Detailed studies of Be stars in environments with different metallicities have been performed only in recent years. In particular, Mennickent et al. (2002) presented a catalogue of Be star candidates in the SMC based on an inspection of the OGLE II data base. These stars were classified in 4 types according to the shapes of their I-band light curves. Two of these groups are type-1 stars (showing outbursts) and type-3 stars (showing periodic variations). One of the hypothesis proposed by Mennickent et al. to explain the nature of type-1 stars is that they could be pre-main sequence stars with accretion disk thermal instabilities producing the outbursts.

In these pages we resume the results of three studies motivated by the need to understand the nature and causes of these types of variability recently discovered in Be star candidates of the SMC.

2. PHOTOMETRIC PROPERTIES OF BE STAR CANDIDATES OF THE LMC AND THE SMC

We have completed a search for Be star candidates in the LMC using the OGLE II database in order to find the same types of variables of the SMC and to compare their photometric properties statistically. The result was a catalogue with photometric data of 2446 Be star candidates in the LMC (Sabogal et al. 2005), which could be classified in the same four groups defined by Mennickent et al. (2002) for Be stars in the SMC. We performed a statistical study of duration, asymmetry and amplitude distributions of the outbursts observed in the I-band light curves of type-1 LMC and SMC stars. We studied also amplitude and period distributions of the light curves of type-3 LMC and SMC stars. Then, we performed a statistical comparison of the results for both galaxies and found that SMC type-1 star outbursts are brighter, longer and have slower declines than LMC type-1 star outbursts. We also found bimodal period distributions of type-3 stars in both galaxies. One of the modes of these distributions is related with the double-periodic blue variables (DPVs) recently discovered in the SMC (Mennickent et al. 2003). Period and amplitude distributions of these stars in the LMC are statistically different from those of LMC stars. These results suggested that mechanisms causing the photometric variability observed in type-1 and type-3 stars

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depend on metallicity. In particular, because the outbursts are more energetic in a low metallicity environment and faster rotation is favoured at those metallicities too, we concluded that probably these outbursts are primarily caused by rotation, maybe combined with non-radial pulsations.

3. BE STAR CANDIDATES IN THE DIRECTION OF THE GALACTIC BULGE

In order to select a sample of stars useful to perform future analysis about the dependence on metallicity of the mechanisms producing the photometric variations of type-1 and type-3 stars, we carried out the first systematic search for Be star candidates in the direction of the GB, using 48 OGLE II fields of the GB (containing $\sim$ 30 million stars). The selection criteria were based on the ranges of magnitudes and colors, and in the typical shapes of the light curves of classical Be stars. From the variable stars sample we select those with amplitudes between 0.05 and 1.00 mag. A total of 29053 stars were selected as Be star candidates.

Finally we used a statistical filter to select without visual inspection the stars with light curves similar to those of the Type-1 to Type-3 stars found in the MC. This sample contains 1488 stars, 198 of them being periodic variables showing short and mid-term variations. Some of these stars could be double or multiperiodic variables and will be useful in the study of type-3 stars and the DPVs.

The final catalogue is a list of 29053 Be star candidates in the direction of the GB (Sabogal et al. 2008), 198 of them periodic, and most of them probably members of the disk. These stars will be ideal targets for future observing programs based on multiobject spectroscopy or Hα imaging surveys to establish their true nature.

4. HYDROGEN INFRARED LINES OF GALACTIC BE STARS

With the aim to analyze the infrared region around 3 μm, looking for signatures of dust that could confirm the proposed hypothesis for Type-1 star outbursts, we performed a study of L band infrared spectra of 13 Galactic outbursting Be stars (Hubert, Floquet & Zorec 2000). These spectra were obtained with the ISAAC spectrograph of ESO VLT/UT1 at Cerro Paranal, in service mode. The long slit low resolution spectroscopy mode with a central wavelength of 3.5 μm was selected. 2 setups were used: a slit of 0.3 arcsec (resolving power of 1200), and other of 2 arcsec (resolving power of 180). Image were reduced with the ISAAC pipeline and the telluric corrections were performed by using G-type telluric standards whose photospheric lines were subtracted with help of synthetic spectra of solar type at the same resolution of the observations. The spectra taken with the wide slit were flux calibrated using the spectrophotometric standard star BS5471 (B3V), in order to obtain L magnitudes for these stars. The transmission curve of L filter used was that of Bessell & Brett (1988). L values are between 5.25 and 8.00 mag. The other spectra were normalized to continuum and used to obtain line strength ratios, equivalent widths (EWs) and full width at half maximum (FWHM) of the emission lines.

Since emission bands in 3.3, 3.4 and 3.5 μm were not observed, we concluded that there is not trace of dust emission and the hypothesis of thermal instabilities producing type-1 star outbursts is incorrect.

Only 8 spectra shown strong emission lines, including the Humphreys series of the Hydrogen, and some lines of the Pfund and Brackett series. The comparison of the line strengths with the optically thin line recombination theory (Case B) and with the optically thick case, allows to conclude that these lines are formed in a high density circumstellar envelope (CE), which could have strong changes in density or extension at some distance of the star, showing probably optically thin lines up to a wavelength of about 3.7 μm, and optically thick lines for larger wavelengths. All but 2 stars (V341 Sge y μ Cen) shown this change on the envelope properties.

We found that EW/λ increases with the decreasing of FWHM, implying that inner part of the CE rotates faster than outer. Due to the FWHMs are at least 2 times greater than the projected rotational velocities of the stars, these envelopes rotate faster than the stellar photospheres.

We also found a group of stars that are probably in a stage of the Be-phenomenon in which they have lost an important part of their envelopes and do not show infrared emission lines.

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