

Determining the Be/(B+Be) fraction in the LMC and SMC

V. L. Schiavolim¹, A. C. Carciofi¹ & A. L. Figueiredo¹

¹ Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo - IAG/USP e-mail: vittoriaschiavolim@usp.br e-mail: carciofi@usp.br e-mail: andrefigueiredo.astro@gmail.com

Abstract. Be stars are rapidly rotating B-type stars surrounded by viscous decretion disks, whose formation and evolution are still not fully understood. Population studies of Be stars in stellar clusters provide a powerful way to constrain their evolutionary pathways and the role of environmental effects such as metallicity. In this work, we present a homogeneous photometric analysis aimed at estimating the Be/(B+Be) fraction in two young open clusters in the Magellanic Clouds: NGC 1850 (LMC) and NGC 330 (SMC). Using OGLE *V* and *I* band time-series photometry, we characterize stellar variability through amplitudes and Lomb-Scargle periodograms, combined with color-magnitude diagram diagnostics. An interactive classification pipeline is employed to identify variability patterns compatible with viscous decretion disk behavior. Preliminary results indicate a higher incidence and stronger expression of Be-type variability in NGC 330 compared to NGC 1850, in agreement with expectations from metallicity effects and with the results of Figueiredo et al (2025).

Resumo. Estrelas Be são estrelas do tipo B em rápida rotação, circundadas por discos de decreção viscosos, cuja origem e evolução ainda não são completamente compreendidas. Estudos populacionais em aglomerados estelares oferecem uma via robusta para investigar os cenários evolutivos dessas estrelas e os efeitos do ambiente, como a metalicidade. Neste trabalho, apresentamos uma análise fotométrica homogênea com o objetivo de estimar a fração Be/(B+Be) em dois aglomerados jovens nas Nuvens de Magalhães: NGC 1850 (LMC) e NGC 330 (SMC). Utilizamos séries temporais fotométricas nas bandas *V* e *I* do survey OGLE, caracterizando a variabilidade por meio de amplitudes e periodogramas de Lomb-Scargle, em conjunto com diagnósticos em diagramas cor-magnitude. Resultados preliminares sugerem uma maior incidência de variabilidade do tipo Be em NGC 330 em relação a NGC 1850, em concordância com expectativas teóricas associadas à metalicidade e com os resultados de Figueiredo et al (2025).

Keywords. Stars: rotation – Stars: emission-line, Be – open clusters and associations: individual: NGC 1850 & NGC 330

1. Introduction

Be stars are non-supergiant B-type stars that exhibit Balmer line emission arising from a gaseous circumstellar disk, commonly described within the viscous decretion disk (VDD) framework. These objects are characterized by rapid rotation and episodic mass ejection events, yet the origin of their high angular momentum remains an open problem. Proposed scenarios include formation as fast rotators, spin-up through binary mass transfer, and internal angular momentum redistribution during main-sequence evolution. Population studies of Be stars in stellar clusters provide a powerful way to test these hypotheses, as cluster members share common ages, distances, and chemical compositions.

The Magellanic Clouds offer an ideal laboratory for such studies, hosting numerous young clusters in lower-metallicity environments where the Be phenomenon is expected to be enhanced. Traditional surveys based on narrow-band H α imaging are effective at identifying active Be stars but are limited by their snapshot nature, potentially missing quiescent phases and introducing contamination. Long-term time-series photometry, on the other hand, enables a dynamic view of Be star activity, capturing disk formation and dissipation episodes through characteristic variability patterns.

In this work, we apply a homogeneous photometric analysis of OGLE *V* and *I* band time-series data to investigate the Be star populations of NGC 1850 (LMC) and NGC 330 (SMC). By identifying Be-like variability and estimating the Be/(B+Be) fraction in each cluster, this study provides a population-level observational constraint on the role of metallicity in shaping the incidence and expression of the Be phenomenon.

2. Data and Methodology

We use *V* and *I* band photometry from the OGLE survey for the regions of NGC 1850 and NGC 330. Cluster membership is inferred through a spatial selection combined with photometric criteria based on the color-magnitude diagram (CMD). For each star, the median *V* and *I* magnitudes are computed from the time-series data and used to construct a representative CMD for each cluster, as seen in Fig. 1

The CMDs are employed to define the main sequence locus of the clusters and to restrict the analysis to a magnitude range where the sample is approximately complete. Within this diagram, we select the region of the main sequence where B-type stars are expected to be found, corresponding to the spectral-type range in which the Be phenomenon occurs. This CMD-based selection reduces contamination from non-B-type stars and defines the parent sample used for the subsequent variability analysis.

Stellar variability is characterized by estimating photometric amplitudes and computing Lomb-Scargle periodograms. For each object, an interactive routine presents the light curves, the CMD track color-coded by time, and the corresponding Lomb-Scargle periodogram. This approach allows for a homogeneous phenomenological classification while preserving sensitivity to complex, non-periodic variability patterns that are characteristic of disk formation and dissipation events in Be stars.

Be star candidates are identified when their photometric behavior is compatible with signatures expected from viscous decretion disks, such as long-term brightening and reddening episodes and correlated variations between magnitude and color, excluding cases dominated by noise or short-period variability unrelated to disk activity. An example of a star exhibiting Be-like photometric behavior is shown in Fig. 2.

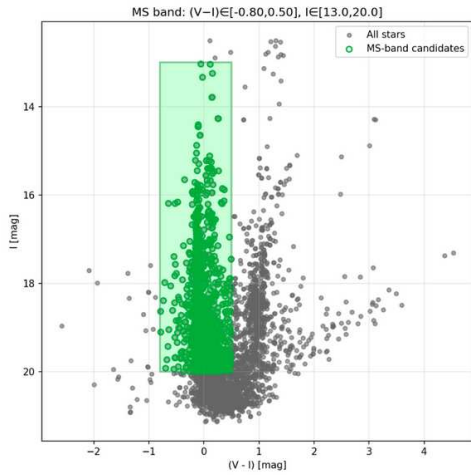


FIGURE 1. Color-magnitude diagram of NGC 1850 constructed using median I magnitudes and $(V - I)$ colors from OGLE photometry. Gray points represent all stars in the analyzed field, while green symbols indicate stars selected within the main-sequence band used to define the B-type parent sample. The shaded region illustrates the adopted CMD window.

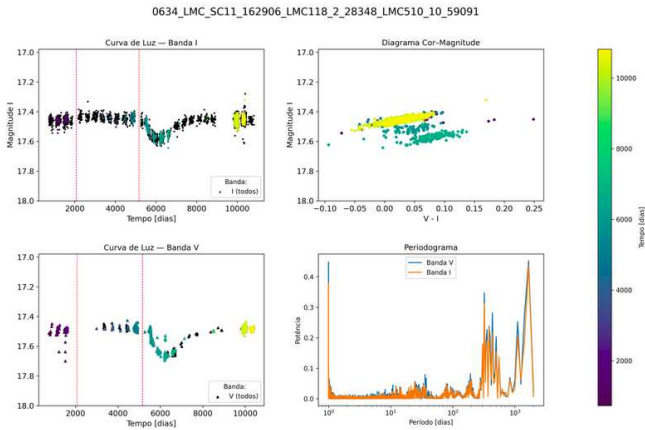


FIGURE 2. Example of a reddening episode in a star located in NGC 1850. The left panels show the light curves in the V and I bands. The top right panel displays the star position in the CMD, while the bottom right panel shows the Lomb-Scargle periodogram.

3. Preliminary Results

More than 7 000 stars in NGC 1850 and over 4 000 stars in NGC 330 have been analyzed using OGLE time-series photometry. After applying the CMD-based selection criteria described in Sect. 2, the working samples were reduced to approximately 3 300 stars in NGC 1850 and 1 750 stars in NGC 330. Individual inspection and phenomenological classification of the light curves are currently ongoing.

Figure 3 presents the relative distribution of variability classes in the two clusters, normalized by the total number of analyzed stars in each sample. Stars classified as Be and Be candidates represent a larger fraction of the population in NGC 330 than in NGC 1850, while the fraction of objects classified as non-Be is correspondingly higher in NGC 1850. These results are consistent with those obtained in Navarete et al. (2024)

The periodic variability presented by the Lomb-Scargle periodograms is still being analyzed, as it contributes to the com-

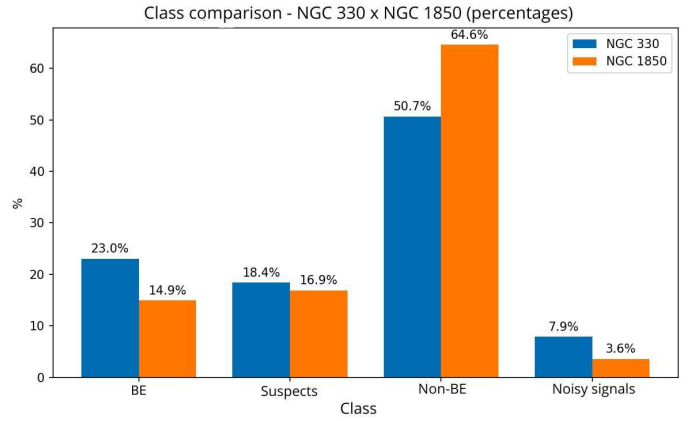


FIGURE 3. Relative distribution of variability classes in NGC 330 and NGC 1850. Bars show the percentage of stars classified as Be, Be candidates (Suspects), non-Be, and noisy light curves, normalized by the total number of analyzed stars in each cluster. The comparison highlights a higher fraction of Be-like variability in NGC 330 with respect to NGC 1850.

prehension (and the discovery) of eclipsing binary Be stars, an interesting research branch of some of our collaborators.

These preliminary results indicate a higher incidence and stronger expression of Be-like variability in NGC 330 compared to NGC 1850. This behavior is consistent with theoretical expectations that lower metallicity environments, such as the Small Magellanic Cloud, favor the Be phenomenon (Figueiredo et al. 2025, and references therein).

4. Conclusions and Future Work

The photometric pipeline presented here enables a consistent identification of Be star candidates and a homogeneous estimation of their fraction across different clusters. Preliminary findings support a metallicity-dependent behavior of the Be phenomenon.

Future work includes the systematic incorporation of $H\alpha$ observations for confirmation, the expansion of the analysis to additional clusters in the Magellanic Clouds, the refinement of completeness and contamination corrections, and the extraction of parameters such as the duty cycle and disk duty cycle to enhance our comprehension of the time evolution of these populations.

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