Analisys of Spectroscopic and Photometric Data of Luminous Blue Variable Stars

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Introduction

Questions about the evolution of **massive stars** still persist. Some post-main-sequence phases of these stars are brief and not well understood. One of these phases is, the **Luminous Blue Variables (LBV)** phase. It estimated to last around 25,000 years [1]. These stars have luminosities around 10^6 $L_\odot$ and transit between eruptive and quiescent states, with temperatures from 6,000 K to 30,000 K, respectively. The cause of this episodes of instability is another open question.

Sample

There are only **61 stars classified as LBVs**, and **85 LBV candidates** in our Galaxy and in the Local Group of Galaxies [3]. From these 146 stars, **we selected 15 that exhibit significant variability** in their photometry. These stars are: η Car, AG Car, HR Car, VRMF 55, WRAY 16-137, [GMK2012] WS1, and WRAY 17-96 in the Milky Way; S Dor, RMC 71, RMC 110, RMC 127, and HD 269582 in the LMC; RMC 40 in the SMC; and AE And and AF And in M31. WRAY 17-96 is the only star in our sample classified as an LBV candidate.

Data

The photometric data come from: 1) OGLE-III [ULACZYK ET AL., 2013, 2017]; 2) Hipparcos and Tycho catalogs [PERRUMAN & ESA, 1997]; 3) American Association of Variable Star Observers (AAVSO); 4) Long-term photometry of variables at ESO (LTPV); and 5) All Sky Automated Survey (ASAS). The most recent data for this work are from the All Sky Automated Survey for SuperNovae (ASAS-SN) and 6) by our group at OPD/LNA (Brazil) [2]. **The spectroscopic data** come from public data from UVES, XSHOOTER, and HARPS. Additionally, our group conducted observations using ESO/FEROS.

References

[1] **Humphreys**, R. M. & Davidson, K., Astronomical Society of the Pacific, 106, 1025 (1994)

[2] **Campagnolo**, J. C. N., Master's Thesis, National Observatory (2014)

[3] **de Almeida**, K. P. R., Master's Thesis, National Observatory (2024)

[4] **Campagnolo**, J. C. N., Borges Fernandes, M., Drake, N. A., Kraus, M., Gerrero, C. A., & Pereira, C. B., A&A, 613, 33 (2018)

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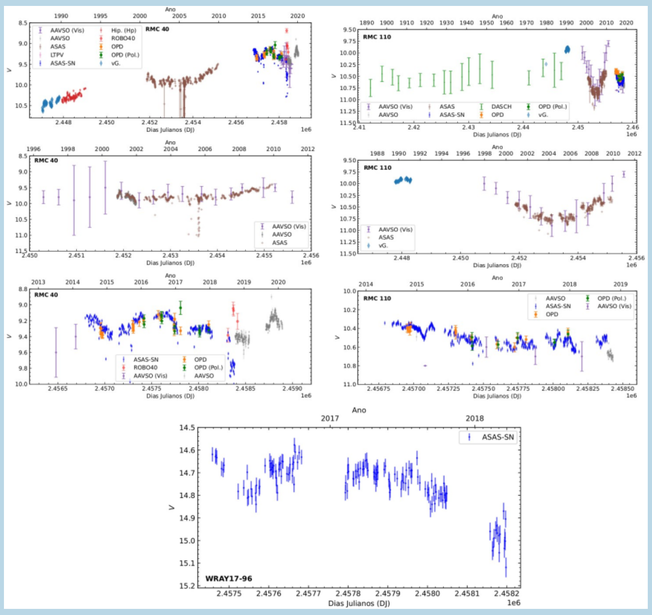
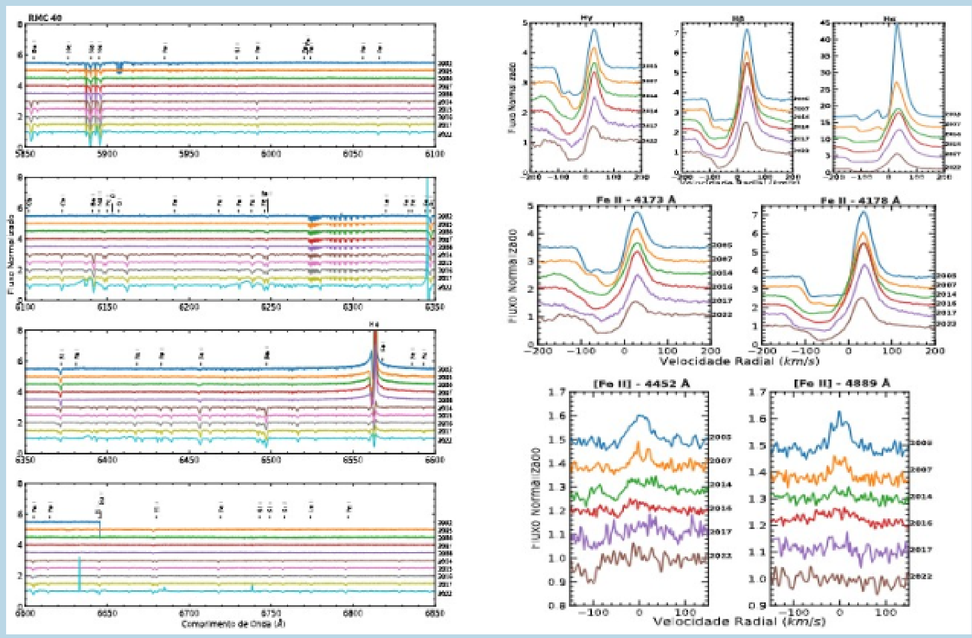
Photometric Data Analysis

Much of our data has already been published, but we recently accessed some new data. Here, we present the **light curves of three stars**. **RMC 40** and **RMC 110** had recently eruptions reported in the literature [4]. We are including in the light curves new data obtained after 2018, confirming eruptive stages. For **WRAY 17-96**, we present for the first time its light curve, where it is possible to note magnitude oscillations.

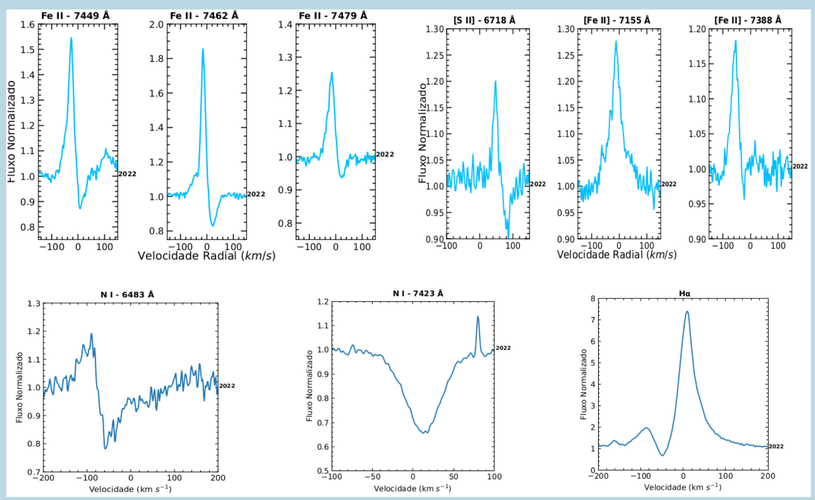


Spectroscopic Data Analysis

We obtained spectroscopic data for eight stars, being most of them are already well-known. **RMC 40** and **RMC 110** present spectra showing continuous eruptions.



We obtained for **WRAY 17-96**, classified as an LBV candidate, a high-resolution spectrum with FEROS in 2022. We identified that most of the lines are in emission lines with absorption components, possibly indicating an inverted P Cygni profile, which suggests mass accretion. All lines appear very strong, with Hα displaying a P Cygni profile.



Conclusão

As discussed, our light curve analysis confirmed some previously documented eruptions and identified potential new ones. For example, RMC 40 experienced a new maximum in 2019 and is still erupting. AE And, AF And, and WRAY 17-96 are stars that typically do not have light curves in the visible band. Additionally, spectroscopic analysis confirmed how the spectra of LBV stars vary between eruptive and quiescent states. Moreover, we obtained new spectra for WRAY 17-96, suggesting that it is likely in a quiescent state with an intense wind present.

Perspectives

1) Continous study photometric and spectroscopic observation of LBVs in both optical and IR to identify new eruptions.

2) Apply radiative transfer codes such as MOOG, CMFGEN, and HDUST for modeling the spectra of eruptive and quiescent phases.