Boletim da Sociedade Astronômica Brasileira, **34**, no. 1, 290-291

Polarimetry of the asynchronous magnetic cataclysmic variables 1RXS J083842.1-282723 and IGR J19552+0044

Fernando Falkenberg Marques[1], C. V. Rodrigues[1], Isabel de Jesus Lima[2], Julio C. N. Campagnolo[3], Ana Carolina Mattiuci Figueiredo[1], & Eder Martioli[4]

[1] Instituto Nacional de Pesquisas Espaciais (INPE) e-mail: fernando.marques@inpe.br
[2] CONICET, Universidad de Buenos Aires, Instituto de Astronomía y Física del Espacio (IAFE)
[3] Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET/RJ)
[4] Laboratorio Nacional de Astrofisica (LNA)

Abstract. In 2018 we performed three observing runs at Pico dos Dias Observatory (Brazil), using the IAGPOL polarimeter, in order to collect photometric and polarimetric time series of the objects 1RXS J083842.1-282723 and IGR J19552+0044, which are two quasi-synchronous magnetic cataclysmic variables. In this work we used for the first time a new software for astronomical data processing in Python language called ASTROPOP for the reduction of time series and circular polarization data. We are collaborating with the group responsible for improving ASTROPOP and developing automatic procedures for the reduction of the data to be obtained with the instrument SPARC4.

Resumo. Realizamos no ano de 2018 três missões no Observatório Pico dos Dias, com o polarímetro IAGPOL, dedicadas à coleta de séries temporais fotométricas e polarimétricas dos objetos 1RXS J083842.1-282723 e IGR J19552+0044, duas variáveis cataclísmicas magnéticas quase síncronas. Neste trabalho, utilizamos, pela primeira vez na redução de séries temporais e de dados de polarização circular, um novo software para processamento de dados astronômicos em linguagem Python chamado ASTROPOP. Em particular, estamos colaborando com o grupo responsável pelo aprimoramento do ASTROPOP e desenvolvimento dos procedimentos para redução automática dos dados a serem obtidos com o instrumento SPARC4.

Keywords. Infrared: stars – Instrumentation: polarimeters – Magnetic fields – Methods: observational – Polarization

1. Introduction

Magnetic cataclysmic variables (MCVs) are compact binary star systems where a red dwarf transfers mass to its highly magnetic companion, a white dwarf (WD), through Roche's lobe overflow phenomenon. MCVs can be classified, according to their magnetic fields and mass accretion rates, as polars, that have the WDs spin period ($P_{\rm spin}$) equal to the orbital period of the system ($P_{\rm orb}$), or as intermediate polars (IPs), that have typically $P_{\rm spin}/P_{\rm orb}$ of the order or equal to 0.1. Among the few hundreds known MCVs, there are four polars with $P_{\rm spin}$ different from $P_{\rm orb}$, that we call asynchronous polars (APs), and six IPs with $P_{\rm spin}/P_{\rm orb} > 0.1$, that we call near synchronous IPs. There are three other objects that show differences between $P_{\rm spin}$ and $P_{\rm orb}$ of around 3% to 20%. It is uncertain the classification of those last three objects as APs or as near synchronous IPs (see Table 1). Two of those systems, 1RXS J083842.1-282723 and IGR J19552+0044, are studied here.

1RXS J083842.1-282723 was discovered in 1996 using data from ROSAT mission and classified as a CV by Masetti et al. (2013). Furthermore, Halpern et al. (2017) and Rea et al. (2017) studied this object with great detail.

IGR J19552+0044 was identified as a MCV by Masetti et al. (2010). Thorstensen et al. (2013) acquired spectroscopic and photometric time series, but with insufficient coverage to determine the system's periods unambiguously. Bernardini (2013) studied this system in X-rays using XMM-Newton data.

As far as we know, no polarimetric study has been done regarding those two systems. Therefore, this work aims to acquire new information to further improve our knowledge about their periodicities and hence our understanding of those systems characteristics and evolution. It is expected that our data allows to a more reliable classification of those systems as APs or as near synchronous IPs.

Table 1. List containing thirteen near synchronous MCVs, in order of $P_{\rm spin}/P_{\rm orb}$ ratio (higher to lower)

Objects	$P_{\rm spin}$ (s)	$P_{\rm orb}$ (s)	$P_{\rm spin}/P_{\rm orb}$	Classification
V1432 Aquilae	12150	12116	1.002	AP
V1500 Cyg	11890	11994	0.991	Ap
CD Ind	6579	6649	0.989	AP
BY Camelopardalis	11961	12089	0.989	AP
IGR J19552+0044	4887	5016	0.974	?
1RXS J083842.1-282723	5340	5940	0.898	?
Paloma	7800	9360	0.833	?
EX Hydrae	4022	5895	0.682	IP
V598 Pegasi	2500	4987	0.501	IP
DW Cancri	2315	5166	0.448	IP
V1025 Centauri	2147	5077	0.423	IP
IGR J18173-2509	1663	5520	0.301	IP
RX J2015.6+3711	7196	45940	0.157	IP

2. Methodology

In 2018 we performed three observing runs using the IAGPOL instrument (Magalhães et al. 1996) at Pico dos Dias Observatory to collect photometric and polarimetric time series of the two objects. These data were processed using the capabilities of the ASTROnomical POlarimetry and Photometry pipeline (ASTROPOP) software in Python language (Campagnolo 2019), that includes: creation of master frames; calibration of images using master frames; gain correction; cosmic ray extraction; image sets alignment; aperture photometry; polarimetry for dual-beam polarimeters; automatic identification of ordinary and extraordinary image pairs; among other reduction procedures.

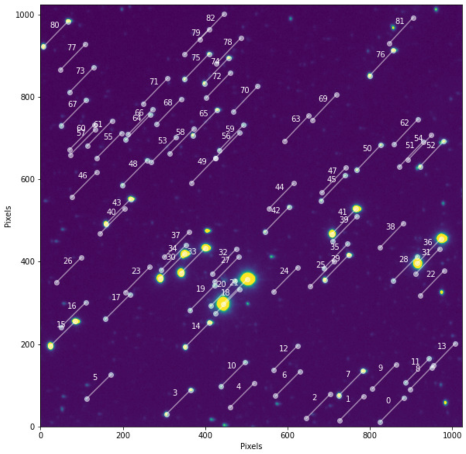

Figure 1. Image of the field of view of the standard linearly polarized star HD 110984 (brightest star in the field) obtained on 03/17/2018 in the V filter, with pairs indicated by the ASTROPOP software.

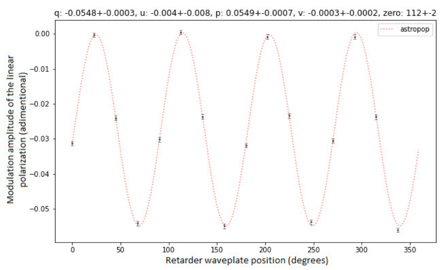

Figure 2. Modulation of the ratio between the difference of fluxes ordinary and extraordinary and the total flux as function of the retarder waveplate position of the star HD 110984 obtained on 03/17/2018.

3. Results

In order to obtain the circular polarimetry of our targets, we performed the standard procedures of bias and flat-field corrections. The polarimetric standard stars are used to determine the correction to the equatorial reference system of the linear polarization angle and calculate the zero position of the quarter-wave retarder. We also observed an unpolarized standard star in order to verify the presence of spurious instrumental polarization. Figure 1 shows one image of HD 110984 where the flux of each object are split in ordinary and extraordinary fluxes. Figure 2 is an example of the reduction of its linear polarization obtained with ASTROPOP.

For HD 110984 in the V filter we have obtained 5.49% ± 0.07% of linear polarization, which is consistent with the values found in literature (Turnche et al. 1990). The ASTROPOP software for the reduction of linear polarimetry thus proves to be reliable.

Figure 3 shows the ordinary and extraordinary polarimetric pair of 1RXS J083842.1-282723, indicated by red circles. Figure 4 shows a circular polarization of 3 ± 4% and a linear polarization of 30 ± 6% for this same object in the I filter.

4. Conclusion

Our results so far demonstrate that ASTROPOP is a suitable alternative to the use of other softwares such as IRAF. The next

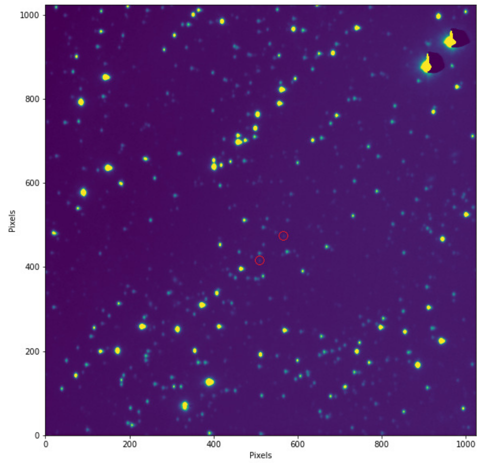

Figure 3. Image of RX0838, indicated by the red circles, obtained on 03/18/2018 in the I filter.

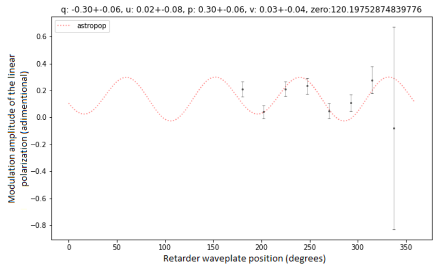

Figure 4. Modulation of the ratio between the difference of fluxes ordinary and extraordinary and the total flux as function of the retarder waveplate position of RX0838 obtained on 03/18/2018 in the I filter.

step in our research is to complete the data reduction. After that we hope to be able to better understand the nature of this class of objects.

Acknowledgements. This work was supported by the institution Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), process number 8887.600777/2021-00. CVR thanks partial support from CNPq (Proc: 310930/2021-9)

References

Bernardini, F. et al., 2013, Monthly Notices of the Royal Astronomical Society, vol. 435, p. 2822.
Campagnolo, J. C. N., 2019, Publications of the Astronomical Society of the Pacific, vol. 131, p.024501.
Halpern, J. P., Bogdanov, S., & Thorstensen, J. R. 2017, ApJ, vol. 838, p. 124. doi:10.3847/1538-4357/838/2/124
Magalhães, A. M. & Rodrigues, C. V. & Margoniner, V. E. & Pereyra, A. &Heathcole, S., 1996, Astronomical Society of the Pacific Conference Series, vol. 97, p.118.
Masetti, N. et al., 2010, Astronomy & Astrophysics, vol. 519, p. A96.
Masetti, N. et al., 2013, Astronomy & Astrophysics, vol. 559, p. A58.
Rea, N. et al., 2017, MNRAS, vol. 471, p. 2902.
Thorstensen, J. R. & Halpern, J., 2013, The Astrophysical Journal, vol. 146, p. 107.
Turnchek, D. A., 1990, Astronomical Journal, vol. 99 , p. 1243 .