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Symbiotic Stars in the Local Group of Galaxies: POINT-AGAPE Catalogue Revisited

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Abstract. This research was prompted by the discovery of 35 new or candidate symbiotic stars during a targeted search in the Local Group of Galaxies. A catalogue of a further 200 or so such objects has now been compiled. Many of them could be identified with counterparts in the POINT-AGAPE Catalogue. However, information in the Catalogue is limited to position, brightness and possible period, and light-curves are not available. The poster presented an example of a light-curve of a symbiotic star retrieved from original Point-Agape Catalogue data.

Keywords. Cataclysmic variables, binaries: symbiotic, stars: fundamental parameters

1. Introduction

Symbiotic stars (SySt) are interacting binaries comprised of an evolved star (usually a red giant) as the donor and a compact object (usually a white dwarf) as a source of ionising radiation. Not a single type Ia supernova progenitor has been observed, and it is thought that SySt, with their complex structures, could be candidates as they are a group of stars that one day may go ballistic, independently of the causes leading to their eruption (e.g. Mikołajewska 2012).

Ever since it became possible to study individual objects with sufficiently sensitive spectroscopy, it was feasible to search for SySt among a sample of the brightest stars in the Local Group of Galaxies; 35 definite or candidate objects have already been discovered in such a search (Mikołajewska *et al.* 2014). The target stars that we chose for the investigation are red objects that appear bright in Hα in the publicly available images of Local Group Galaxy Survey (LGGS, Massey *et al.* 2006, 2007; for more selection details see Mikołajewska *et al.* 2015); they were observed with the Hectospec multi-fibre positioner and spectrograph on the 6.5-m MMT telescope (Fabricant *et al.* 2005).

Additional selection criteria were constrained with the Panchromatic Hubble Andromeda Treasury (PHAT) photometric catalogue (Williams *et al.* 2014). Comparisons with our spectra obtained in the first year of collecting data enabled us to select additional possible red giants with the characteristic blue/UV excess.

2. POINT-AGAPE Catalogue

Among over 1200 objects in M 31 so far observed spectroscopically, we found 186 counterparts in the POINT-AGAPE catalogue (PAC, An *et al.* 2004). The POINT-AGAPE collaboration was focused on identifying microlensing events. A by-product was

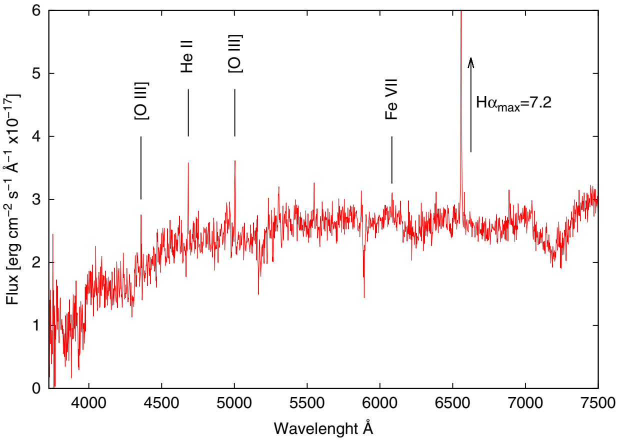

Figure 1. Spectrum of an example of a symbiotic star (see section 4).

a catalogue of 37,657 variable stars in M 31. The survey was carried out over three years, though the complete data sample contains an extra fourth-year run. The spatial coverage corresponds roughly to half of the light of this galaxy.

We used VizieR to access information in the PAC. Data accessed by VizieR are limited to position, amplitude and period. However, for long-period objects like SySt, information about periodicity could be erroneous since the periods of some SySt are longer than time-span of the project; furthermore, any variability is not necessarily periodic.

3. Extraction of Light-Curves

To recover all the crucial information required, we decided to analyse the data once more, together with previously unpublished data from that forth observing season. A complete data-set contains about 300 frames for each of 8 fields in the Sloan i' and r' colours. The data were processed as described by Darnley *et al.* (2004). Aperture photometry was performed with Source Extractor (Bertin & Arnouts 1996).

Sources from each frame were extracted independently, and then combined into light-curves to within an uncertainty of 1 pixel. That approach ensured that we did not miss any transients. To date, Northern Field #1 has been completed; about 35,000 light-curves have been extracted in both colours.

Being a semi-automatic massive light-curve extractor, our method was not free from errors; some of the light-curves proved to be artefacts that had only one data point, or they were faint objects at the very limit of detection (∼21.5 mag). Nevertheless, the vast majority are genuine objects. By the end of this project we expect to have collected more than 200,000 light-curves in both colours.

4. Sample Result

According to Azimlu *et al.* 2011, whose work was based on LGGS observations, the sample object presented here is indeed Hα bright, and fulfills our requirements for PHAT colours. However, it is not listed as Hα bright in the LGGS catalogue, and we could not confirm the presence of emission in Hα in the publicly available LGGS frames obtained in 2001.

Spectra collected during three observing seasons were normalised to I magnitude (see (Fig. 1). Since they do not show any significant changes in either the continuum or the emission lines (see Fig. 3), they could be smoothed by using the average of three consecutive points.

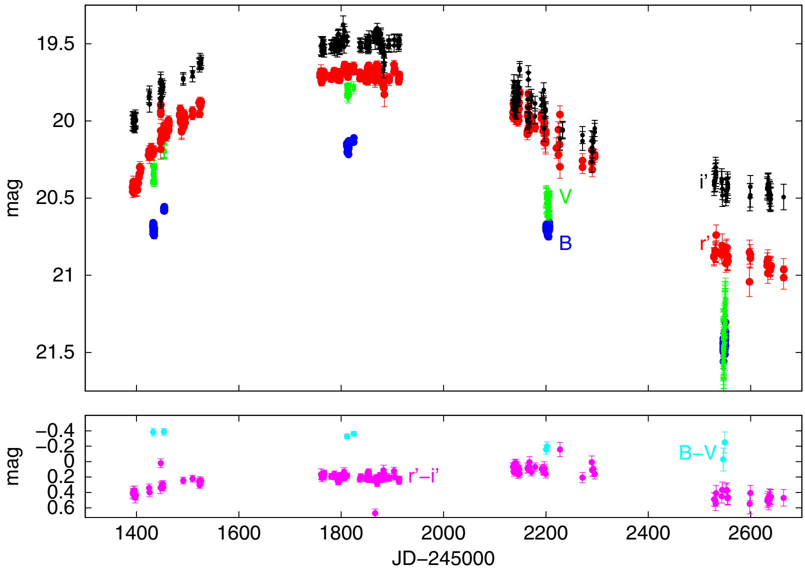

Figure 2. *Upper:* Light-curve of a new symbiotic star. Symbols, ranged upwards, represent measurements in B (lowest), V (Vilardell *et al.* 2006), then r' and i' (highest) respectively (this work). *Lower:* Colour changes in $(B–V)$ (upper symbols) and in r' - i' (lower symbols).

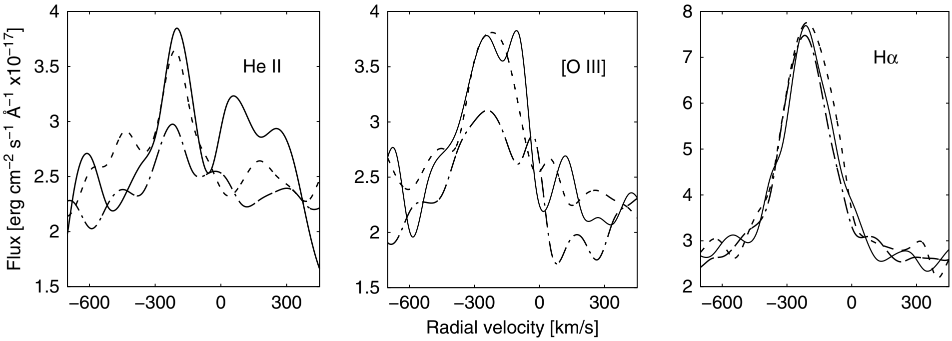

Figure 3. From left to right: Changes in He II λ 4686 Å, [O III] λ 5007 Å and Hα emission-line profiles, presented in radial-velocity space. Solid, dashed and dot-dashed lines correspond to observations made on 2015 Sept. 18, 2015 Dec. 11 and 2016 Oct. 6, respectively.

The object exhibits a bright He II line and has a spectral type of M3 III (according to Kenyon & Fernandez-Castro 1987), so by applying the classification criteria outlined in Mikołajewska *et al.* (2015) we could label it SySt. Its counterpart can be found in the original PAC catalogue, where it is listed as having a period of 897 days. However, our re-analyses show a much longer period (Fig. 2).

Changes in the light-curve resemble an asymmetric wave-like modulation of a period P ∼2700 days with amplitude ∼1 mag in all colours. Long periods of $\geqslant$ 1500 days have been observed in several others SySt (Gromadzki, Mikołajewska, & Soszyński (2013) and references therein). In only some of the cases have the causes of those changes been correlated with radial-velocity changes and orbital motion. Since the resolution of our spectra is too low to detect any velocity changes in absorption bands, we cannot offer any conclusive explanation for this photometric behaviour.

The general shape of the light-curve agrees with data from Vilardell *et al.* 2006. Their catalogue covers roughly the same baseline as PAC, but in V and B bands. They found a

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period of $P = 83$ days for this object, although we were unable to confirm it with either our own data or with theirs. Nonetheless, the B and V light-curves clearly follow the changes that we observed in r' and i'.

We commenced collecting spectroscopic data for this object in 2015 – almost exactly two cycles after the first maximum observed in PAC (assuming $P = 2700$ d). We obtained three spectra of this object within one year. Fig. 3 shows changes in the three most prominent emission lines (He II 4686, [O III] 5007 and Hα). Since maximum brightness lacks a sharp peak and lasts for about a year, it is unfortunately not easy to detect any significant changes; most of the changes we see can readily be attributed to noise, or the generally low spectral resolution.

Acknowledgments

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References

An, J., *et al.* 2004, *MNRAS*, 351, 1071
Azimlu, M., Marcinak, R., Barmby, P. 2011, *AJ*, 142, 139
Bertin, E. & Arnouts, S. 1996, *A&AS*, 117, 393
Darnley, M., *et al.* 2004, *MNRAS*, 353, 571
Fabricant, D. *et al.* 2005, *PASP*, 117, 1411
Gromadzki, M., Mikołajewska, J. & Soszyński, I. 2013, *AcA*, 63, 405
Kenyon, S., & Fernandez-Castro, T. 1987, *AJ*, 93, 938
Massey, P. *et al.* 2006, *AJ*, 134, 2474
Massey, P. *et al.* 2007, *AJ*, 131, 2478
Mikołajewska, J. 2012, *Baltic Astron.*, 21, 5
Mikołajewska, J., Caldwell, N., & Shara, M. M. 2014, *MNRAS*, 444, 586
Mikołajewska, J. *et al.* 2015, *EAS Publications Series*, Vol. 71–72, p. 199
Vilardell, F., Ribas, I., & Jordi, C. 2006, *A&A*, 459, 321
Williams, B. F., *et al.* 2014, *ApJS*, 215, 9