

## NSV 1907 - A new eclipsing, nova-like cataclysmic variable



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### HIGHLIGHTS

- A spectrum and multicolour photometric observations are presented for NSV 1907.
- NSV 1907 was identified as a deeply eclipsing, nova-like cataclysmic variable.
- We find  $P_{orb} = 0.2761069$  days and establish the presence of a secondary minimum.
- We propose NSV 1907 as a new moderately bright long-period SW Sextantis star.
- We find a possible 4.2 day period (the nodal precession period of the disc?).

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### ABSTRACT

NSV 1907, formerly listed as an irregular variable in variability catalogues, was classified as an Algol-type eclipsing binary in the Catalina Surveys Periodic Variable Star Catalogue. We have identified NSV 1907 as an ultraviolet (UV) bright source using measurements from the GALEX space telescope and detected obvious out-of-eclipse variability in archival photometric data from the Catalina Sky Survey, which instigated a closer examination of the object. A spectrum and extensive multicolour photometric observations were acquired, from which we deduce that NSV 1907 is a deeply eclipsing, nova-like cataclysmic variable. Apart from the orbital variations (deep eclipses with a period of  $P \approx 6.63$  hours), changes in mean brightness and irregular short-term variability (flickering) were observed. The presence of a secondary minimum at phase  $\varphi \approx 0.5$  was established, which indicates a significant contribution of the companion star to the optical flux of the system. We find possible evidence for sinusoidal variations with a period of  $P \approx 4.2$  d, which we interpret as the nodal precession period of the accretion disc. No outbursts or VY Scl-like drops in brightness were detected either by the CSS or during our photometric monitoring. Because of its spectral characteristics and the observed variability pattern, we propose NSV 1907 as a new moderately bright long-period SW Sextantis star. Further photometric and spectroscopic observations are encouraged.

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### 1. Introduction

Cataclysmic variables (CVs) are interacting binary systems which comprise a low-mass secondary star (mostly a red dwarf) losing material to a white dwarf (WD) primary star. They exhibit complex photometric variability, which is characterised by a variety of phenomena like e.g. eclipses, rapid oscillations, ellipsoidal

modulation and abrupt and conspicuous brightenings (i.e. dwarf nova eruptions or nova outbursts). Other tell-tale signs of CVs are the presence of strong emission lines in their optical spectra, their blue colour and, especially in the case of magnetic CVs, their X-ray luminosity, all of which are made good use of in searches for this kind of variable stars. For a general review of CVs, the reader is referred to Warner (1995) and Hellier (2001).

Nova-like cataclysmic variables are characterised by high mass transfer rates and prominent steady state accretion discs and do not show large amplitude outbursts. Among this subgroup of CVs,

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the SW Sextantis stars are set apart by several common traits, which include unusual V-shaped eclipse profiles, single-peaked emission lines exhibiting central absorption dips around orbital phases  $\varphi \approx 0.4 - 0.7$ , a substantial orbital phase lag (0.1–0.2 cycle) of the radial velocities of the Balmer lines and high-velocity emission S-waves with maximum blueshift near phase  $\varphi \approx 0.5$  (Thorstensen et al., 1991; Rodríguez-Gil et al., 2007b). SW Sex systems are not rare but dominate in the period range  $2.8 \leq P_{orb} \leq 4$  hours (Rodríguez-Gil et al., 2007a; Schmidtbreick et al., 2012), just above the period gap. Recently, evidence has been mounting that the SW Sex phenomenon is an evolutionary stage in the life of CVs (Schmidtbreick et al., 2012).

Optical transient surveys such as the Catalina Real-time Transient Survey (CRTS; Drake et al., 2009) and the All-Sky Automated Survey for SuperNovae (ASAS-SN1; Shappee et al., 2014) are routinely discovering new dwarf novae by the hundreds through detection of their outbursts. Equally, X-ray observatories like e.g. ROSAT (Voges et al., 1999), INTEGRAL (Ubertini et al., 2003) or Swift (Cusumano et al., 2010) have contributed to the discovery of many magnetic CVs.

However, our knowledge of the intrinsic population of the nova-like CVs, which neither show large amplitude outbursts nor the X-ray emission typical of their magnetic brethren, is probably still rather incomplete. Here we outline a new method of identifying nova-like variables, and report the identification of NSV 1907 as a candidate moderately bright long-period SW Sex star. The method of identification and observations of our target star are presented in Section 2. Our data analysis is described in Section 3 and we conclude in Section 4.

## 2. Method of identification and observations

### 2.1. Method of identification

As has been pointed out above, nova-like cataclysmic variables are difficult to identify because of the absence of large-scale outbursts that are readily detected by optical transient surveys. However, the optical spectra of nova-like stars, including the SW Sex stars, are characterised by very blue continua. It is therefore not surprising that a substantial fraction of this class of variables has been discovered in ultraviolet (UV) excess surveys (Rodríguez-Gil et al., 2007a).

As a starting point in the search for nova-like CVs, we have investigated the extensive sample of variable stars compiled in the Catalina Surveys Periodic Variable Star Catalogue (Drake et al., 2014) using UV photometry from the GALEX (Galaxy Evolution Explorer Space Telescope; Martin et al. 2005) satellite, which has been monitoring the sky in *FUV* (1344 – 1786 Å,  $\lambda_{eff} = 1538.6$  Å) and *NUV* (1771 – 2831 Å,  $\lambda_{eff} = 2315.7$  Å) simultaneously (Morrissey et al., 2007). To this end, both source catalogues were cross-matched and the resultant list of objects was investigated in *FUV* vs. *NUV* color space. The result is shown in Fig. 1.

Groups of interest were identified, like e.g. post-common envelope binaries (class code '16' in Drake et al. 2014; denoted by open squares in Fig. 1) and definite or probable SW Sex stars from the 'Big List of SW Sextantis Stars' (Hoard et al., 2003)<sup>1</sup> (represented by filled triangles in Fig. 1). UV bright objects situated near the expected loci of nova-like CVs were investigated in more detail. We concentrated in particular on stars that had been classified as short-period eclipsing binaries in the Catalina Surveys Periodic Variable Star Catalogue, which brought to our attention NSV 1907 (*FUV* = 16.028 mag; *NUV* = 16.043 mag; *FUV* – *NUV*)  $\approx 0$ ; position indicated by the grey square marked with a cross in Fig. 1).

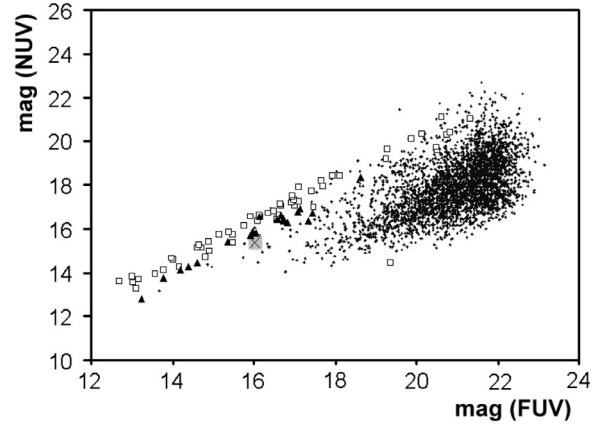


Fig. 1. *FUV* vs. *NUV* diagram of all sources in the Catalina Surveys Periodic Variable Star Catalogue (Drake et al., 2014) with good GALEX photometry. Post-common envelope binaries are denoted by open squares. Definite or probable SW Sextantis stars from the 'Big List of SW Sextantis Stars' (Hoard et al., 2003) are represented by filled triangles. The grey square marked with a cross indicates the position of NSV 1907.

Inspection of the corresponding light curve from the Catalina Sky Survey (CSS; Drake et al. 2009) resulted in the detection of obvious out-of-eclipse variability, which instigated a closer examination of the object.

### 2.2. Target star

The variability of GSC 00104-02193 = USNO-B1.0 0935-0067535 = 2MASS J05165408+0332525 (RA, Dec (J2000) = 05h 16m 54s.085, +03° 32' 52".45; UCAC4 position) was discovered by C. Hoffmeister on Sonneberg plates and the star was announced as a long-period variable with an amplitude of 0.5 mag (Hoffmeister, 1963). The star was primarily designated as S 8003 and later included in the New Catalogue of Suspected Variable Stars (Kukarkin and Kholopov, 1982) as NSV 1907. No more information on the type of variability had been available until the object was included in the Catalina Surveys Periodic Variable Star Catalogue (Drake et al., 2014) under the designation of CSS J051654.1+033252 and classified as an Algol-type eclipsing binary (GCVS-type EA) with a period of  $P = 0.2761060$  d and an eclipse depth of 1.10 mag.

### 2.3. Archival photometry

Archival photometry of NSV 1907 was procured from the CSS, which observed NSV 1907 during a timespan of about 2915 days. 283 observations of NSV 1907 are available in Data Release 2, which were downloaded from the corresponding website<sup>2</sup>. Magnitudes derived from the CSS are unfiltered values that have been calibrated against V-band magnitudes and are designated hereafter as 'mag (CV)'. The CSS light curve is shown in Fig. 2. The corresponding phase plot, folded with the ephemeris given in Drake et al. (2014), is given in Fig. 3. Note the obvious out-of-eclipse variability and the irregular depression suggestive of a shallow secondary minimum at phase  $\varphi \approx 0.5$ . Also included are the CSS light curves of three constant, nearby stars of similar magnitude (C1 = CSS J051653.6+033028; C2 = CSS J051648.0+033034; C3 = CSS J051651.3+033311; the light curves of C2 and C3 have been offset by respectively -1.0 mag and -1.8 mag to match the light curve of C1). The constancy of their light curves gives credit

<sup>1</sup> <http://www.dwhoard.com/biglist>

<sup>2</sup> <http://nesssi.cacr.caltech.edu/DataRelease/>

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