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# First multi-colour photometric study of the short period K-type contact binary NSVS 2701634

M. Martignoni[a], F. Acerbi[b,*], C. Barani[c]

[a] Via Don G. Minzoni 26/D, 20020 Magnago (MI), Italy
[b] Via Zoncada 51, 26845 Codogno (LO), Italy
[c] Via Molinetto 35, 26845 Triulza di Codogno (LO), Italy

## HIGHLIGHTS

- We present the first multi-color light curve analysis of the eclipsing binary star NSVS 2701634.
- The orbital period variation are studied for the first time.
- The system belong to the W-subtype W Ursae Majoris systems.
- Its spectral type K makes interesting this study on NSVS 2701634.
- Both the components of NSVS 2701634 follow the general pattern of the W-subtype systems in the logM-logL diagram.

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## ABSTRACT

We present the first CCD sets of complete light curves for the W Ursae Majoris W-type system NSVS 2701634. The observations were performed in the B, V and $I_c$ bands using the 0.25 m telescope of the "Stazione Astronomica Betelgeuse" Italy, during 8 nights in April 2015.

From our observations we were able to confirm and revise the short-period (0.24 days) variation found by Shaw and collaborators in their online list (http://physast.uga.edu/~jss/nsvs/) of periodic variable stars found in the Northern Sky Variability Survey.

Using our 12 times of minimum light, the orbital period variations of NSVS 2701634 are studied for the first time. The general trend of the (O-C) curve reveals that its period is varying by a downward parabola that means that period is decreasing, this fact could be explained by a mass transfer between the components of the system.

The light curves were modelled using the Wilson–Devinney code and the elements obtained from this analysis are used to compute the physical parameters of the system in order to study its evolutionary status.

A reasonable fit of the synthetic light curves of the data indicated that NSVS 2701634 is an late-type (K3−K4+K6) contact binary system of W-Subtype of the W Ursae Majoris systems, with a mass ratio of $q = 2.60$, a degree of contact factor $f = 15.3\%$ and inclination $i = 72°$. The light curves show asymmetries at the maxima that are fitted adding an hot spot on the surface of the more massive star, known as inverse O'Connell effect.

From an estimation of the absolute dimensions of the system and from the log$M$-log$L$ diagram, it is seen that both components of NSVS 2701634 follow the general pattern of the W subtype W Ursae Majoris systems.

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## 1. Introduction

Contact binary systems are believed to be formed from initially detached binaries with orbital periods of a few days, which are losing angular momentum (AML) (Vilhu, 1981; Rahunen, 1981; Ruciński, 1982; Li et al., 2004a).

* Corresponding author. Tel.: +3937733054; fax: +3937733054.
*E-mail addresses:* massimiliano.martignoni@alice.it (M. Martignoni), acerbifr@tin.it (F. Acerbi), cvbarani@alice.it (C. Barani).

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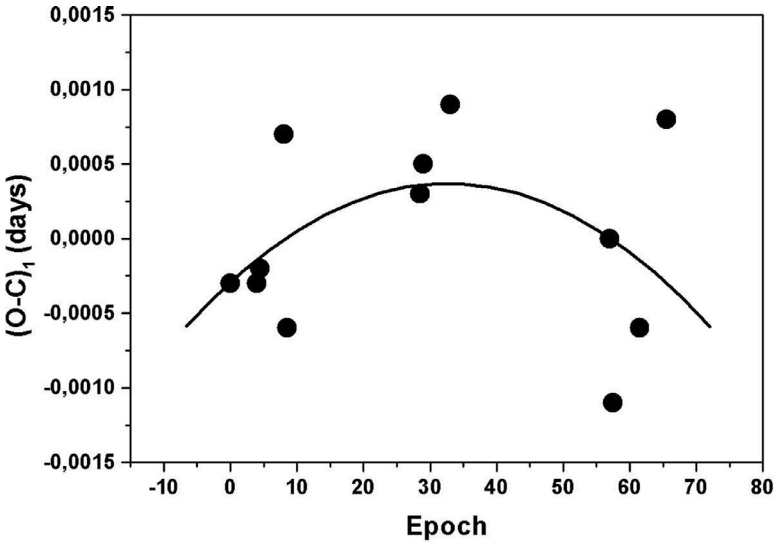


**Fig. 1.** O-C diagram of NSVS 2701634 with respect to the second order polynomial fit of the ephemeris (1).

**Table 1**
CCD times of minima of NSVS 2701634.

| HJD | Epoch (1) | O-C(1) | Error |
|---|---|---|---|
| 2457120.3909 | 0.0 | −0.0003 | 0.0015 |
| 2457121.3698 | 4.0 | −0.0003 | 0.0027 |
| 2457121.4922 | 4.5 | −0.0002 | 0.0037 |
| 2457122.3496 | 8.0 | 0.0007 | 0.0015 |
| 2457122.4707 | 8.5 | −0.0006 | 0.0014 |
| 2457127.3659 | 28.5 | 0.0003 | 0.0015 |
| 2457127.4884 | 29.0 | 0.0005 | 0.0008 |
| 2457128.4677 | 33.0 | 0.0009 | 0.0014 |
| 2457134.3400 | 57.0 | 0.0000 | 0.0008 |
| 2457134.4612 | 57.5 | −0.0011 | 0.0012 |
| 2457135.4406 | 61.5 | −0.0006 | 0.0011 |
| 2457136.4208 | 65.5 | 0.0008 | 0.0011 |

The evolutionary expansion of the more massive component together with the orbital shrinkage due to AML should result in a mass transfer whereby a contact system is formed (Stępień, 2006; Stępień and Gazeas, 2012).

The majority of W-type contact binaries show shallow contact characteristics (Zhu et al., 2010). Studies on close binary stars can provide some invaluable information for testing the thermal relaxation oscillation theory (TRO theory) (Lucy, 1976; Flannery, 1976; Robertson and Eggleton, 1977; Li et al., 2004a; 2004b; 2005; Yakut and Eggleton, 2005).

During the contact phase, the TRO model predicts that the binaries could evolve in a cycle around the marginal contact state, oscillating between contact and semi-detached configurations and alternatively show EW and EB light curves (Zhu et al., 2010). It is supposed that a large number of short-period contact binaries may be W-type systems of spectral type K.

Recently, Liu et al. (2014) argued that K-type contact binaries with very short periods (periods shorter than 0.3 days) are important objects for explaining the period cutoff phenomenon. Among them, however, only a few systems are well studied, especially the binaries with periods shorter than 0.25 days.

This makes our study on this K-type system interesting.

NSVS 2701634 (TYC 4171-779-1) was revealed to be variable by Shaw et al., in their online list (http://hal.physast.uga.edu/~jss/nsvs/) of periodic variable stars found in the Northern Sky Variability Survey (NSVS, Woźniak et al. (2004), see also http://skydot.lanl.gov/nsvs). The first period estimate was indicated as

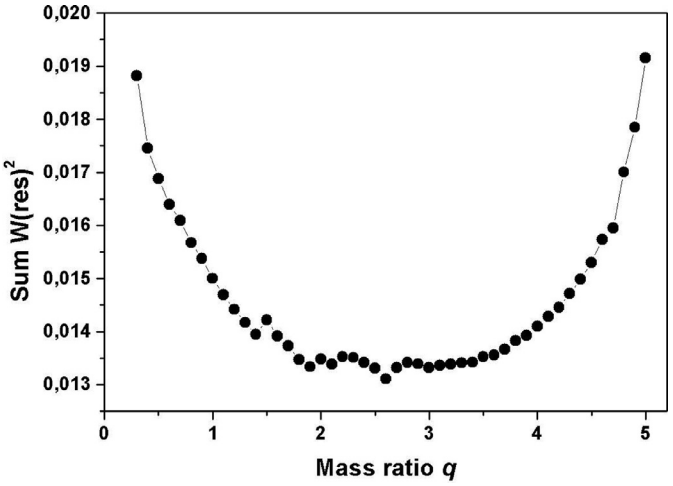


**Fig. 2.** The relation $\Sigma(res)^2$ versus mass ratio q in Mode 3 in the WD code for NSVS 2701634.

$P = 0.24473771$ days and the type of variability was suggested as W UMa system. No further observations were published since its discovery.

In this paper, multi-color charge-coupled device (CCD) observations are presented in order to study the period variation and to find a photometric solution which would define the Roche configuration and the orbital parameters of the system. The multi-color light curves are analysed by the Wilson–Devinney method (Wilson and Devinney, 1971; Wilson, 1990; 1994; Wilson and van Hamme, 2004).

## 2. Observations and data reduction

The measurements were collected by one of us (MM) using the instruments of the "Stazione Astronomica Betelgeuse" (MPC code B75) located in Magnago, Italy, consisting in a 0.25 m f/10 Schmidt–Cassegrain telescope equipped with a Kodak KAF-0261E CCD Camera (512x512 pixels of 20x20 micron), 16 bit A/D converter, without antiblooming gate. The raw images were reduced using Astronomical Image Processing for Windows (AIP4Win) code by Richard Berry and James Burnell; data reduction (dark subtraction, flat field division) and automatic aperture photometry of

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