

# M-dwarf stars eruptive activity monitoring – flare in GJ 3236 Cas eclipsing binary

L. Šmelcer, L. Lenža

Valašské Meziříčí Observatory, Valašské Meziříčí, CZ,  
E-mail of the author: lsmelcer@astrovm.cz

## Summary:

In this paper we introduce already existing project of Valašské Meziříčí Observatory focused on eruption activity monitoring of red dwarfs in eclipsing binaries. We present R-band photometry of GJ 3236 Cas, Algol-type eclipsing binary of spectral class M4. A noticeable brightening was observed on March 20, 2014 and April 17, 2014 both near secondary minima of binary. These intense and rapid flares are most likely a manifestation of eruptive activity of the star.

## Introduction

Red dwarfs of spectral class M with mass less than 0.6 solar masses are the most abundant group of stars in our galaxy. To date is known only about twenty eclipsing binaries, where both components are red dwarfs, because this low luminosity systems are quite difficult to uncover. Using high dispersion spectroscopy it is possible to determine basic parameters of the components with an accuracy of about 1%. This is sufficient for evolutionary modeling of these stars, which also play a key role in our understanding of stellar physics of main sequence stars at the bottom part of the HR diagram.

Massive convection affects the significant part of the atmosphere of red dwarfs and generates a strong magnetic field, source of the high activity, which manifests itself due intensive flares probably originating in the chromosphere and the corona of red dwarfs.

## GJ 3236 Cas

Star GJ 3236 Cas was for the first time mentioned in the *Third Catalogue of Nearby Stars - Gliese* (Gliese, W. 1991) (1). In 1995, Hawley, S.L., et al. (2) published spectroscopic survey of M class dwarfs in the northern hemisphere. In 1999 (3) Hunsche, M. et al. included GJ 3236 Cas in the catalog of nearby stars observed by satellite ROSAT and since then is this object listed also as X-ray source. Gershberg, R. E. et al. (4) in 1999 issued Catalogue of UV Cet-type flaring stars in the solar neighborhood, where GJ 3236 Cas is also shown.

In January 2008, long-term photometric data obtained during Mearth observing campaign (whose main goal was to discover transiting super-Earths around M class dwarfs) revealed GJ 3236 Cas as an eclipsing binary. Irwin et al. published in this paper (5) the basic parameters of both stars: orbital period is 0.77126 days (first observed minimum HJD = 2454734.9959); mass of primary component was determined as  $0.376 \pm 0.017 M_{\odot}$  (secondary  $0.281 \pm 0.015 M_{\odot}$ ), radius of the primary as  $0.3828 \pm 0.0072 R_{\odot}$  (secondary  $R_{\odot} 0.2992 \pm 0.0075$ ) and temperatures  $T_1 = 3280$  K and  $T_2 = 3205$  K. Also based on spectroscopic data the synchronous rotation of both stars with an orbital period was derived.

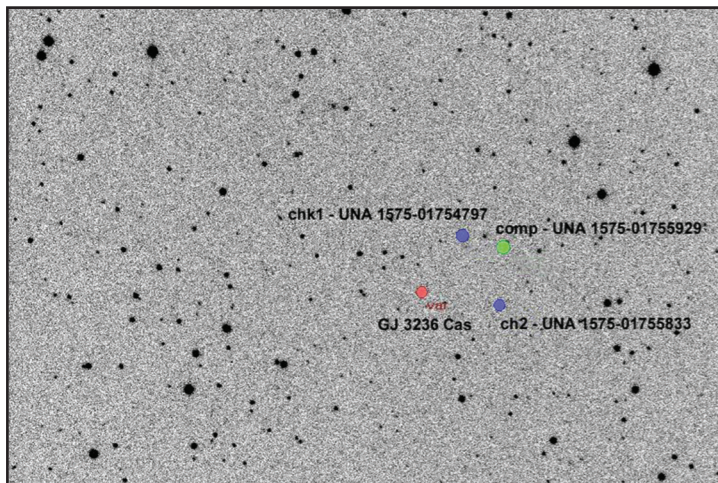


Figure 1: Starfield around GJ 3236 Cas (red dot) with comparison and check stars (green and blue).

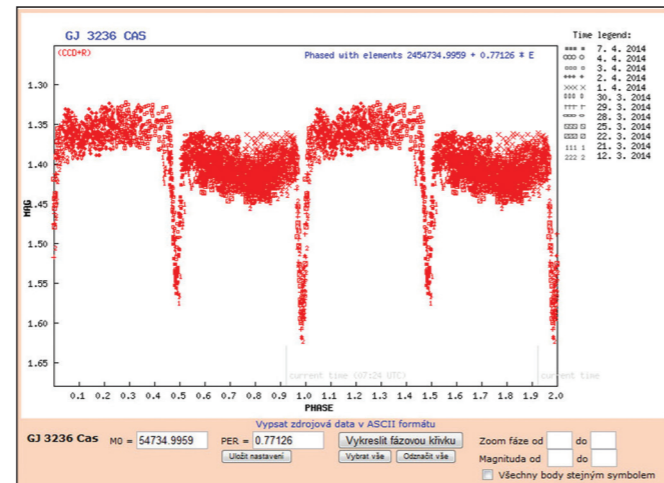


Figure 2: Phase curve showing CCD R-band data obtained from March 12, 2014 to April 7, 2014. Besides primary and secondary minima the modulation of brightness is also visible. Period of modulation is equal to orbital period.

## Instruments, observations and methodology

Presented observations have been obtained on Valašské Meziříčí Observatory using a 254 mm f/4.7 Newtonian reflecting telescope and G2–402 CCD camera (Moravian Instruments) with KAF-0402ME sensor (768x512 pixels, square pixel linear dimension 9  $\mu\text{m}$ ). All of the frames have been taken with photometric Johnson-Cousins R-band filter. Exposure time was 60 s.

GJ 3236 Cas was observed during 20 nights from March 12, 2014 to May 12, 2014. Between March 12 and April 17 the star was observed 76 hours of total time and this time span represents about 8,7 % of the interval. During this period – on March 20 and April 17 – two intense brightening were recorded.

Data were analysed as follows: all frames have been reduced in software package C-Munipack (6) – dark frame calibrated and flat-field corrected. Differential aperture photometry has been performed also in C-Munipack. Comparison stars are UNA 1575-01755929 (comp), UNA 1575-01754797 (chk1) and UNA 1575-01755833 (ch2).

## Optical flares

From the recent observations the best documented dwarf eclipsing binary with optical outbursts are *CU Cnc* and *CM Dra*. S. B. Qian (2012) reported CCD R-band photometry of *CU Cnc* flare on October 28, 2009 using the 60-cm telescope at the Yennan Observatory. Brightening had amplitude 0.52 mag, duration 73 minutes and characteristic flare shape – rapid increase in pulse phase followed by a gradual decline. With 90 seconds exposure time maximum increase duration can be estimated to about 12 minutes. It is interesting that this eruption was observed almost at the time of primary minimum; therefore this event was most likely associated with secondary component. Subsequently three other small outbursts were observed with duration of 3 minutes and the average amplitude of 0.046 mag.

As a definition of the flare the following criteria were accepted: event has to take several minutes, has to be covered by more than one point and the peak amplitude should not be less than 0.03 magnitude.

Also star *CM Dra* is known due its relatively high activity. Photometric monitoring lasting over 155 hours carried out in the years 1996-1997 recorded three eruptions within one month (from August 9, 1997 to September 6, 1997). Nelson and Coton (IBVS 5789 - 2007) recorded 6 eruption during six days in the course of campaign lasting 105 hours, both roughly during four orbital periods and in a relatively narrow range of orbital phase 0.26 to 0.52. This suggests that the flares occurred in one large active region. All flares were observed in R-band, while most of this high-energy events are usually observed in other photometric bands U, B and V. Flares in eclipsing binaries were reported previously (Eggen, 1967, Lacy, 1977, Metcalfe 1996, Kim 1997, Kozhevnikov 2004) with amplitudes in the range from 0.02 to 0.7 magnitudes of frequency 0.05 to 0.02 flare per hour.

## Optical brightening GJ3236 Cas

Until now no other observation of the flare for these eclipsing binaries was published, although in M. Irwin et al. (5) (Figure 3, phase curves GJ 3236) are two prominent overshooting points on the light curve, which could be interpreted as decline of flare.

The first brightening was recorded on March 20, 2014 at 22h 03m 13s UT (JDG = 2,456,737.41890). Lasted approximately 12 minutes with amplitude at least 0.4 magnitude. This event was followed by a smaller one with a maximum brightening time 22h 24m 59s UT (JDG = 2456737.43401) and amplitude of less than 0.1 mag. The event occurred at the phase 0.31185, then 3h 29m before observed secondary minimum.

The second brightening was recorded on April 17, 2014 in 23h 17m 29m UT (JDG = 2,456,765.47048). It took four minutes with an amplitude at least 0.3 magnitude. Event occurred at the phase of 0.6813, thus 3h 21m after observed secondary minimum.

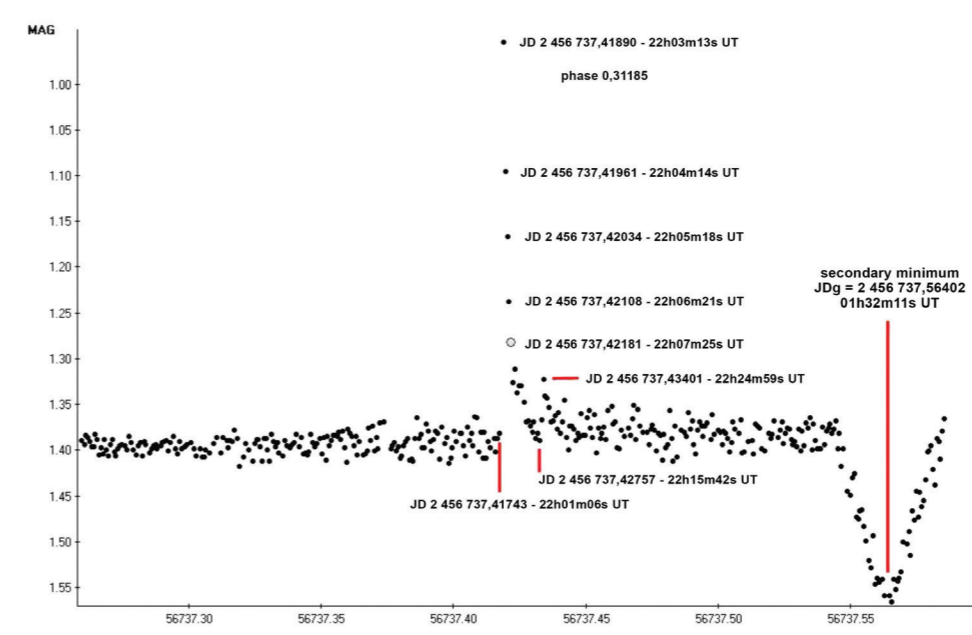


Figure 3: Light curve of GJ3236 Cas eclipsing binary from March 20, 2014 (JD 2456737) with a sudden brightening lasting for 12 minutes. Secondary minimum is following. Data were taken in R-band with a Newtonian telescope (d = 254 mm, f/4,7) and G2-CCD camera.

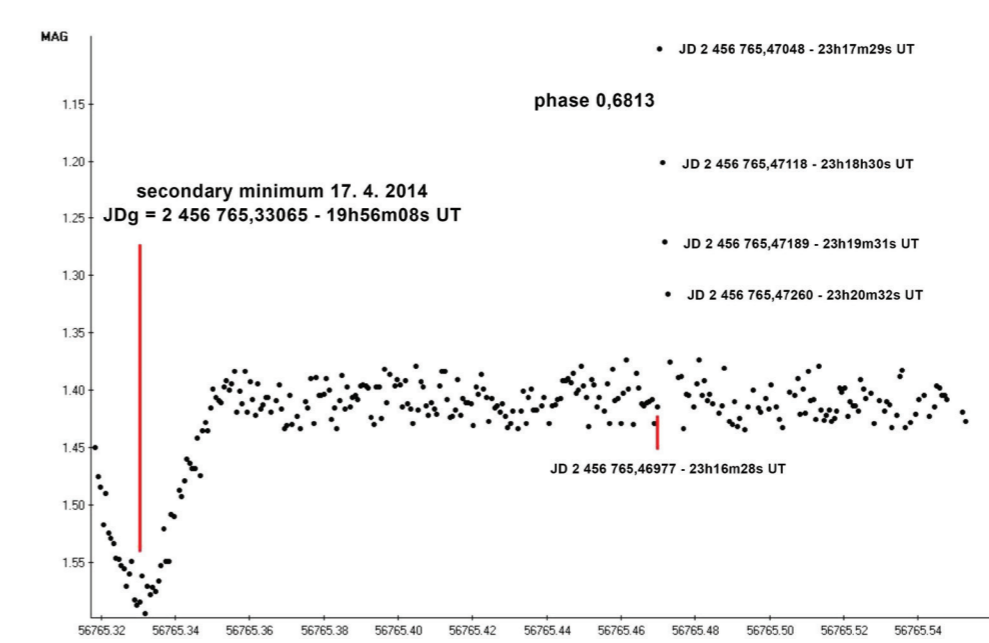


Figure 4: Light curve of GJ3236 Cas eclipsing binary from April 17, 2014 (JD 2 456 765) with a sudden brightening lasting for about 4 minutes. Data were taken in R-band with a Newtonian telescope (d=254 mm, f/4,7) and G2-CCD camera.

After further data processing we were able to detect modulation of the light curve differing from eclipses and flares. Data were analyzed with Peranso program (7) version 2.5. Amplitude period of 0.7712 day was found, which exactly corresponds to the orbital period. The amplitude of modulation was found to be in range 0.05 magnitude.

We assume that these changes in brightness are most likely connected with large spots on the surface of the star, periodically appearing and disappearing due orbital geometry. Generally, more spots are expected on the warmer primary star, which can modulate the light curve of the system between the eclipses. Since the brightness modulation minima occurs approximately at the binary phase of 0.8, that is, when near side of the primary component relative to the observer is visible, the spots are likely to reside on the primary component. This fact, among others, confirms the previously determined binary system with bound rotation.

## Conclusion

In this poster we present observational results of flares in dwarf eclipsing binary star GJ 3236 Cas. During March and April 2014 two distinctive flares were recorded. On the phase light curve is apparent modulation with amplitude of 0.05 magnitudes and period equal to the orbital period of the eclipsing binaries. This modulation is most likely due to the presence of spots on surface one of the stars. In the following months we plan further monitoring of this star and other similar eclipsing systems.

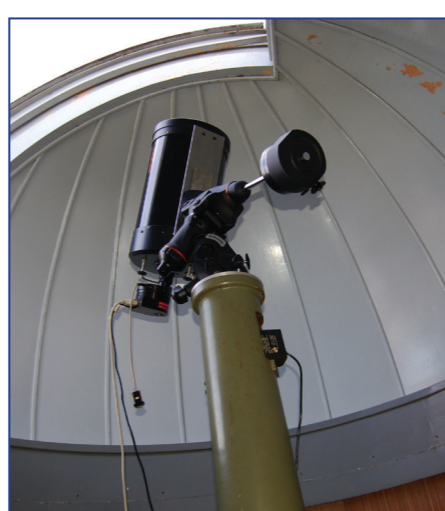
## References:

- (1) *Preliminary Version of the Third Catalogue of Nearby Stars - Gliese*, W.; Jahreiß, H. (1991)ad.c...G)
- (2) *The Palomar/MSU Nearby Star Spectroscopic Survey, II. The Southern M Dwarfs and Investigation of Magnetic Activity*, Hawley, Suzanne L.; Gizis, John E.; Reid, I. Neill (1996AJ...112.2799H)
- (3) *The ROSAT all-sky survey catalogue of the nearby stars*, Hünsch, M.; Schmitt, J. H. M. M.; Sterzik, M. F.; Voges, W. (1999A&AS..135..319H)
- (4) *Catalogue and bibliography of the UV Cet-type flare stars and related objects in the solar vicinity*, Gershberg, R. E.; Katsova, M. M.; Lovkaya, M. N.; Terebizh, A. V.; Shakhovskaya, N. I. (1999A&AS..139..555G)
- (5) *GJ 3236: A New Bright, Very Low Mass Eclipsing Binary System Discovered by the MEARTH Observatory*, Irwin, Jonathan; Charbonneau, David; Berta, Zachory K.; Quinn, Samuel N.; (2009ApJ...701.1436I)
- (6) *C-Munipack*, Motl, D., 2009, <http://c-munipack.sourceforge.net/>
- (7) *Program PERANSO 2.5*, Tonny Vanmunster, CBABelgium.com, 2004-2006

## Observation site - Valašské Meziříčí Observatory, Czech republic



„South dome“ - telescope Newton 254/1200 + CCD G2 402 (Moravian Instruments)



„West dome“ - telescope Celestron 280/1765 + CCD G2 4000 (Moravian Instruments)



„East dome“ - telescope Celestron 355/2460mm + CCD G2 1600 (Moravian Instruments).



„South“ bulding of Valašské Meziříčí Observatory.



Main bulding of Valašské Meziříčí Observatory.