# Searching for optical flickering in 3 symbiotic stars *

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**Abstract.** We observed the symbiotic systems NQ Gem, ZZ CMi and BF Cyg in the period January – March 2011 with the 60-cm telescope of the Rozhen National Astronomical Observatory in $B$-band. In our monitoring these systems did not show flickering. However, the systems ZZ CMi and BF Cyg demonstrated low (below 0.01 mag), but statistically significant intra-night parabolic trend of variability, while NQ Gem did not.
**Key words:** stars:binaries:symbiotic – stars:individual:ZZ CMi, BF Cyg, NQ Gem

## Introduction

Symbiotic stars are interacting binaries composed of an evolved red giant or Mira-like variable, and a hot component – white dwarf, subdwarf, neutron star or Main Sequence star. The compact object accretes hydrogen-rich material from the stellar wind of the mass-donor star. This material powers activity, including occasional eruptions and jets.

The flickering is stochastic light variations on timescales of a few minutes with an amplitude of a few tenths of a magnitude. The flickering is observed in three types of binary systems that contain white dwarfs – cataclysmic variables, supersoft X-ray binaries and symbiotic stars (Sokoloski 2003). Among $\sim 200$ symbiotic stars, only 8 present flickering - RS Oph, T CrB, MWC 560, V2116 Oph, CH Cyg, RT Cru, o Cet and V407 Cyg (Dobrzycka, Kenyon & Milone 1996; Sokoloski, Bildsten & Ho 2001; Gromadzki et al. 2006).

## 1 Observations and processing

The symbiotic stars NQ Gem and ZZ CMi were observed on the night of 2011 January 25/26. Another symbiotic star, BF Cyg, was observed on the night of 2011 March 27. The observations were performed with the 60-cm Cassegrain telescope at Rozhen National Astronomical Observatory, equipped with a FLI PL09000 CCD with 3056 x 3056 pixels and field of view 18' x 18'. All observations were performed in $B$-band.

IRAF[1] standard packages were used for data reduction and aperture photometry. Table 1 represents the log of the observations and the results of the processing are summarized in Table 2.

Fig. 1 shows the observnal results. All light curves show intra-night trends and they are fitted here with second-order polynomials. The RMSD of the

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[1] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

light curves in respect to their mean values, $s_0$, and the RMSD of the light curves in respect to their second-order polynomials $s_2$, are given in Table 2.

We apply F-tests to verify the statistical significance of the original variability, characterized by $s_0$, in comparison with the residual variability, characterized by $s_2$, through the ratio $s_0/s_2$ (given also in Table 2).

**Table 1.** Log of the observations of the symbiotic stars: date of the observation, name of the observed star, UT of start and end of run, total time duration of run, single exposure time, number of CCD frames obtained and mean IRAF-DAOPHOT photometric error.

| Date | Star | UT start-end | Run duration [min] | Exp-time [sec] | N | Err [mag] |
|---|---|---|---|---|---|---|
| 2011 Jan 25 | ZZ CMi | 20:34–22:29 | 115 | 60 | 113 | 0.007 |
| 2011 Jan 25/26 | NQ Gem | 23:28–01:13 | 105 | 5 | 900 | 0.013 |
| 2011 Mar 27 | BF Cyg | 00:08–01:59 | 111 | 60 | 109 | 0.007 |

The F-distribution is used most commonly in Analysis of Variance. It concerns the ratio of two Chi-square distributions. Here the ratio is $F = s_0^2/s_2^2$. (The denominator must be less than the numerator.) The specific F-distribution is denoted also by the degrees of freedom for the numerator Chi-square and the degrees of freedom for the denominator Chi-square. Here we adopt degree of freedom $\nu = 100$ for both distributions. [2] When the observed ratio is less than the theoretic value, the variability which is responsible for the numerator is considered as significant, not in accident.

Here we use the critical limits the F-values $(F_{99})^{1/2} = 1.17$ and $(F_{95})^{1/2} = 1.12$ for 99% and 95% significant, respectively (cf. Tucker 1962, Neter et al. 1992; $http://socr.ucla.edu/applets.dir/F_Table.html$
$http://www.statsoft.com/textbook/distribution-tables/$).

**Table 2.** Results from the processing of data: name of the observed star, average magnitude, RMSD of the light curve in respect to the average, RMSD of the light curve in respect of second-order polynomial and ratio of the RMSDs

| Star | $\bar{m}$ [mag] | $s_0$ [mag] | $s_2$ [mag] | $s_0/s_2$ |
|---|---|---|---|---|
| ZZ CMi | 11.511 | 0.0073 | 0.0061 | 1.21 |
| NQ Gem | 10.071 | 0.0042 | 0.0040 | 1.05 |
| BF Cyg | 9.998 | 0.0244 | 0.0082 | 2.99 |

The ratios in the last column in Table 2 give evidence that the first and third star show statistically significant variability ($s_0/s_2 > (F_{99})^{1/2}$), but the

[2] The light curve of NQ Gem was additionally reduced six-times by averaging with aim to have 118 data points, compatible with the number of points of other stars.

second does not. The variability in the third case is higher than in the first case because of the significant almost linear rend of the third light curve. Large amplitude flickering is missing in all light curves.

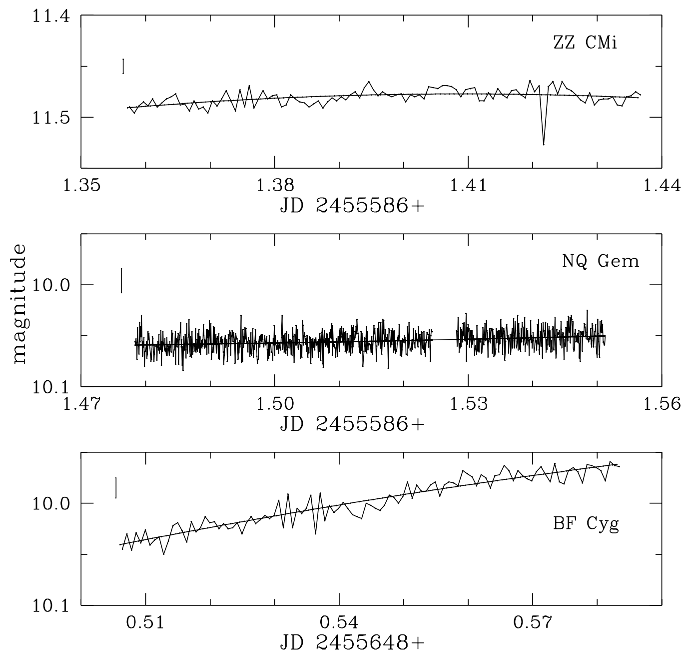


**Fig. 1.** Observations of ZZ CMi, NQ Gem and BF Cyg in *B*-band. The light curves are fitted by second-order polynomials. The error bars in the upper left corners of the panels represent the typical photometric error.

## 2 Individual objects

### 2.1 ZZ CMi

Iijima (1984) classified ZZ CMi as a symbiotic star and the results of the UBV observations of Zamanov & Tomov (1992) are in agreement with this classification. The profile of H$\alpha$ line (Bopp 1984) confirmed that a late-type star is a donor and give evidences for the symbiotic nature of the object. Our light curve confirms only the intra-night variability of this system, which is well fitted by a second-order polynomial.

### 2.2 NQ Gem

Keenan & Morgan (1941) classified the red giant in NQ Gem as a C6.2. NQ Gem is suspected as a symbiotic star in the investigation of Johnson et al. (1988). The system shows highly variable $UV$ continuum with strong $CIV]$ emission and $SiIII]/CIII]$ ratio similar to symbiotic stars. Luna et al. (2010) detected X-ray emission from the accretion disks in the systems NQ Gem and ZZ CMi. According to our light curve this system does not show significant intra-night variability.

### 2.3 BF Cyg

BF Cyg is a S-type symbiotic star. The system consists of an M-giant star and a hot compact star, probably a white dwarf, with an orbital period of 757.3 d. Sokoloski, Bildsten & Ho (2001) report low-amplitude variability in the light curve in $B$-band. Our observations show significant parabolic trend of the intra-night brightness increasing, however without statistically significant fluctuations.

## Conclusion

In our monitoring the symbiotic systems NQ Gem, BF Cyg and ZZ CMi do not show flickering. However, NQ Gem and ZZ CMi systems possesses low, but statistically significant intra-might brightness trends, presented by parabolas.

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