THE BERLIN EXOPLANET SEARCH TELESCOPE II CATALOG OF VARIABLE STARS. II. CHARACTERIZATION OF THE CoRoT Sfe02 FIELD

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ABSTRACT

Time-series photometry of the CoRoT field Sfe02 was obtained by the Berlin Exoplanet Search Telescope II (BEST II) in 2009. The main aim was to conduct a ground-based follow-up of the CoRoT field in order to detect variable stars with better spatial resolution than what can be achieved with the CoRoT Space Telescope. A total of 1846 variable stars were detected, of which only 30 have been previously known. For nine eclipsing binaries the stellar parameters were determined by modeling their light curves.

Key words: binaries: eclipsing – stars: variables: general – techniques: photometric

Supporting material: figure set, machine-readable table

1. INTRODUCTION

CoRoT is a 27 cm diameter space telescope equipped with four charge-coupled device (CCD)-cameras. Two of them were used for observing a dozen of pulsational and other kinds of light variations of bright stars with high time-sampling (so-called asteroseismological channel), while another two CCDs were used to search for transit signals of about 6000 stars per CCD (so-called exo-channel). In the exo-channel there were biprisms in front of the CCDs that produced low (∆λ/λ ≈ 3) resolution spectra for each star. This avoided the saturation of many stars, and like defocusing, helped to increase the signal-to-noise ratio. Because of the available telemetry rate, most of the photometric masks of the pre-selected stars were read-out every 512 s, but a few hundred stars had a flux measurement every 32 s, as well as a few hundred stars for whom different parts of the photometric masks were read-out separately, yielding the so-called CoRoT-blue, CoRot-green, and CoRot-red light curves. For details see Baglin et al. (2007) and Auvergne et al. (2009).

But due to this technique, the point-spread function of CoRoT’s exo-channel was typically 80 × 20 arcsec and was varying from star to star. Therefore nearby stars in the frame can pollute the observed stars, spreading a certain amount of their flux inside the photometric mask. Such a polluting star is called a contaminating star in CoRoT-terminology. The process for determining which star is contaminating and how contaminating it is described in Pasternacki et al. (2011a) and Gardes et al. (2011). However, in those calculations the contaminating star is considered to be a constant star. If it is variable then it is possible that a contaminating source is a foreground or background eclipsing binary and a small amount of its light is contaminating the main target, causing a false positive as a diluted, small transit-like signal in the CoRoT target. Therefore additional, ground-based, higher spatial resolution photometry is necessary to filter out such cases.

Deeg et al. (2009) describes how different kinds of such photometric studies help to reveal the true nature of the observed CoRoT transit signals. Our previous (Karoff et al. 2007; Kabath et al. 2007, 2008, 2009b, 2009a; Fruth et al. 2012, 2013; Klagyivik et al. 2013) and present works report our contribution to this subject, as well as report the detected variables and their basic properties. Future studies of CoRoT light curves can utilize these data to remove the variability stemming from a possible contaminator.

Beyond the much better angular resolution the main advantage of our data is the different epoch of the observation. For periodic sources (e.g., eclipsing binaries, planetary candidates) this helps to determine a more accurate period, while for non-periodic sources a much longer observation is available, which is helpful for describing the nature of the light variation.

In this paper we present our independent study on the variable stars in the direction of the CoRoT field Sfe02, detected by BEST II. Section 2 presents the observations and a description of the telescope used. In Section 3 we present the variable star selection method and a description of the classification scheme. The previously known and the newly detected variable stars are in Section 4. In Section 5 we present the fitted models of nine selected eclipsing binaries. A summary and the conclusions of this paper are presented in Section 6.

2. OBSERVATIONS AND DATA REDUCTION

The observations were performed with the BEST II telescope located at the Universitäts-sternwarte Bochum near the Observatorio Cerro Armazones in Chile. The system consists of a Takahashi 25 cm Baker-Ritchey-Chrétien telescope equipped with a 4k × 4k Finger Lakes CCD.
The corresponding field of view is $1\degree 7 \times 1\degree 7$, with an angular resolution of $1\arcsec 5$ pixel$^{-1}$. In order to maximize the photon yield and to get more accurate photometry of the fainter stars, no filter was used. The exposure time was 120 s for all of the images.

BEST II observed the CoRoT target field SRc02 during a total of 32 nights between 2009 May 4 and July 28. An illustration of the BEST II and the CoRoT field SRc02 is shown in Figure 1. $\sim 65\%$ of the CoRoT field is covered by BEST II, which was centered on the coordinates

$$\alpha(J2000.0) = 18^h 59^m 47^s$$
$$\delta(J2000.0) = -03^\circ 07' 37".$$

The acquired observations were processed using the BEST automated photometric pipeline as described in Kabath et al. (2009b), Rauer et al. (2010), Pasternacki et al. (2011b), and Fruth et al. (2012). The resulting data sets consist of 1307 observations of 86,944 stellar objects. Note that CoRoT observed 11,408 targets in the SRc02 field, which is much less than the targets observed by BEST II. The most important difference is the target selection. Instead of observing all targets down to a certain magnitude limit, CoRoT observed a pre-selected sample of stars optimized for transiting planet detection and stellar pulsation studies. BEST II has a much better angular resolution than CoRoT, which has a point-spread function of $\sim 80\arcsec 0 \times 20\arcsec 0$; however, the typical number of BEST II objects in a CoRoT PSF is only 1–3. Another important difference is the limiting magnitude, which is $\sim 2$–3 magnitudes deeper for our current survey.

All stars are matched with the UCAC3 catalog (Zacharias et al. 2010) in order to assign equatorial coordinates and to adjust instrumental magnitudes to a standard magnitude system. The astrometric calibration achieves an average residual of 0.23 arcsec. The magnitude calibration is obtained by shifting each data set by the median difference between all instrumental magnitudes and their respective catalog value (R2MAG of UCAC3). Since the photometric systems are comparable but not identical, this calibration yields an absolute accuracy of $\sim 0.5$ mag and ranges from 12 to 20 mag. The number of stars measured below 1% relative accuracy is 4535. The relative photometric accuracies of all targets are shown in Figure 2.
3. VARIABLE STARS

3.1. Detection

For detecting the variable sources, we apply the functioning method described by Fruth et al. (2012). It is based on the widely-used variability index $J$ (Stetson 1996; Zhang et al. 2003) and a multiharmonic period search (Schwarzenberg-Czerny 1996), but also involves an automatic process of dealing with systematic variability. All light curves with $J > 0$ (86%) were fitted with seven harmonics and ranked using the modified analysis-of-variance statistic $q$ (see Fruth et al. 2012). A cutoff limit was set to $q > 5$ based on empirical experiments, resulting in 7677 variable star candidates.

All candidates were inspected visually and classified on an individual basis. We detected a total of 1846 variable stars, of which only 30 were previously known and 1816 are new discoveries.

The variable star catalog and the observed light curves are presented here in Table 1 and Figure 3, respectively, for guidance regarding its form and content. Table 1 and Figure 3 are published in their entirety in the electronic edition of the Astronomical Journal. The data are also available upon request from the co-author A. Erikson (anders.erikson@dlr.de).

3.2. Classification

The classification of the periodic variable stars was based on the period, amplitude, and shape of their light curve according to a simplified scheme based on the General Catalog of Variable Stars (GCVS, Samus et al. 2009).

Intrinsic variable stars were sorted into Delta Scuti (DSCT), $\gamma$ Doradus (GDOR), Cepheid (DCEP), RR Lyrae (RR), and Beta Cephei (BCEP) types.

Eclipsing binary stars were classified as detached (Algol type, EA), semi-detached (Beta Lyrae type, EB), or contact (W Ursae Majoris type, EW) systems. The subtype of one eclipsing binary remains undefined; it is marked as E.

Variables having sinusoidal-like light curves are classified as ellipsoidal variables (ELL). Stars with light curves that exhibit features of starspots are marked as spotted stars (SP). The light variation in these objects is caused by stellar rotation.

Stars that vary on timescales longer than the observational baseline are classified as probably long periodic (LPV). Stars with periodic variations and unstable light curves were marked as $\alpha^2$ Canum Venaticorum (ACV) stars. Non-periodic variables were classified as miscellaneous (MISC). Due to the insufficient coverage of the epochs of the observations, numerous periodic variable stars can be hidden in this category. Cases with questionable light curves were marked as mixed types (EW/DSCT, ELL/SP).

An overview of the classification result is given in Table 2.

4. FIRST RESULTS

4.1. Known Variables

The stars observed with BEST II are cross-checked with the variable star index10 (VSX) of the American Association of Variable Star Observers (AAVSO) and with the General Catalogue of Variable Stars (GCVS, Samus et al. 2009). In the variable star catalog (Table 1) the previously known stars are marked with the flag “k.”

Within the observed field there are 30 previously known variable stars. We could confirm the variability for all of these stars. Of these variables, 27 belong to the long period variable (LPV) type.

NSVS 13967794 was marked as an irregular variable, which is consistent with MISC in our data set. V914 Aql is an Algol type eclipsing binary with an orbital period of 3.33722 ± 0.00001 days and with quite different primary and

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10 http://www.aavso.org/vsx/
| BEST ID    | Flag | 2MASS ID          | α(J2000.0)          | δ(J2000.0)          | $R_B$ (mag) | $T_0$ (rHJD) | $P$ (day) | $A$ (mag) | Type   | Other Names |
|-----------|------|-------------------|---------------------|---------------------|-------------|--------------|-----------|-----------|--------|-------------|
| SRc02_00036 | ...  | 18564181–0249366  | 18°56′34″08        | -02°49′36″00       | 14.63       | ...          | ...       | ...       | LPV    | ...         |
| SRc02_00049 | c    | 18561019–0324329  | 18°56′10″22        | -03°24′33″11       | 14.98       | 60.721       | 0.9233 ± 0.0003 | 0.69 ± 0.02 | EA     | ...         |
| SRc02_00148 | ...  | 18562223–0311543  | 18°56′32″22        | -03°11′54″33       | 14.91       | ...          | ...       | ...       | MISC   | ...         |
| SRc02_00278 | ...  | 1855591–0344030   | 18°55′53″9         | -03°44′03″11       | 14.92       | 61.977       | 7.53 ± 0.05 | 0.14 ± 0.05 | EA     | ...         |
| SRc02_00309 | c    | 18560034–0337067  | 18°56′00″3         | -03°37′06″8        | 14.57       | ...          | ...       | ...       | MISC   | ...         |
| SRc02_00371 | ...  | 18564095–0252272  | 18°56′40″9         | -02°52′27″1        | 15.77       | 56.923       | 0.1832 ± 0.0002 | 0.04 ± 0.02 | DSCT   | ...         |
| SRc02_00427 | ...  | 18560426–0333164  | 18°56′04″3         | -03°33′16″4        | 15.09       | 60.726       | 0.821 ± 0.002 | 0.05 ± 0.02 | RR     | ...         |
| SRc02_00436 | ...  | 18570987–0221013  | 18°57′09″9         | -02°21′01″6        | 15.74       | 56.852       | 0.09014 ± 0.00005 | 0.03 ± 0.03 | DSCT   | ...         |
| SRc02_00438 | ...  | 18564549–0247448  | 18°56′45″5         | -02°47′44″5        | 14.65       | ...          | ...       | ...       | MISC   | ...         |
| SRc02_00458 | ...  | 18565190–0240475  | 18°56′41″9         | -02°40′47″4        | 16.01       | ...          | ...       | ...       | MISC   | ...         |
| SRc02_00539 | ...  | 18571441–0216385  | 18°57′14″4         | -02°16′38″8        | 15.51       | 56.768       | 0.06263 ± 0.00003 | 0.03 ± 0.03 | DSCT   | ...         |
| SRc02_00589 | c    | 18563332–0301561  | 18°56′33″3         | -03°01′56″1        | 14.08       | ...          | ...       | ...       | MISC   | ...         |

**Note.** The flag `c` denotes stars affected by crowding. Previously known objects are flagged with `k`. Their IDs from VSX or GCVS can be found in the last column. $R_B$ is the apparent magnitude in the BEST II photometric system. The Epoch $T_0$ is given in reduced Julian date [rHJD] in respect to $T = 2,454,900.0$. It denotes the first minimum in the light curve. $P$ is the period of the light variation and $A$ is the amplitude of the variability. (This table is available in its entirety in machine-readable form.)
secondary eclipse depths. This indicates a large difference between the masses of the components.

4.2. Newly Detected Variables

The most populous group is the long periodic variables, with 453 objects. This is distinctive among the fields observed by BEST II. Another large group is the class of eclipsing binaries (EA, EB, EW, and E-type stars) with a total of 241 members. A more detailed study of these binaries is discussed in Section 5.

4.2.1. SRc02_30243

SRc02_30243 is an RR Lyrae with a pulsation period of 0.46 days showing the Blazhko effect (Blazhko 1907). This effect is a periodic modulation of the light variation in the range of tens of days. The origin of this modulation is still a puzzle more than a hundred years after its discovery.

4.2.2. SRc02_78984

This star has a similar light curve to the new class of variable young stellar objects found by Rodríguez-Ledesma et al. (2012) in the Orion Nebula Cluster, Klagyivik et al. (2013) in the young open cluster NGC 2264, and Pawlak et al. (2013) in the Small Magellanic Cloud. This kind of light curve shape can be reproduced with a hot spot either on the star or on an accretion disk around it.

5. ECLIPSING BINARIES

In a recent paper we developed a simple model to calculate the fraction of observable Algol type eclipsing binaries in a random field (Klagyivik et al. 2013). On that observational run this model resulted in a fraction of 0.104 ± 0.004%. In the SRc02 field we identified 125 Algos among the total of 86,944 stars, which means 0.14 ± 0.02%. This is in fairly good agreement—with 2σ—with the model.

5.1. Notes on Selected Eclipsing Binaries

We study individual eclipsing binaries in more detail by modeling their light curves with our own code described by Csizmadia et al. (2009). All details of the modeling are the same as in Klagyivik et al. (2013). The selection criteria are
the brightness and the amplitude, for bright binaries with deep
eclipses are easier to model correctly.

The effective temperatures of the primaries are calculated
using the 2MASS $J - K$ data. Note that this method can
introduce systematic errors due to unknown reddening. We use
the $R$-band linear bolometric and quadratic limb darkening
coefficients published by van Hamme (1993) and Claret &
Bloemen (2011), respectively, since this is the closest filter to
our filterless observations. Since all stars are cooler than
6000 K we fix the gravity darkening exponents to $g = 0.32$ and
fix the albedos to $A = 0.5$ (see Lucy 1967; Rucinski 1969).

The free parameters are mass ratio, inclination, fill-out
factors of the two components, effective surface temperature of
the secondary star, epoch, and height of the maximum
brightness refining the normalization of the light curve. We
add a stellar spot to one or both of the components if needed.
We try all the possible combinations up to two spots in total (no
spot, one spot on the primary star, one spot on the secondary
component, etc.). When the fitted mass ratio ($q = m_2/m_1$) is
higher than 1.0 we reverse the components to keep the primary
component more massive. The temperature of a spot is
described as the temperature ratio of the spot and the star
(temperature factor $= T_{\text{spot}}/T_{\text{star}}$). The fits with the smallest $\chi^2$
values are accepted and are summarized in Table 3 and
Figure 4. The errors in Table 3 include only modeling
uncertainties but no systematic errors of the input parameters.
The individual systems are discussed below.

5.2. SRc02_00049

This system consists of two very ellipsoidal stars, which can
be calculated from the fill-out factors and the mass ratio.
The primary star has a polar fractional radius (defined as $R/a$
where $R$ is the actual stellar radius and $a$ is the semimajor
axis of the orbit) of $0.457 \pm 0.004$, and the equatorial stellar
fractional radii are $0.505 \pm 0.005$ in the direction of the other
star, $0.536 \pm 0.005$ in the anti-companion direction, and
$0.489 \pm 0.004$ in the direction of motion (these are called
polar, point, back, and side radii according to the binary star
terminology). The secondary star has fractional radii of

$$
r_{\text{pole}} = 0.219 \pm 0.002, \quad r_{\text{point}} = 0.263 \pm 0.003,$$
$$
r_{\text{back}} = 0.248 \pm 0.002, \quad r_{\text{side}} = 0.226 \pm 0.002.
$$

The polar oblateness, defined as $1 - r_{\text{pole}}/r_{\text{side}}$, is nearly 7% for
the primary and 3% for the secondary. Although the two
stars are quite close to each other, they are far from Roche-lobe
filling. The primary has an average radius of 74% of its own
Roche-lobe size, while the secondary is only 67% of its own
Roche-lobe size. Therefore it seems they have not undergone
mass-transfer yet, and hence they have their original masses.
The light curve modeling was able to reproduce the observed
flux variations with synchronous rotation, so they are fast
rotators, which means that the stellar shape is deformed by
strong tidal rotation. These and the fast rotation make this
and similar objects good targets to determine and to study the
relationship between internal stellar structure (and $J_2$
parameter) and stellar shapes under strong rotational and tidal
interactions.

Although the light curve fit required a spot, the temperature
factor of the spot is poorly determined and it allows also an
unspotted star.

5.3. SRc02_16165

This object is a semi-detached binary where the secondary
fills out the Roche-lobe. The O’Connell-effect is clearly visible,
the two maxima differ from each other by 0.01 mag, and it
seems to be stable during the observational window. This was
reproduced by a dark spot on the secondary. One can expect
period variations during the mass transfer, and observations of
this variation on longer timescales would be important to
establish which phase of the mass transfer occurs in this
system. Its brightness makes it a favorable target for further
spectroscopic and photometric investigation.

5.4. SRc02_30685

SRc02_30685 is a high-amplitude system with a considere-
able reflexion effect and light curve distortion. From the end of
the primary minimum to the beginning of the secondary
minimum, the flux level increases by 0.04 mag due to
reflection. However, from the secondary to the primary
minimum the flux level is close to constant with what we
understand as a spot. Actually, this bright spot is necessary on
the primary to explain the observed out-of-eclipse variations.
Such spots are common in binaries, but less frequent than the
dark spots.

5.5. SRc02_32071, 37225, 78521

These three systems are so-called contact or overcontact
binary systems, where the two stars are so close to each other
that both components fill out their own Roche-lobe, and thus
they are geometrically in contact, or—in the case of over-
contact systems—the two stellar cores have a common
convective envelope.

SRc02_32071 is a low-inclination ($i = 56^\circ$) overcontact
binary system with an 11% over-filling factor. It belongs to the
W-subtype of overcontact binaries according to the definition
of Binnendijk (1965), since the secondary object is smaller
($r_{\text{avg}} = 0.253$) and warmer ($T_{\text{eff}} = 4790$ K) than the primary
($r_{\text{avg}} = 0.525$ and $T_{\text{eff}} = 3877$ K). The secondary maximum is
at a slightly higher flux level (by 0.01 mag) than the primary
maximum, indicating a negative O’Connell-effect. The
O’Connell-effect was observed in several other, well-studied
systems too, but only the minority, 24% of the systems (19 out
of 78), showed such a negative value in the list of Maceroni &
vant’Veer (1996).

SRc02_37225 is an unspotted contact binary. It seems to be
in the state of exact Roche-lobe filling. According to theoretical
expectations, exact Roche-lobe filling is quite unlikely because
it lasts for an extremely short time-interval. It brakes or it
evolves to overcontact. More precise photometry is needed to
confirm that we have a fill-out factor of zero, so a rare type of
contact binaries have been found, or we have a very low fill-out
factor in this system. If it is in exact contact, then it can be an
important test object for theoretical studies.

SRc02_78521 is a common A-subtype overcontact binary
with well-determined fill-out factor ($f_1 = f_2 = 0.04 \pm 0.01$).
In case of contact binaries, long-timescale magnetic cycles
(10–20 years, e.g., Borkaovits et al. 2005), spot-induced eclipse
timing variations (Tran et al. 2013), effect of mass transfer,
third bodies, and irregular variations occur (Qian 2001a, 2001b,
2003; Borkaovits et al. 2005; Tran et al. 2013; Nelson
et al. 2014). Since this target is bright even for small
telescopes, it is a good target for such period variation studies.
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### Table 3
Fitted Parameters of the Modeled Binary Systems

| BEST ID       | SRc02_00049       | SRc02_16165       | SRc02_30685       |
|---------------|-------------------|-------------------|-------------------|
| Orbital period (days) | 0.9233 ± 0.0003   | 0.39607 ± 0.00006 | 0.7416 ± 0.0005  |
| Mass ratio $q$  | 0.21 ± 0.03       | 0.21 ± 0.02       | 0.65 ± 0.06      |
| Inclination $i$ ($^\circ$) | 68.2 ± 2.0        | 59.0 ± 1.0        | 89.9 ± 0.5       |
| Fill-out factor $f_1$ | −0.91 ± 0.52      | −0.55 ± 0.30      | −5.29 ± 0.37     |
| Fill-out factor $f_2$ | −0.54 ± 0.12      | 0.00 ± 0.10       | −2.39 ± 0.16     |
| Temperature $T_1$ (K) | 3743 ± 234        | 3558 ± 48         | 3720 (fixed)     |
| Temperature $T_2$ (K) | 5029 (fixed)      | 4893 (fixed)      | 3772 ± 35        |

Spot
- On which star? primary, secondary, primary
- Colatitude $\phi_1$ ($^\circ$) | 179 ± 19 | 111 ± 64 | 136 ± 34 |
- Longitude $\lambda_1$ ($^\circ$) | 127 ± 142 | 111 ± 56 | 200 ± 4 |
- Diameter $d_1$ ($^\circ$) | 65 ± 34 | 19 ± 10 | 9.5 ± 3.6 |
- Temperature factor | 0.66 ± 0.59 | 0.84 ± 0.25 | 1.26 ± 0.07 |

$\chi^2$ | 0.757 | 0.647 | 0.779 |

| BEST ID       | SRc02_32071       | SRc02_37225       | SRc02_78521       |
|---------------|-------------------|-------------------|-------------------|
| Orbital period (days) | 0.7377 ± 0.0003   | 1.3094 ± 0.0007   | 0.3838 ± 0.0004   |
| Mass ratio $q$  | 0.22 ± 0.02       | 0.202 ± 0.006     | 0.52 ± 0.08       |
| Inclination $i$ ($^\circ$) | 55.6 ± 0.7        | 55.7 ± 0.5        | 66.2 ± 0.3        |
| Fill-out factor $f_1$ | 0.11 ± 0.01       | 0.00 ± 0.21       | 0.04 ± 0.01       |
| Fill-out factor $f_2$ | 0.11 ± 0.01       | 0.00 ± 0.21       | 0.04 ± 0.01       |
| Temperature $T_1$ (K) | 3877 ± 39         | 4115 ± 52         | 4664 (fixed)      |
| Temperature $T_2$ (K) | 4790 (fixed)      | 3968 (fixed)      | 4582 ± 55         |

Spot
- On which star? secondary, secondary
- Colatitude $\phi$ ($^\circ$) | 162 ± 18 | ... | 159 ± 42 |
- Longitude $\lambda$ ($^\circ$) | 262 ± 109 | ... | 46 ± 38 |
- Diameter $d$ ($^\circ$) | 42 ± 17 | ... | 15 ± 12 |
- Temperature factor | 0.14 ± 0.40 | ... | 1.73 ± 0.28 |

$\chi^2$ | 0.919 | 0.525 | 1.269 |

| BEST ID       | SRc02_33910       | SRc02_43701       | SRc02_71988       |
|---------------|-------------------|-------------------|-------------------|
| Orbital period (days) | 0.28172 ± 0.00004 | 0.36663 ± 0.00007 | 1.371 ± 0.002    |
| Mass ratio $q$  | 0.19 ± 0.03       | 0.72 ± 0.10       | 0.64 ± 0.28       |
| Inclination $i$ ($^\circ$) | 62.5 ± 0.6        | 83.5 ± 0.6        | 84.5 ± 0.4        |
| Fill-out factor $f_1$ | −0.72 ± 0.08      | −0.11 ± 0.05      | −6.8 ± 2.1        |
| Fill-out factor $f_2$ | −0.80 ± 0.14      | −0.07 ± 0.04      | −4.3 ± 0.3        |
| Temperature $T_1$ (K) | 4172 (fixed)      | 4128 ± 30         | 4734 ± 52         |
| Temperature $T_2$ (K) | 3576 ± 18         | 3847 (fixed)      | 5055 (fixed)      |

Spot
- On which star? primary, secondary, secondary
- Colatitude $\phi$ ($^\circ$) | 148 ± 48 | 104 ± 62 | 39 ± 86 |
- Longitude $\lambda$ ($^\circ$) | 126 ± 141 | 18 ± 50 | 100 ± 102 |
- Diameter $d$ ($^\circ$) | 11 ± 9 | 7.6 ± 4.1 | 4.9 ± 2.2 |
- Temperature factor | 2.0 ± 0.5 | 1.14 ± 0.12 | 0.83 ± 0.25 |

$\chi^2$ | 1.290 | 0.583 | 1.286 |

Note. The temperature factor of the spots means $T_{\text{spot}}/T_{\text{sun}}$.

5.6. SRc02_33910, 43701, 71988

These three systems are detached Algol-type eclipsing binaries. The light curves of SRc02_33910 and SRc02_43701 show some similarities to each other, but SRc02_43701 is almost a near-contact binary while SRc02_33910 is a wider system that probably later evolves to a near-contact system. SRc02_71988 is a well-detached Algol-type system.

The SRc02_33910 system requires a new light curve solution based on multi-color photometry, which helps to establish the exact temperature difference between the components. It seems to be a short-period, detached system. SRc02_43701 has average fractional radii $r_{\text{pri}} = 0.397 \pm 0.004$ and $r_{\text{sec}} = 0.339 \pm 0.003$. The sums of the point fractional radii are exactly $0.900 \pm 0.008$ (0.478±0.004 and 0.422±0.004 for the primary and secondary star, respectively). The inner Lagrange-point is at a distance of
0.53 ± 0.01 from the primary’s center, while the primary’s point radius is 0.478 ± 0.004, quite close to the inner Lagrange-point. That is why this system is a pre-near-contact binary, and most likely it will later evolve to a contact system.

The residual light curve of SRc02_71988 has a significantly larger scatter in the primary and secondary minima than out of transit. This can be due to surface brightness inhomogeneities (e.g., stellar spots) on the side faced toward its companion, which is occulted during the eclipses.

6. SUMMARY

We presented a study of the variable stars in the CoRoT field SRc02 observed by BEST II in 32 nights in 2009. We detected 1846 variable stars out of 86,944 stars in our field of view, out of which 1816 are new detections and only 30 were previously known. Most of them are long period variables (classified as LPV), or show irregular variability (MISC class).

The total number of eclipsing binaries is 241. There are 125 Algol-type eclipsing binaries in our database, which means 0.14% of all stars. This is in good agreement with our simple model of EAs (Klagyivik et al. 2013).

We studied the light curves of nine eclipsing binaries using our own modeling code. SRc02_37225 seems to be in exact Roche-lobe filling and it can be an important test object for theoretical studies, while SRc02_43701 is a pre-near-contact system and will probably evolve to a contact system.

A new RR Lyrae showing Blazhko modulation was also found (SRc02_30243), however, the observational run was not long enough to determine the period of the Blazhko cycle.

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