The Shortest-Period M-Dwarf Eclipsing System: BW3 V38

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ABSTRACT. The photometric data for a short-period (0.1984 day) eclipsing binary V38 discovered by the OGLE microlensing team in Baade’s Window field BW3 have been analyzed. The light-curve synthesis solution of the I-filter light curve and dereddened color \( V-I_c = 2.3 \) suggest a pair of strongly distorted M dwarfs, with parameters between those of YY Gem and CM Dra, revolving on the tightest known orbit among binaries consisting of main-sequence stars. The primary, more massive and hotter, component may be filling its Roche lobe. The very small amount of angular momentum in the orbital motion makes the system particularly important for studies of angular-momentum loss at the faint end of the main sequence. Spectroscopic observations of the orbital radial-velocity variations as well as of activity indicators are urgently needed for a better understanding of the angular momentum, internal structure, and evolutionary state of the system.

1. INTRODUCTION

The variable star V38 in the third (BW3) field of Baade’s Window is one of the most interesting objects discovered by the OGLE microlensing project. With an orbital period of only 0.1984 day, it was the shortest-period known binary consisting of main-sequence stars. BW3 V38, from now on called BW3.038 \( (\alpha_{2000} = 18^h 04^m 44.1^s, \delta_{2000} = -30^\circ 09' 05.1", P = 0.19839 \text{ day}, I_{\text{max}} = 15.83, (V-I_c)_{\text{max}} = 2.45, \Delta I = 0.78) \), appeared in the second installment of the OGLE Catalog of periodically variable stars (Udalski et al. 1995a) among contact binaries of the W UMa-type (EW), it was mentioned as rediscovered in the overlap with BW7 in the third part of the Catalog (Udalski et al. 1995b). However, it did not pass the Fourier filter applied to the light curves and used for impersonal selection of contact binaries. As a result, it has not been included in the discussion of contact systems in Baade’s Window (the R sample) by Rucinski (1997 = R97). But this rejection was a marginal one because the Fourier filter had been constructed for the most common G-type systems observed in the V band, whereas in this case, it was applied to an M-type system observed in the I band. It can be argued that light curves of contact binary systems are primarily dependent on the strongly perturbed geometry of the stars, and weakly dependent on the atmospheric properties (Rucinski 1993), but it is possible that application of the Fourier filter was carried too far for the case of BW3.038. A full light-curve solution seemed to be in order.

The importance of BW3.038 stems from its very short period, but also, if it is a contact system, from its very late spectral type. Short-period, late-type systems are common among contact binaries, but the period distribution of these systems shows a sharp cutoff, which is well defined by the system CC Comae, with the orbital period being 0.221 day and the intrinsic color \( V-I_c = 1.39 \) (Bradstreet 1985). In the volume-limited sample to 3 kpc formed from the OGLE sample (R97), contact binaries appear with high apparent frequency only within intervals of orbital periods and intrinsic colors \( 0.25 < P < 0.5 \text{ day} \) and \( 0.4 < V-I_c < 1.2 \). This color range translates into the range of spectral types of about F2–K5. It is an interesting puzzle of the stellar structure theory to determine why the short-period cutoff is so well-defined and sharp, and why there are no contact binaries consisting of late K and M dwarfs. Some arguments have been presented in favor of the stellar structures converging to the fully convective state (Rucinski 1992), but — quite possibly — the reasons for nonexistence of very low-mass systems are different and more complex. The discovery of BW3.038 possibly confronts us with a contact system beyond the current period cutoff. The spectral type of BW3.038 must be much later than that of CC Com, as the observed colors of the two systems are \( V-I_c = 2.45 \) and 1.39, respectively. A simple estimate of the reddening based on the maps prepared by Stanek (1996) (see Sec. 2.1) suggests \( E_{V-I} = 0.18 \). Thus, BW3.038 is much cooler than CC Comae and consists of M-type dwarfs.

Even if BW3.038 is not a contact system, it is an extremely interesting object since it is a very close binary consisting of M-type dwarfs. Most stars in the Galaxy are
M-type dwarfs, yet — because of their faintness — we know very little about them. In fact, the low end of the main sequence is calibrated by only two eclipsing systems, YY Gem and CM Dra. Because of large numbers of the M-type dwarfs, small systematic errors made in analyses of these two stars may have profound effects in our understanding of even so remotely related subjects as the dynamics of the Galaxy or the critical density of the Universe. In addition, analysis of old, late-type dwarfs can give us such basic data as the primordial helium and metal abundances (Paczynski and Sienkiewicz 1984; Chabrier and Baraffe 1995; Metcalfe et al. 1996). We should note that CM Dra is probably a Population II object while YY Gem belongs to the sextuple α Gemini (Castor) system which must be relatively young as it contains an unevolved A1V star. Thus, we urgently need more systems to clearly understand the effects of age and metallicity in the lower main sequence.

The strong distortion of components is directly visible in the light curve (Fig. 1) of BW3.038. With continuing angular-momentum loss, which must operate in such a late-type system, the binary is apparently on its way to becoming a contact system. The major question is: Why do we not see such systems in large numbers? Is the angular momentum loss so severe that contact systems very quickly merge and form single stars? Or, at the other extreme, is the angular momentum loss so feeble that most close M-dwarf pairs do not lose enough angular momentum in the lifetime of the Galaxy to form contact systems? If the latter is the case, is BW3.038 one of the oldest among such close M-type binaries?

This paper is meant as a first, exploratory attempt to extract as much information from the extant data as possible. We hope to stimulate interest in this important system; in particular we hope that the much needed spectroscopic observations will be obtained soon.

2. THE LIGHT-CURVE SOLUTION

2.1 Assumptions

While attempting a more detailed study of BW3.038, one is confronted with the limited extent of the available data. The OGLE data published in the catalogs and available over the ftp service consist of the light curve in the I band, the maximum-light $V-I_C$ color, and the orbital period. The light curve (Fig. 1) is rather noisy, with a standard error at maxima of $=0.02$ mag, but with deep eclipses ($\Delta I = 0.78$) suggesting a high value of the inclination. An analysis of the light curve is still sensible, but one has to be careful about the solution strategy and about the estimation of uncertainties of the derived parameters. With any standard light-curve synthesis method, such as the Wilson and Devinney (1971 = WD) program (we used its updated 1992 version), the main and the most obvious concern would be the choice and the number of free parameters. We address this matter below, but first we look into the available information concerning the components of BW3.038.

The observed, possibly strongly reddened $V-I_C$ color is the only information about the spectral type of the components. To derive the dereddened color and the approximate absolute magnitude of the system, we used a simple iterative procedure which followed the one presented in R97. The R97 computations were based on Stanek (1996) reddening maps of Baade’s Window and on the period-color-magnitude calibration established for W UMa binaries. We do not know whether BW3.038 is actually a contact system. Therefore, we used the same iterative approach as in R97, but replaced the W UMa calibration with the main sequence $M_V = M_C(V-I_C)$ relation of Reid and Majewski (1993), shifted upward by 0.75 mag for a binary system of identical components. The results are: $(V-I_C)_0 = 2.3\pm0.1$, assuming errors of 0.03 and 0.5 in $V-I_C$ and $M_V$, respectively; the predicted absolute magnitude of the system $M_I = 7.5$, and the distance $d = 400\pm85$ pc, leading to the $z$ distance of about 30 pc below the galactic plane. The relatively red intrinsic color corresponds to an M3 spectral type, so that a reasonable value of primary effective temperature is $T_1 = 3500$ K (Bessell 1979, 1990).

Extensive tables of limb darkening coefficients for R, I, J, K bands have been recently published by Claret et al. (1995). We used the (linear) limb darkening coefficient, $x = 0.56$, corresponding to the primary effective temperature and log $g$ between 4 and 5. The gravity darkening and reflection coefficient were fixed at the standard values for convective envelopes ($g = 0.32, A = 0.5$; Lucy 1967; Rucinski 1969). The low effective temperature of the primary does not allow the use of the model-atmosphere option in the WD code which is limited to the temperature range 4000–25,000 K (we note that this option in the 1992 version of the code uses the obsolete model atmospheres from 1969). All computations were therefore performed in the blackbody approximation. For a one band-pass light curve in $I$, this is definitely not a critical assumption.

The maxima of the light curve show slightly different heights. The difference is about $\delta I = 0.02$ which can be modeled by a dark spot on the larger star. In order not to introduce too many free parameters into the geometric-elements solution, the spot parameters were determined by trial and error before starting the differential correction procedure. Since the spot characteristics are very weakly constrained by light-curve solutions without spectroscopic in-
formulation (Maceroni and Van’t Veer 1993), we assumed the spot to be located on the equator of the primary component. The other fixed parameters were: longitude and angular radius of the spot $290^\circ$ and $11^\circ$, respectively, and the temperature factor $T_{\text{spot}}/T_{\text{star}} = 0.8$. The advantage of having a spot is in preventing occurrence of oscillations in the iterative procedure between solutions which fit one maximum at a time.

### 2.2 Results of the solution

The input model for the light-curve solution consisted of a system of two identical stars with the characteristics described in the previous section and exactly filling the inner critical Roche surfaces. From this point, the surface potentials were either assumed to be equal as for a contact configuration (WD “mode 3”) or were given the freedom to vary in an independent way (“mode 2”), which is normal for detached systems. The solutions always evolved away from the contact configuration and required the use of the detached configuration. We used seven adjustable parameters: the orbital inclination $i$ (in degrees), the mass ratio of the system $q$ (expressed as the mass of the eclipsing component to the eclipsed one in the deeper minimum), the two surface equipotentials $\Omega_1$ and $\Omega_2$ (defined as in the WD code), the secondary effective temperature $T_2$, the primary component luminosity $L_1$ in the spectral band used, and the phase shift of the primary eclipse $\Delta \phi$ (expressed in units of the orbital period). Their subdivision in two subsets (Wilson and Biermann 1976) helped to control the strong interdependencies present among some of the parameters during the iteration process. The procedure quickly converged to the final model is presented in Fig. 2. The two components are very close to, but still inside, their respective Roche critical surfaces. However, for the more massive and hotter component, the results are consistent at the one-sigma level, with the star actually filling its critical inner potential, popularly known as the “Roche lobe.”

### 2.3 Uncertainties of Parameters

It is well known in the community of users of the Wilson–Devindey program that this fine code provides excellent light curves, but that the estimates of errors of the adjustable parameters are unrealistically small. The reason is partly the strong correlation between the relatively many parameters, and partly the non-normal distribution of measurement errors. The WD code provides the “probable” errors, $\epsilon_i$, which are derived by the differential correction routine and are related to the standard errors of the linearized least-squares algorithm through $\epsilon_i = 0.6745 \sigma_i$. The errors $\sigma_i$ can be used as a measure of the uncertainties only for normal distributions of the errors.

As explained in the book *Numerical Recipes*, Sec. 15.6 (Press et al. 1992), the technique of bootstrap resampling is probably the most useful for estimation of confidence levels for complex least-squares solutions. It uses input data resampled with repetitions, establishing confidence levels from the spread in resulting parameters. However, its application was not possible with the current WD code, which — by intent — was designed on the principle of the user-controlled “interactive branching” during the differential correction procedure (Wilson 1988). Combining the interactive branching with the bootstrap resampling would mean performing thousands of separate solutions “by hand.” Instead, we used a simplified bootstrap approach in which 10,000 least-squares solutions were made within the minimum already established by a single, iterated solution. Thus, only one set of light-curve deviations and parameter

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**Table 1**

| Parameter | Solution mean and std err | Bootstrap median and 1-sigma |
|-----------|-----------------|-----------------------------|
| $i$ (deg) | 85.7 ± 1.2 | 85.8 ± 2.2 |
| $q$ | 0.77 ± 0.09 | 0.70 ± 0.18 |
| $\Omega_1$ | 3.48 ± 0.13 | 3.40 ± 0.32 |
| $\Omega_2$ | 3.55 ± 0.25 | 3.36 ± 0.48 |
| $T_2$ ($T_2 = 3500$ K) | 3459 ± 15 | 3456 ± 28 |
| $L_1/\left(L_1 + L_2\right)$ | 0.597 ± 0.036 | 0.597 ± 0.065 |
| $\Delta \phi$ (phase units) | +0.0020 ± 0.0006 | +0.0018 ± 0.0012 |
| $r_1$ (side) | 0.380 ± 0.011 | 0.383 ± 0.026 |
| $r_2$ (side) | 0.322 ± 0.050 | 0.323 ± 0.039 |
| $\rho_1$ (g cm$^{-3}$) | 4.8 ± 0.4 | 5.1 ± 0.6 |
| $\rho_2$ (g cm$^{-3}$) | 6.1 ± 3.4 | 5.9 ± 1.5 |
| $\rho_1$ (g cm$^{-3}$) lim. | > 4.17 ± 0.07 | > 4.09 ± 0.15 |
| $\rho_2$ (g cm$^{-3}$) lim. | > 4.60 ± 0.05 | > 4.66 ± 0.11 |

*Notes to Table 1*

$r_1$, $r_2$, $\rho_1$, $\rho_2$ have been derived from the solution of the first seven parameters. See the text for explanations of the lower limits to $\rho_1$ and $\rho_2$. 

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**Fig. 2** — The three-dimensional picture at the orbital phase 0.25 (upper panel) and the equatorial section (lower panel) of BW3.038, with the critical Roche equipotentials shown by a dashed line.
derivatives were used. This, by necessity, would give us underestimates of the real errors. However, as we have found through application of this approach, these estimates are larger than the formal mean standard errors; they also show directly the strong interparametric correlations. We should remember that interparametric correlations are not always a detrimental circumstance, as some derived parameters (such as radii) may show smaller uncertainties than for the case of simple quadrature addition of uncorrelated errors. The bootstrap-estimated errors also tend to be somewhat pessimistic as some resamplings give light curves so clumpy and unevenly covered that nobody would ever attempt solving them. Since we see potential for under- and overestimation of the errors, in Table 1 we give both sets of error estimates, the mean standard errors for the iterated solution, and the one-sigma ranges around the median values for the bootstrap experiment.

A selection of contour plots giving two-dimension representations of the one-sigma uncertainty levels is shown in Figs. 3 and 4. They have been obtained by finding contours enclosing 68.3% of the bootstrap solutions around their respective median values. They are frequently elliptical (indicating interparametric correlations), but symmetric around the medians of the respective seven primary parameters. The symmetry is due to the use of one set of derivatives within the minimum of the summed squared deviations. It should be noted that the bootstrap solutions tend to cluster slightly away from the best, iterated solution. This is caused by the fact that the bootstrap solutions are always based on light curves with poorer coverage than the full solution. This biases the distribution of the mass-ratio q, as this essential parameter is determined solely from the distortion of the light curve between minima. If this part of the light curve is poorly covered, or if observations have large errors, then the mass ratio would tend to take smaller values. The only proper resolution of this difficulty would be to obtain spectroscopic radial-velocity data which would stabilize the solution.

2.4 Relation to the Roche Geometry

Figure 4 contains uncertainty plots for the relative radii of the components. Here we used the "side" radii in the orbital plane which — as can be shown — are practically equal to the volume radii. In addition to the mean radii from the iterated solution, we also show the median values. Note that the medians are not exactly in the centers of the one-
Fig. 4—Additional combinations of parameters in the “bootstrap resampling” solutions. The broken lines refer to critical (Roche) surface values. Since the radii are the derived parameters, their median values are sometimes shifted from the centers of the one-sigma contours.

sigma contours, as for the primary elements. This is due to the interparametric correlations, since the radii are given by expressions of the type \( r = r(\Omega, q) \).

As we can see in Fig. 4, the results for the radii are not well constrained. However, a plot in the same figure of the uncertainty contours for the surface potential of the larger component, \( \Omega_1 \), indicates that the primary almost fills its Roche lobe, as the potential is slightly larger than the critical one. The one-sigma contour follows the critical potential curve for the relatively large range of mass ratios permitted by the current solution. If the primary actually fills its lobe, any possible mass transfer between components would be undetectable in the current, single-epoch, photometric data.

3. DISCUSSION OF BW3.038 PROPERTIES

3.1 Comparison to YY Gem and CM Dra

With the photometric solution of the light curve given in Table 1 we still have rather modest information about the system. Four parameters result from the solution (\( i, q, \) and \( \Omega_1, \Omega_2, r_1, r_2 \)), two describe the relative luminosity characteristics of the components (\( T_2 \) and \( L_1 \)) and two more come from the original observations (\( V-I_C, P \)). On the basis of these, we can attempt to place BW3.038 relative to other eclipsing M dwarfs on the main sequence. There are only two such systems: YY Gem (Castor C), analyzed by Bopp (1974) and by Leung and Schneider (1978) and CM Dra analyzed by Lacy (1977) and by Metcalfe et al. (1996). Both are well-detached systems with orbital periods 0.81 and 1.27 day, and both show only moderate proximity effects, in that no mutual illumination of the components is visible and the stars are practically undistorted by tidal forces. In this respect, BW3.038 is very different as this is the first known M-type binary showing strong distortion of components, directly linked to the very short orbital period of 0.198 day. The ages of the reference stars are very different: YY Gem belongs to the Castor (\( \alpha \) Gem) system whose age must be young as it contains hot, unevolved stars, whereas CM Dra is probably a Population II object. Nothing is known at this moment about the population characteristics of BW3.038. Its location, almost exactly in the galactic plane, offers a very weak support for a suggestion of a young-disk association of the system.

The color of BW3.038, \( (V-I_C) = 2.3 \pm 0.1 \), gives us information about its effective temperature relative to YY

\[ \text{According to probably the best extant spectral classification of Garrison and Beattie (1997), the hot components of the systems have spectral types A1m, A2Va, A2m, A5V. A simple comparison with the Pleiades (where the earliest spectral types are B6IV and B8V) and Hyades (where the earliest spectral types are A2m and A5) with ages of about 80 and 600 Myr, respectively, indicates that the age of sextuple system of Castor must be roughly 500 Myr.} \]
Gemin and CM Dra. Both reference systems were discussed by Monet et al. (1992) in relation to other intrinsically faint stars. In particular, their Kron–Cousins colors were plotted in Fig. 11 of Monet et al. which relates the colors to the effective temperature. These unpublished data had come from observations at the U.S. Naval Observatory.\(^5\) YY Gem, \(V-I_C = 1.92;\) CM Dra, \(V-I_C = 2.94.\) Bessel (1990) previously measured CM Dra in the same system and obtained \(V-I_C = 2.92.\) Thus, judging by the colors, BW3.038 is placed halfway between YY Gem and CM Dra in the effective temperature.

An independent evaluation of the relation of BW3.038 to YY Gem and CM Dra can be obtained from mean densities of the stars. The published masses and radii for YY Gem and CM Dra permit direct determination of the component densities in both systems. They are: \(3.0\pm0.4\) and \(4.1\pm0.6\) g cm\(^{-3}\) for YY Gem and \(21\pm3\) and \(22\pm3\) g cm\(^{-3}\) for CM Dra. For BW3.038 we can use Kepler’s law, as rewritten by Mochanaki (1981): \(p_1 = 0.079/\left[V_1(1+q)^2\right]\) and \(p_2 = 0.079 d\left[V_2(1+q)^2\right] g cm^{-3},\) with the period \(P\) in days. This form emphasizes the orbital period which is known practically with no error. The relative volumes of the components, \(V_1\) and \(V_2\) (in orbital units), are obviously poorly known as they contain uncertainties in radii in third power. Inserting our results for BW3.038, we obtain \(p_1 = 4.8\pm0.4\) and \(p_2 = 6.0\pm3.4\) g cm\(^{-3}\). These are evaluations based on the assumption that the errors in \(q\) and \(R_1\) are uncorrelated. The bootstrap sampling estimates which explicitly take into account the correlations are less pessimistic: \(p_1 = 5.1^{+0.6}_{-0.7}\) and \(p_2 = 5.9^{+1.6}_{-1.5}\) g cm\(^{-3}\).

Instead of using the derived geometric parameters, we can note that the components of BW3.038 are apparently just inside their critical Roche lobes. Therefore, relatively firm lower limits on the densities can be estimated by using the volume of these lobes, \(V_1(q)\) and \(V_2(q).\) The only source of uncertainty in these estimates is then in the mass–ratio \(q.\) We used the formulae of Eggleton (1983) to determine the Roche lobe volumes, \(V_1(q).\) Using the iterated solution, we obtained \(p_1 \geq 4.17\pm0.07\) and \(p_2 \geq 4.66^{+0.18}_{-0.11} g cm^{-3},\) whereas the bootstrap sampling experiment gave: \(p_1 \geq 4.05^{+0.15}_{-0.17}\) and \(p_2 \geq 4.66^{+0.18}_{-0.11} g cm^{-3}.\)

The results on the density clearly show that the densities of the components of BW3.038 are larger than those of the YY Gem and that the primary component in the system may have relatively lower density than its companion, which would be consistent with it being the slightly more evolved of the two. However, it is doubtful if the densities of the stars in BW3.038 are as high as those in CM Dra because the firm lower limits are probably very close to the actual values. Thus, we have another indication that in terms of the location on the main sequence, the components of BW3.038 are between those for YY Gem and CM Dra. Such a location is interesting as it is very close to the full-convection boundary on the main sequence.\(^6\)

\(^5\)We are indebted to Dr. Conard Dahn for sending us the data.

\(^6\)We are indebted to Dr. Ed Guinan for analysis of the ROSAT data.

3.2 Angular Momentum of BW3.038

The short period of BW3.038 brings up the question of the angular momentum (AM) of the system, \(H.\) Disregarding the spin angular momenta which can contribute about 10% to the total AM, the formula for the orbital angular momentum is \(H = 1.2\times10^{29}q(1+q)^2(P/1d)^{1/3}(M_\text{tot}/M_\odot)^{5/3} \text{ in cgs units.}\) For the current period of 0.2 day, and assuming \(M_\text{tot} = M_\odot,\) the system now contains about \(H = 1.8\times10^{31}\) cgs. This is a very small amount. Obviously, the system can be young and could have been born with the small amount of AM, but we do not know of such systems: All short-period systems that we know, ranging from cataclysmic variables to contact binaries seem to be old, being at later stages of the angular momentum loss (AML) evolution. The question is: How much AM has been lost by BW3.038 in its evolution? Unfortunately, since we do not know the age of the system, we cannot evaluate the amount of the AM loss. If we assume that, on its way through progressively tighter orbits and shorter periods, the components became interlocked in the spin–orbit synchronization at the orbital period of about \(P \approx 2\) days (when \(H = 3.9\times10^{41}\) cgs), then we see that BW3.038 has lost as much AM in evolving from \(P = 2\) to 0.2 day as it now contains. These are however just speculations, as we have no idea about the age and evolutionary state of the system.

Since the AML for BW3.038 was probably appreciable, studies specifically addressing the questions of the age and evolution of the system will definitely shed light on the poorly explored subject of the AML for rapidly rotating M dwarfs. The angular momentum loss is normally thought to be related to the overall level of magnetic activity of stars, but the relation is still poorly known. It appears that both the activity and the AML tend to be “saturated” at high–rotation rates (Vilhu 1987). Stepień (1995) presented a formula for the AML in solar-type stars which explicitly relates it to the X-ray activity.

Results of further studies of BW3.038 may have important ramifications ranging from the AM evolution soon after reaching the main sequence (Hartmann and Noyes 1987; Collier Cameron and Jianke 1994; Stauffer 1996; Soderblom 1996) to the famous period gap in cataclysmic variable stars (Rappaport et al. 1983; Spruit and Ritter 1983; King 1994). In the case of solar-type components, the secular evolution of the orbital period due to the AML, and the AM transfer by spin–orbit synchronization have been studied by several authors (Vilhu 1982; Maceroni and Van’t Veer 1991; Maceroni 1992).

At present, we have no measurements of activity of BW3.038 except an upper limit of its X-ray emission. A deep, pointed observation with the ROSAT satellite (Guinan, private communication\(^7\)), shows no X-ray emission at the place of the star with the upper limit of about 0.003 counts/sec, which translates into the upper limit to the X-ray flux: \(f_x < 1.8\times10^{-13}\) erg cm\(^{-2}\)s\(^{-1}\). This upper limit is unfortunately about ten times higher than the expected level of X-ray emission using the following chain of arguments: For

\(^7\)We are indebted to Dr. Ed Guinan for analysis of the ROSAT data.
We have presented analysis of the I band light curve and of the photometric colors for the closest known pair of M-type dwarfs orbiting each other with a period of less than 0.2 day. The components of BW3.038 appear to have properties intermediate between those of YY Gem and CM Dra, very close to the full-convection boundary on the main sequence. What sets apart BW3.038 from these well-studied systems, is the strong distortion of its components. In fact, the photometric solution indicates that the more massive component is very close to or at its critical Roche lobe. The present solution is, however, of moderate quality as the properties intermediate between those of YY Gem and CM Dra, we obtain the expected X-ray flux 1.9×10^{-14} \text{erg cm}^{-2}\text{s}^{-1}. Thus, with the present sensitivity, BW3.038 could not be detected in X rays (nor could CM Dra or YY Gem, if placed at the same distance). Additionally, this estimate does not include the neutral-hydrogen absorption which may be large in this direction, at the distance of about 400 pc. It is known (Pye et al. 1994), however, that binary systems — even wide ones — can have considerably elevated X-ray activity, so that the matter is definitely not closed.

4. CONCLUSIONS

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