COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5849

Konkoly Observatory
Budapest
22 August 2008

HU ISSN 0374 – 0676

THE COOL DWARF INTERACTING ECLIPSING BINARY, HH95-79

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HH95-79 ([HH95] FS Aur-79) [Henden and Honeycutt, 1995; GSC 1874-399; $\alpha(2000)=$ $05^{\rm h}48^{\rm m}03\overset{\rm s}{.}82$, $\delta(2000)=28^\circ30'48\overset{''}{.}13$] was observed as a part of our study of near-contact, solar-type binaries with possible stream impacts. Also, its rare combination of an EB-type light curve and very short period indicated that the system was made up of dwarf components, possibly harboring a brown dwarf.

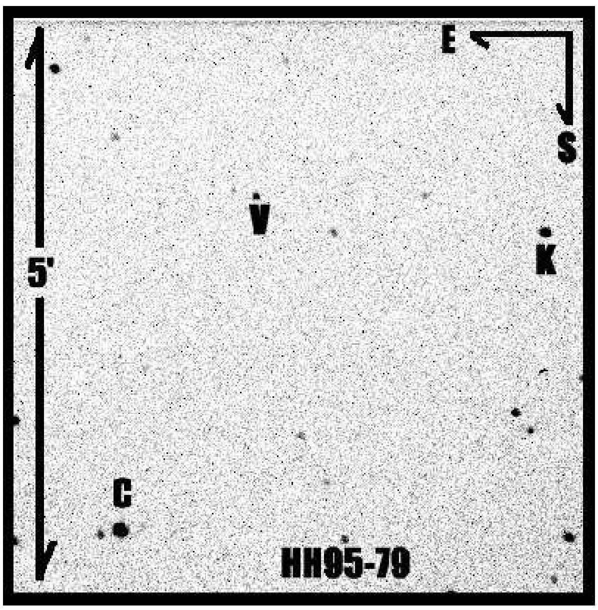

Figure 1. Finding chart, HH95-79, comparison star (C) and check star (K).

The system was discovered by Robertson et al. (2004) who gave the following ephemeris:

$$\text{HJD Tmin I} = 2452963.744(\pm 0.004) + 0.2508(\pm 0.0001)\text{d} \times \text{E}. \quad (1)$$

After the initial presentation of the present work in May 2005 (McKenzie et al., 2005), Austin et al. (2007) took observations in December 2005 in UBV and obtained single line radial velocity curves of the primary and a spectroscopic identification of the primary of spectral type dM3e ($T \sim 4100$K). A synthetic light curve solution was given indicating a mass ratio of 0.52. They found that emission features were present confirming chromospheric activity and possibly circumstellar material. However, they did no modeling of a third light as we do here. They indicated a near contact configuration. Since their absolute masses were based on single line curves, we can not regard these as definitive. The Center for Backyard Astrophysics observed 66 times of minimum light for the paper, some of which are duplicate epochs. They give an improved ephemeris:

$$\mathrm{HJD\ Tmin\ I} = 2452963.74445 + 0.250816(\pm 0.000001)\mathrm{d} \times \mathrm{E}. \qquad (2)$$

No changes in the period over the rather brief period (~ 2 years) are indicated, which is expected. This does not indicate, however, that the period is not changing.

Our U, B, V, R, I light curves were taken at the taken Southeastern Association for Research in Astronomy (SARA) observatory on Kitt Peak using a 0.9-m reflector with the AP7 CCD camera and standard $UBVR_cI_c$ filters. The CCD observations were taken on 7, 8 December 2004 and 21 March 2005 in remote mode by RGS and NCH. More than 100 In the B, V, R, I passbands, 97, 90, 94 and 95 images were taken, respectively as well as a 7 in the U pass band (see Figure 1.). The stars [GSC 2336-0621, $\alpha(2000) = 05^{\mathrm{h}}48^{\mathrm{m}}10\overset{\mathrm{s}}{.}29$, $\delta(2000) = 28°27'34''.38$] and [GSC 1874-0609, $\alpha(2000) = 05^{\mathrm{h}}47^{\mathrm{m}}47\overset{\mathrm{s}}{.}37$, $\delta(2000) = 28°29'46''.60$] were used as the comparison (C) and check (K) stars, respectively. A finding chart of HH95-79 (V), the comparison star (C), and check star (K) is given in Figure 1. The light curves are given in Figure 2, as normalized flux versus phase. Our standardized observations are given in Table 1 (available through the IBVS website as `5849-t1.txt`) as Variable-comp magnitudes.

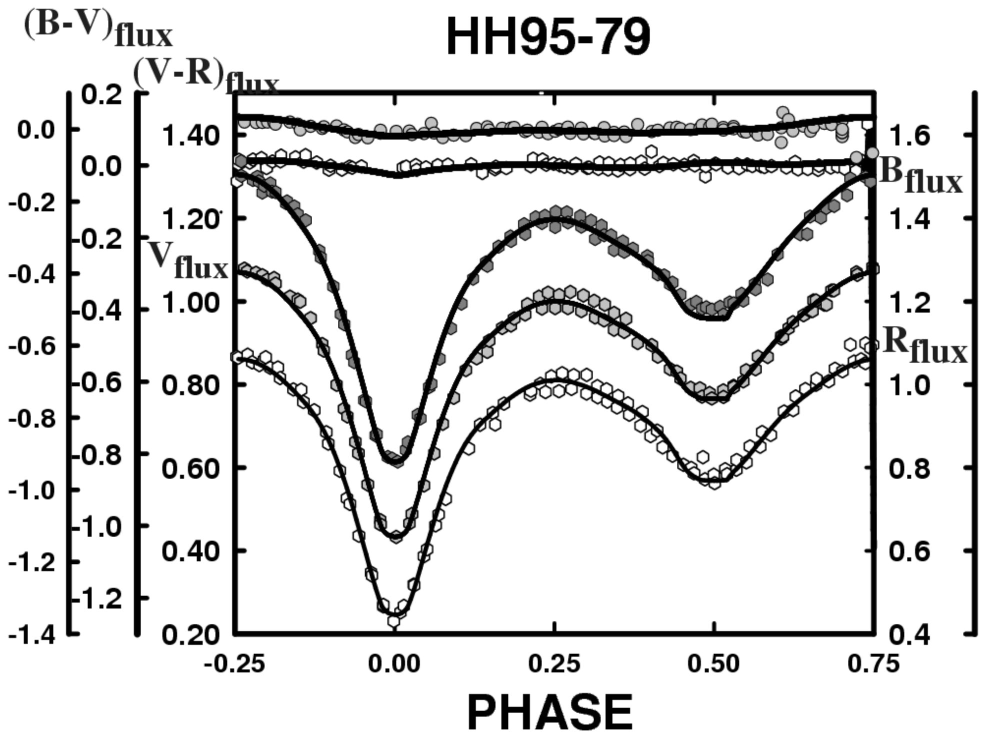

Figure 2. B,V,R normalized flux light curves for HH95-79 with synthetic light curve solution overlaid.

Six mean epochs of minimum light were determined from eclipse timings in all pass bands, using parabola fits: HJD Tmin I = 2453348.7476 (±0.0011), 2453349.0008 (±0.0028) and HJD Tmin II = 2453347.8687 (±0.0015), 2453348.8715 (±0.0013), 2453441.6739 (±0.0010), 2453450.7025 (±0.0030).

From all available observations (we used only primary eclipses and thus well determined ones from the CBA observations), we calculated the following definitive improved linear ephemeris:

$$\mathrm{HJD\ TMin\ I} = 2453348.7473(\pm0.0001) + 0.25081621(\pm0.00000008)\mathrm{d} \times \mathrm{E} \qquad (3)$$

The times of minimum light are given in Table 2 (available through the IBVS website as `5849-t2.txt`). Further observations are needed to better characterize the period behavior of this system.

From standard star measurements taken on 7, 8 December 2004 we were able to obtain standard magnitudes at all quadratures, and of C and K. The results are given in Table 3 (available through the IBVS website as `5849-t3.txt`). The photometrically determined spectral types for the variable ranged from K7 to K9 while the comparison was K7±1 and check, G9±5. The apparent magnitude range of the variable was $V = 13.75 - 14.47$ mags while the comparison was 10.05±0.01 and check, 13.83 ±0.02 mags in V.

Our light curves were premodeled with Binary Maker 2.0 (Bradstreet, 1992) and fits were obtained in B and V using semi-detached and contact configurations. The hand model parameters gave starting values for a simultaneous BVR synthetic light curve solution using the 2004 version of the Wilson Code (Wilson and Devinney, 1971; Wilson, 1990, 1994; Van Hamme and Wilson, 1998) which includes Kurucz atmospheres, and a detailed reflection treatment along with 2-D limb darkening coefficients and iterative spot modeling. We removed the I-curve since it was discrepant. We suppose this was due to local atmospheric effects, probably variable humidity.

Our BVR simultaneous solution yielded a mass ratio of 0.53±0.01, equal to that of Austin et al. (2007), within the errors. We list the parameters of that solution as Table 4, and display the light curve solution overlaying our data in Figure 2. The errors accompanying the corrected parameters in Table 4 are from the full set calculation, rather that subsets. Our displayed solution uses two hot spots two fit asymmetries. Our solutions show a hot spot with a temperature factor near 1.25 on the secondary component. Its location is that of a stream impact spot arising from a coming into contact binary. We believe the mass transfer is not vigorous at this time. The other spot is presumably magnetic in nature, arising from white light faculae. These may dominate the surfaces of short period, chromospherically active binaries (Guinan, 1990). Austin et al. (2007) used cool star spots, only, in their solution. Our Roche lobe model is given as Figure 3 and 4. All indications are that the secondary component is not a brown dwarf, but an early M-type main sequence star.

We wish to thank SARA for their allocation of observing time, and the American Astronomical Society for a small research grant which supported our observing runs.

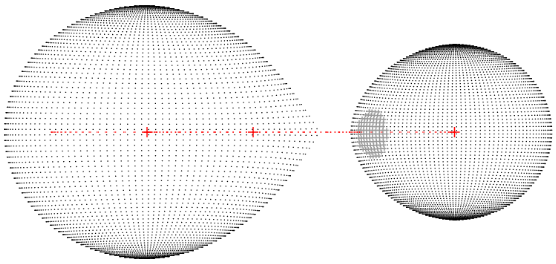

Figure 3. Geometrical representation of HH95-79 at phase 0.24 with stream spot shown on component 2.

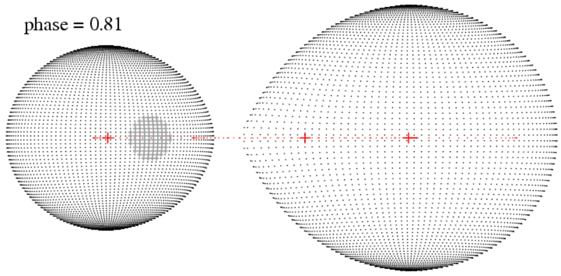

Figure 4. Geometrical representation of HH95-79 at phase 0.81 with second spot region shown on component 2.

Table 4: Synthetic Curve Parameters for HH95-79

Parameter	Simultaneous solution
$\lambda_B, \lambda_V, \lambda_R$ (nm)	440, 550, 640
$x_{\rm bol1,2}, y_{\rm bol1,2}$	0.540, 0.464, 0.276, 0.290
$x_{\rm 1R,2R}, y_{\rm 1R,2R}$	0.724, 0.778, 0.219, 0.336
$x_{\rm 1V,2V}, y_{\rm 1V,2V}$	0.778, 0.824, 0.289, 0.362
$x_{\rm 1B,2B}, y_{\rm 1B,2B}$	0.822, 0.857, 0.213, 0.341
g_1, g_2	0.32, 0.32
A_1, A_2	0.5, 0.5
inclination(°)	86±1
T_1, T_2 (K)	4100, 3257±25
Ω_1, Ω_2	2.927±0.018, 3.045±0.038
$q(m_2/m_1)$	0.53±0.01
JD Zero	53448.74716±0.00017
Period	0.25081±0.00009
$L_1/(L_1+L_2)_R$	0.917±0.004
$L_1/(L_1+L_2)_V$	0.932±0.004
$L_1/(L_1+L_2)_B$	0.947±0.004
r_1, r_2 (pole)	0.410±0.002, 0.285±0.006
r_1, r_2 (point)	0.565±0.005, 0.342±0.017
r_1, r_2 (side)	0.434±0.002, 0.296±0.007
r_1, r_2 (back)	0.463±0.002, 0.319±0.010

Spot Parameters

STAR	Colatitude (°)	Longitude (°)	Spot Radius (°)	Temp. Factor
2	88±9	276±7	14±2	1.47±0.04
2	91±15	35±6	15±6	1.25±0.07

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