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GSC 4181-0713 - A NEW W UMA TYPE ECLIPSING BINARY

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Abstract: GSC 4181-0713 is identified as an eclipsing binary for the first time. Ten times of primary and secondary minima were obtained. The shape and amplitude of the light curve and the period P=$0^d.258742$ implies that GSC 4181-0713 is a short-period W UMa type eclipsing binary. The system shows clearly an O'Connell effect Δ m<0 in its light curve.

During the observation of FU Dra, a known W UMa type eclipsing binary, using a 60 mm (2.4 inch) f/11.7 refractor equipped with a SBIG ST10XME CCD camera, GSC 4181-0713 was within the field of view, which was found to be variable. The star is located at α_{2000}=$15^h28^m12^s.8$, δ_{2000}=+62°01′22″.9 and is also identified as USNO-B1.0 1520-0243976 and N4KC000104 (GSC 2.3). GSC 4181-0713 has a photographic magnitude of $15^m.08$. In GSC 2.3 the magnitude of the V photographic band is listed as V=$15^m.16$.
Further observations of GSC 4181-0713 were carried out during 6 nights between 13 April 2009 and 29 May 2009 using a 14 inch cassegrain telescope at f/6 equipped with a CCD SBIG ST10XME and IR cut-off filter in Gemmingen (Germany). GSC 4181-1766 and N4KC002153, which are located in the vicinity of GSC 4181-0713 and have similar magnitudes, were used as comparison and check stars (see Fig.1).

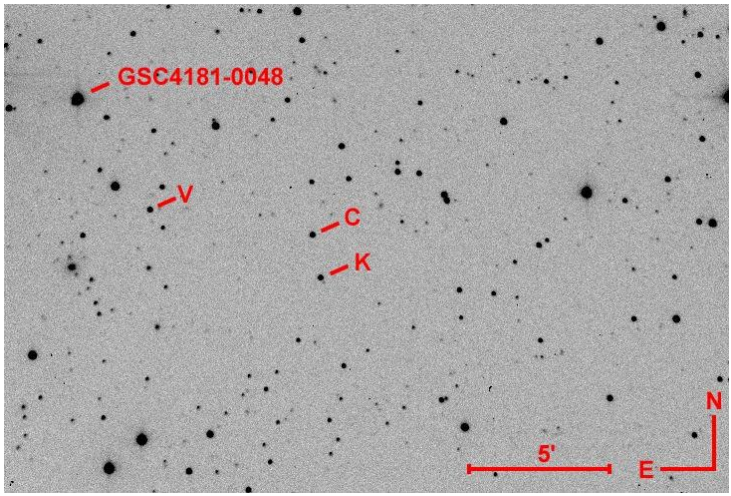

Figure 1: Typical frame of the GSC 4181-0713 field. The field is 24′x 16′. GSC 4181-0713 is labeled as star V; stars C and K are the selected comparison and check stars. GSC 4181-0048 is the brightest star in the field of view with V=$11^m.1$.

The standard deviations of the comp-check magnitudes measured in different nights are ranging from $0\overset{m}{.}012$ to $0\overset{m}{.}022$. Due to the low brightness of the variable star, the exposure time has been set to 180 or 300 seconds for each CCD image depending on the weather conditions. The CCD was configured in a 3x3 binning mode resulting in an angular resolution of 2.0″/pixel (the field of view is 24′x 16′).

The CCD images were reduced with standard procedures in Mira AP[1]. The flatfield correction utilized sky-flat images taken during the morning twillight. Aperture photometry was also performed in Mira AP and differential magnitudes were calculated. In total 521 data points were used in the analysis obtained during 34.4 hours of observation.

The following times of primary and secondary minima have been determined using the Kwee and Van Woerden method (Kwee et al. (1956)).

Table 1: New times of primary (I) and secondary (II) minima of GSC 4181-0713.

date (yyyy-mm-dd)	minimum time HJD 24...	±	type	E	O-C [d]	filter	N
2009-04-13	54935.4516	.0011	I	-43	-0.0007	Ir cut-off	140
2009-04-13	54935.5774	.0019	II	-42.5	-0.0043	Ir cut-off	140
2009-04-14	54936.3535	.0019	II	-39.5	-0.0044	Ir cut-off	151
2009-04-14	54936.4878	.0009	I	-39	+0.0005	Ir cut-off	151
2009-04-14	54936.6168	.0022	II	-38.5	+0.0002	Ir cut-off	151
2009-04-24	54946.4462	.0009	II	-0.5	-0.0026	Ir cut-off	75
2009-04-24	54946.5781	.0008	I	0	-0.0001	Ir cut-off	75
2009-05-20	54972.4525	.0007	I	100	+0.0001	Ir cut-off	44
2009-05-25	54977.4946	.0009	II	119.5	-0.0033	Ir cut-off	50
2009-05-29	54981.5083	.0010	I	135	-0.0001	Ir cut-off	62

A linear fit to the 5 times of primary mimima provides the following ephemeris:

$$\underset{}{\mathrm{HJD}_{\mathrm{MinI}}} = \underset{\pm 2}{2454946.5782} + \underset{\pm 3}{0.258742} \times E.$$

Figure 2 shows the phased light curve for GSC 4181-0713 from all data relative to GSC 4181-1766.

There is an obvious difference between the two out-of-eclipse maxima in the light curve of GSC 4181-0713, a phenomenon which is called the O'Connell effect (Milone (1968)). The size of the asymmetry is usually designated Δm. Following O'Connell's convention, Δm is magnitude of MaxII - magnitude of MaxI; i.e. it is the magnitude of the maxiumum after primary minimum subtracted from the magnitude of the maximum after secondary minimum.

To estimate the size of the observed O'Connell effect and amplitudes, polynomial fits of sixth degree were carried out to each of the primary and secondary minimum and maximum of the data sets individually. Finally, the mean differential magnitudes were calculated. For GSC 4181-0713 the light curve was asysmmetric with MaxII brighter than MaxI and therefore indicates a negative O'Connell effect $\Delta m = -0\overset{m}{.}04$, with an amplitude of $0\overset{m}{.}27$ for the primary minimum.

[1] Mira AP software by Mirametrics, Inc. (USA)

By assuming a photographic magnitude of 14.92±0.40 mag listed in the Guide Star Catalogue for the comparison star GSC 4181-1766, the following magnitudes in the instrumental system can be derived: $14\overset{m}{.}99$ (MaxI), $14\overset{m}{.}95$ (MaxII), $15\overset{m}{.}22$ (MinI) and $15\overset{m}{.}18$ (MinII), respectively.

The shape of the light curve, an amplitude of $0\overset{m}{.}27$ (primary minimum) and the period P=$0\overset{d}{.}258742$ implies that GSC 4181-0713 is a short-period W UMa type eclipsing binary (Rucinski (2007)).

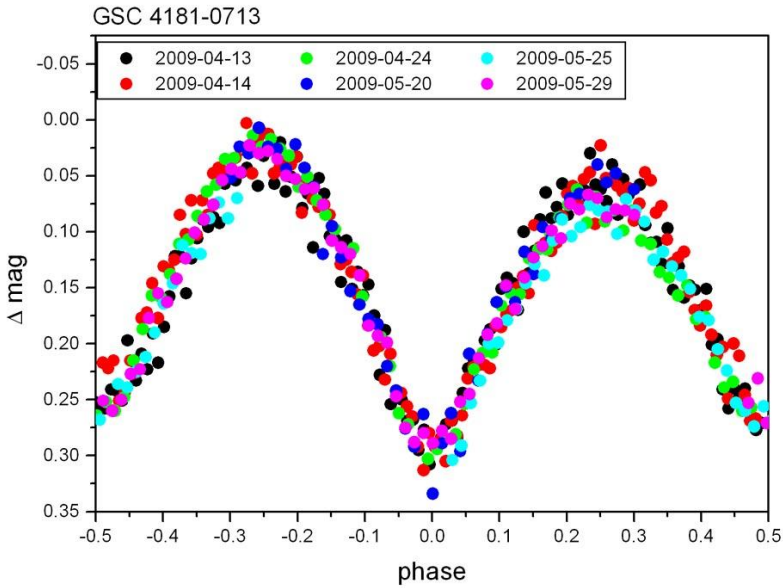

Figure 2: Phased light curve for GSC 4181-0713 calculated with $E_0 = 2454946.5782$ and $P = 0\overset{d}{.}258742$ (differential magnitudes with respect to GSC 4181-1766).

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