ogle-blgl182.1.162852: An Eclipsing Binary with a Circumstellar Disk

N. J. Rattenbury, L. Wyrzykowski, Z. Kostrzewa-Rutkowska, A. Udalski, S. Kozłowski, M. K. Szymański, G. Pietrzyński, I. Soszyński, R. Poleski, K. Ulaczyk, J. Skowron, P. Pietrukowicz, P. Mróz, D. Skowron

1 Department of Physics, University of Auckland, Private Bag 92019, Auckland, New Zealand
2 Warsaw University Observatory, Al. Ujazdowskie 4, 00-478 Warszawa, Poland
3 Institute of Astronomy, University of Cambridge, Madingley Road, CB3 0HA Cambridge, UK
4 Universidad de Concepción, Departamento de Astronomía, Casilla 160–C, Concepción, Chile
5 Department of Astronomy, Ohio State University, 140 W. 18th Ave., Columbus, OH 43210, USA

ABSTRACT
We present the discovery of a plausible disk-eclipse system OGLE-BLG182.1.162852. The OGLE light curve for OGLE-BLG182.1.162852 shows three episodes of dimming by $I \approx 2-3$ magnitudes, separated by 1277 days. The shape of the light curve during dimming events is very similar to that of known disk eclipse system OGLE-LMC-ECL-11893 (Dong et al. 2014). The event is presently undergoing a dimming event, predicted to end on December 30th, 2014. We encourage spectroscopic and multi-band photometric observations now. The next dimming episode for OGLE-BLG182.1.162852 is expected to occur in March 2018.

Key words: binaries: eclipsing; circumstellar matter; stars: individual (OGLE-BLG182.1.162852)

1 INTRODUCTION
There has been a recent increased interest in discovering astronomical events which show transient intervals of dimming (see e.g. Quillen et al. 2014; Meng et al. 2014). Analogous to events which show a transient brightening, such as novae or microlensing, dimming events also offer the opportunity to investigate interesting astrophysical phenomena.

The large-scale long-term sky variability survey OGLE (Udalski 2003) routinely observes millions of stars towards the Galactic bulge and the Magellanic Clouds. The OGLE database is a rich resource for the discovery of a wide range of transient phenomena. In an initial analysis of data from the last three phases of the OGLE project (OGLE-II, OGLE-III and OGLE-IV), we have discovered a number of events which show instances of transient dimming. The full results of this analysis will be presented in a later paper. Briefly; in our analysis we computed the von Neumann statistic (von Neumann et al. 1941; Price-Whelan et al. 2014) and skew for each OGLE light curve and investigated those light curves having extreme values for each of these two statistics. One such light curve, for star OGLE-BLG182.1.162852 (17h59m3.54s, -30°49′6.0") shows three deep, asymmetric dimming events.

2 LIGHT CURVE PROPERTIES
The OGLE light curve for OGLE-BLG182.1.162852 is shown in Figure 1. The three deep minima are spaced by $\sim 1277$ days (3.5 years). Figure 2 shows the data for the second and third dimming events overlaid on the first dimming event. The light curve is well sampled during ingress for all three dimming instances while egress was only covered for the first and third dimming events. While we do not have data which extends completely through the second dimming event, the shape of the light curve during the second dimming event is largely consistent with that of the first and third dimming events. The interval between dimming events is constant, at 1277 days. We speculate that whatever the physical cause of these transient dimming events for OGLE-BLG182.1.162852, they occur with a period of 1277 days. The light curve profile for OGLE-BLG182.1.162852 shows a striking similarity to that for OGLE-LMC-ECL-11893, see Figure 1 of Dong et al. (2014). Dong et al. (2014) find a...
close similarity between the light curve of OGLE-LMC-ECL-11893 and EE Cephei, an eclipsing binary with a circumstellar disk (Galan et al. 2012) and suggest that OGLE-LMC-ECL-11893 is also a disk-eclipse system. We suggest, in turn, that star OGLE-BLG182.1.162852 similarly is an eclipsing binary star with a circumstellar disk around one of the binary star components, the disk periodically obscuring the light from the other star in the binary system.

The depths of the first and third eclipses are $\Delta I \simeq 3$ mag and $\Delta I \simeq 2$ mag respectively. The second eclipse event was not fully covered by OGLE. The eclipse duration is $\simeq 100$ days, with the ingress/egress lasting $\simeq 10$ days, and the declining trough lasting $\simeq 80$ days.

Some $V$-band data were collected for OGLE-BLG182.1.162852 during the third dimming event. The difference between baseline magnitude and the magnitude during the dimming event, $\Delta m$, is shown in Figure 3 for both $V$- and $I$-bands. Since $\Delta m_I \simeq \Delta m_V$, this particular dimming event was colourless. Also shown in Figure 3 are the OGLE $I$-band data available at the time of writing. Star OGLE-BLG182.1.162852 is presently undergoing another dimming event. Data for the present dimming event initially followed the same ingress profile as for previous dimming episodes, but now appear to be tracing out a deeper minimum than that seen previously.

The baseline magnitude for OGLE-BLG182.1.162852 is clearly variable. A spectral analysis of the out-of-eclipse data gives a dominant period of 14.37 days. The average amplitude of the 14.37 period signal in the baseline data is $\sim 0.06$ mag, however, there is clearly variation in the amplitude, and there may be other frequency components present. More detailed analysis of the short period variability of star OGLE-BLG182.1.162852 will be presented in a later paper.

DISCUSSION

Only a handful of disk eclipse systems are known. The basic observed parameters of known disk eclipse systems are given in Table 1 along with those for star OGLE-BLG182.1.162852.

The values for the period, duration and depth of the dimming events in star OGLE-BLG182.1.162852 are broadly consistent with those attributed to transits of the disk in the known disk-eclipse systems listed in Table 1.

The eclipse depth for other known disk-eclipse events $\epsilon$ Aurigae, OGLE-LMC-ECL-17782 and KH 15D vary from one eclipse to another and this is considered to be owing to the precession of the disks in these systems. Figure 2 shows that the depth of the dimming events for OGLE-BLG182.1.162852 also changes from event to event, suggesting that, given a circumstellar disk is the cause of the dimming events, the disk is precessing.

A counterpart to star OGLE-BLG182.1.162852 was found in the GLIMPSE database (Benjamin et al. 2003).
Table 1. Basic observable parameters of known disk-eclipse binary stars, and for star OGLE-BLG182.1.162852.

| System          | Period  | Eclipse Duration | Eclipse Depth | Reference(s)                      |
|-----------------|---------|------------------|---------------|-----------------------------------|
| ε Aurigae       | 27.1 years | ∼ 22 months     | 0.9 (V)       | Kloppenberg et al. (2010), Stefanik et al. (2010) |
| EE Cephei       | 5.6 years | ∼ 30 – 90 days  | 0.5 – 2.0 (B,V) | Galan et al. (2012), Graczyk et al. (2004) |
| KH 15D          | 48.4 days | variable        | ∼ 4 (I)       | Hamilton et al. (2005), Winn et al. (2006) |
| J1407           | > 850 days | ∼ 54 days       | > 3.3 (V)     | Mamajek et al. (2012) |
| OGLE-LMC-ECL-17782 | 13.35 days | 2.67 days       | ∼ 0.4 (I)     | Graczyk et al. (2011) |
| OGLE-LMC-ECL-11893 | 468.124 days | ∼ 15 days       | 1.5 (I)       | Dong et al. (2014) |
| OGLE-BLG182.1.162852 | 1277 days | 100 days        | 2 – 3 (I)     | This work |

*a* presently ∼ 24 days

*b* Duration of the single eclipse event observed to date, during which multiple dimming events occurred.

Table 2. Infra-red photometry for the counterpart to OGLE-BLG182.1.162852 in the Spitzer/GLIMPSE and 2MASS databases.

| OGLE-BLG182.1.162852 | 2MASS | GLIMPSE |
|-----------------------|-------|---------|
|                       | J     | H       | K       | 3.6 | 4.5 | 5.8 | 8.0       |
|                       | 13.778| 12.834  | 12.545  | 12.317| 12.346| 12.426| 12.154   |

of Spitzer photometry [Werner et al. 2004], and also in the 2MASS database [Skrutskie et al. 2006]. Star G359.8611-03.4652 (2MASS 17590354-3049059) lies 0.124 arcsec from the OGLE co-ordinates for star OGLE-BLG182.1.162852 and has infrared magnitudes as given in Table 2. Assuming a constant period for the dimming episodes, the Spitzer and 2MASS observations were taken at out-of-eclipse times for OGLE-BLG182.1.162852. The Spitzer colours for OGLE-BLG182.1.162852 are consistent with a bare stellar atmosphere (Megeath et al. 2004). There is no infra-red excess which could be associated with a circumstellar disk or envelope of gas or dust. It is worth noting that Mamajek et al. (2012) similarly found no infra-red excess in the 2MASS photometry associated for disk-eclipse event J1407.

The position of star OGLE-BLG182.1.162852 on a colour-magnitude diagram of OGLE field stars is shown in Figure 4 for both in- and out-of-eclipse times. Out-of-eclipse, star OGLE-BLG182.1.162852 has a magnitude and colour consistent with a K giant star.

The small amplitude variations in the out-of-eclipse data for OGLE-BLG182.1.162852 are consistent with the presence of spots on the star (Soszyński et al. 2013). The variations in the baseline have a similar amplitude and period to the 9.6 day, 0.1 mag quasi-periodic variations for KH 15D (Hamilton et al. 2005). The visible component of the KH 15D system is a weak-lined T-Tauri star and are attributed to star spots on the surface of this star. J1407 shows 0.1 mag out-of-eclipse variations as well, with a somewhat shorter period of 3.2 days. These variations, too, are consistent with the presence of star spots (Mamajek et al. 2012).

Without spectroscopic measurements of the visible component of OGLE-BLG182.1.162852 we can only speculate on what type of star it is. Similarly, spectroscopic observations during a dimming episode would allow firmer conclusions on what is causing the periodic dimming events.

**CONCLUSION**

The OGLE light curve for OGLE-BLG182.1.162852 is strikingly similar to light curves for binary star systems comprising an eclipsing disk around one of the binary star members. Baseline variability is also consistent with that seen in the light curves of the visible components of other binary disk eclipsing events. The event is presently undergoing a dimming event, which will end around December 30th, 2014. The next dimming episode will be in March 2018. Spectroscopic observations of OGLE-BLG182.1.162852 are strongly encouraged now.
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