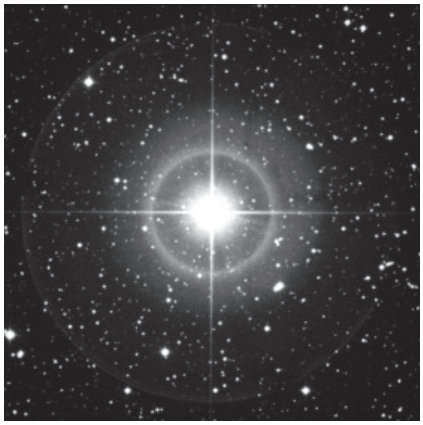
Notable long-period eclipsing binaries. Part I.

Long-period eclipsing binary stars are very important for stellar astrophysicists, because they offer the chance to study the characteristics of isolated stars with a high degree of precision and accuracy. The most interesting fact about eclipsing binaries is that all kinds of stars are found as members of binaries: from normal main sequence stars, variable stars, evolved giants and supergiants, to collapsed objects. Here a list of several interesting long-periodic systems is presented.

Detached eclipsing binaries can provide fundamental physical properties of the components through the analysis of light and radial velocity curves. This allows to determine masses, radii and luminosities of individual stars and provides test bases for stellar structure and evolution models, and internal structure of stars.

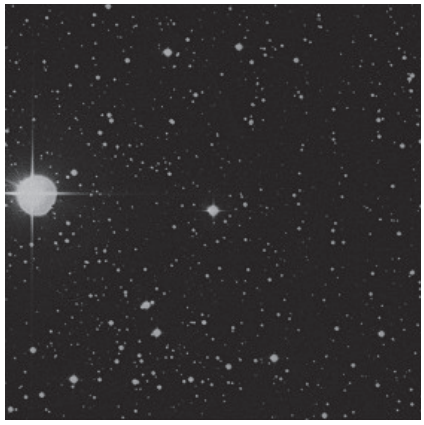


The issue with long-period systems is that eclipse events are quite rare to happen, so their photometric coverage is very valuable, providing a good chance to scientists to gain more statistical data. Not all wide-field photometric surveys have details on even a single eclipse event per long-period eclipsing variables, as they are conducted for a limited period of time.

Below is a set of interesting targets for amateurs that are in need of observations. Each star is accompanied by an image of the star's 12.9 arcmin neighborhood, provided by the *Aladin Sky Atlas* - http://aladin.u-strasbg.fr. Detailed star charts along with photometry tables can be obtained via AAVSO's *Variable Star Plotter* (VSP), available at http://www.aavso.org/vsp

Epsilon Aurigae, Zeta Aurigae and VV Cephei (the next eclipse is expected in 2017) were described in details in separate articles in the bulletin. For **Zeta Aurigae** (see the top-right image here), the next eclipse is expected in July 2014; totality usually lasts for 37 days. So you have enough time to get prepared!

AZ Cassiopeiae



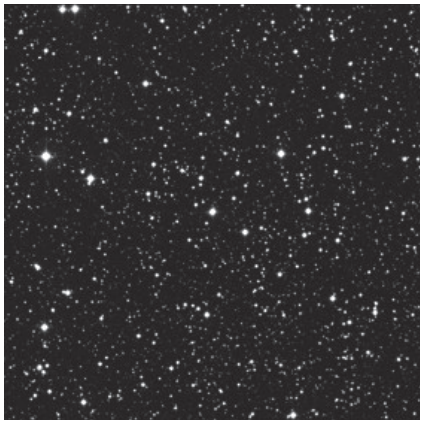
Cassiopeia; J2000: RA = 01h 42m 16.5s; DEC = +61d 25m 16.4s;
Mag.: 9.22 - 9.52 V; Period: 3402 d (9.3 yr); Next eclipse: April 2022

Unfortunately, the most recent eclipse was in January 2013, so the next one is really far away. The variability of AZ Cas was discovered by Beljawski (1931), while the period was determined 25 years later, by Ashbrook in 1956 (see Tempesti, 1979; AASS, 39, 115). In 1947 C. Hoffmeister classified the variable as an R CrB-like star, but Ashbrook found the star to be an eclipsing binary (Larsson-Leander, 1960; Arkiv för Astronomi, 2, 347);

The AZ Cas system consists of an M0I supergiant and B0V hot component (Cowley, Hutchings, & Popper 1977). Its orbital period is 9.3 years with an eclipse duration of ~100 days. No significant light variations in UBVRI outside the eclipse have been found (Nha 1994; Lee & Gim 1994). The spectroscopic orbital parameters revealed an eccentric orbit, e=0.55 (Mikolajewski et al., 2004; ASPCS, 318)

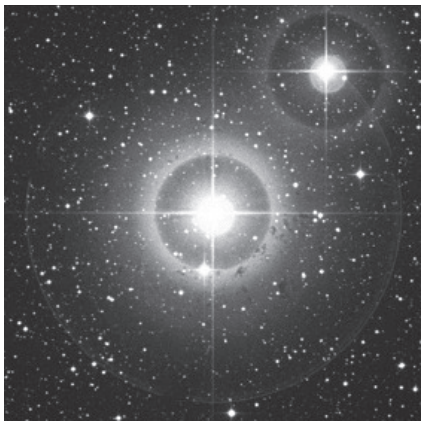
AZ Cas Campaign 2012 – 2014 online:
http://www.astri.uni.torun.pl/~cgalan/AZCas
http://www.astrosurf.com/aras/surveys/azcas/index.htm

EE Cephei



Cepheus; J2000: RA = 22h 09m 22.8s; DEC = +55d 45m 24.2s;
Mag.: 10.72 - 12.15 V; Period: 2050 d (5.6 yr); Next eclipse: August 2014

The eclipsing nature of EE Cep, with a period of 5.6 years, was established after three successive events: in 1958, 1964 and 1969 by Meinunger (1973). The most striking features of the EE Cep minima are large changes of their shape (Graczyk et al. 2003). The observed depths of minima range from about 2m to about 0.m6. Also, the total duration of particular eclipses changes from about 3 weeks to about 2 months. (see Mikolajewski et al., 2004; ASPCS, 318).

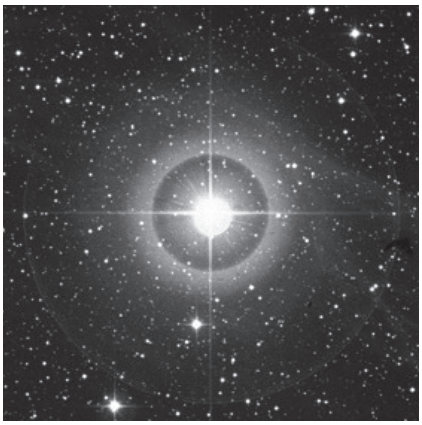


V695 Cygni (31 Cyg, o^1 Cyg)

Cygnus; J2000: RA = 20h 13m 37.9s; DEC = +46d 44m 28.8s;
Mag.: 3.73 - 3.89 V; Period: 3784.3 d (10.36 yr); Next eclipse: March 2024

Another remarkable star with an extremely long period between eclipses. Sadly for those observers who look forward to capture the event soon, its eclipse has just ended. Another is expected in ten years – in 2024. Eclipse duration is two months long. The secondary eclipse occurs at phase 0.64, or 2422 days. A good comparison star is *30 Cyg*, while *26 Cyg* can be used as the check star. The system 31 Cygni is a member of a relatively rare group of eclipsing stars, each composed of a late-type supergiant and a component of early spectral type. It was discovered as a spectroscopic binary in 1901 (Campbell 1901); provisional elements were determined by Christie in 1936 (see Bloomer & Wood, 1973; PASP, 85, 348). For 1982 eclipse analysis please refer to the following publications:

- Stencel, R. E., Hopkins, J. L. et al., 1984; "The 1982 eclipse of 31 Cygni", ApJ, 281, 751
- Hagen Bauer, W., 1994; "Spectroscopic observations of the 1982 eclipse of 31 Cygni", PASP, 106, 244



V1488 Cygni (32 Cyg, o^2 Cyg)

Cygnus; J2000: RA = 20h 15m 28.3s; DEC = +47d 42m 51.1s;
Mag.: 3.90 - 4.14 V; Period: 1147.6 d (3.15 yr); Next eclipse: October 2015

This star system is similar to the 31 Cygni system and is also a member of the group of Zeta Aurigae systems. 32 Cygni is a 4th magnitude star and has a period of 3.15 years. Eclipse totality lasts for 11 days, while ingress/egress is 8.5 days long each. Secondary eclipse occurs at phase 0.65, or 746 days from the primary. Same as for 31 Cygni, *30 Cyg can be used as the* comparison star, and *26 Cyg* - as the check star.

During an eclipse, emission lines can be seen in the spectrum of this system. These originate in the stellar wind escaping from the giant star. In a volume around the B star, this wind becomes ionized, resulting in a circumstellar H II region (Eaton, 2008; JAD, 14, 3). For detailed analysis of variability, refer to:

- Fox, G. K. & Griscom, L., 1996; "The polarimetric variability of 32 Cyg during its 1993 October eclipse", MNRAS, 278, 975
- Dolzan, A., 1987; "32 Cyg: UBV Photometry of Eclipse in 1987", IBVS, 3112
- Gehlich, U. K., Prölss, J., & Wehmeyer, R., 1972; "Photoelectric observations of the 1971-eclipse of 32 Cyg", Astr. and Astroph., 20, 165

22 Vul / QS Vul

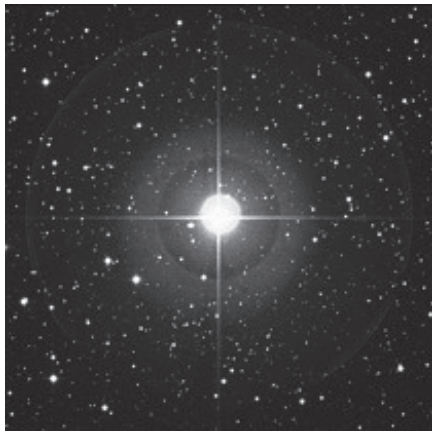
Cygnus; J2000: RA = 20h 15m 30.2s; DEC = +23d 30m 32.0s;
Mag.: 5.03 - 5.27 V; Period: 249.1 d; Next eclipse: August 2014

This star system is a new member of the Zeta Aurigae group. This 5th magnitude star system was discovered during the 1984 eclipse. The eclipse in the "V" band is only 0.05 magnitudes but increases to nearly 0.2 magnitudes for the "B" band and nearly 0.5 magnitudes in the "U" band. Ingress and egress are usually 1 day long, while the totality lasts for 8-10 days.

This system is unique as it is the first one found with a G-type primary, while the spectral type of the secondary is the latest (B9) of all Zeta Aurigae binaries. The period is also short for systems of that kind. More detailed analysis of photometric and spectroscopic measurements during the 1984 eclipse is available in the following publications:

- Ake, T. B. et al., 1985; "The newly discovered eclipsing supergiant 22 Vulpeculae", ApJ, 298, 772
- Parsons, S. B., et al., 1985; "The August 1984 eclipse of 22 Vulpeculae", PASP, 97, 725

tau Persei (18 Per)



Perseus; J2000: RA = 02h 54m 15.5s; DEC = +52d 45m 44.9s;
Mag.: 3.93 - 4.09 V; Period: 1515.81 d; Next eclipse: February 2018

Tau Persei was found by Ake et al. (1986) to be an eclipsing binary. This G5 III + A2 V system has a highly eccentric orbit (e = 0.74) and is oriented in such a way, that superior conjunction of the secondary occurs near periastron. The astrometric orbit by McAlister (1981) from speckle observations indicates high inclination: i = 95 ± 2.4 degrees. The UV spectra during eclipse are found to have added line absorption due to the atmosphere of the G star superimposed on the A-type spectrum (Ake et al., 1986). The high inclination of the orbit leads to the question of eclipses. Based on observed data of 1984 and 1989 events, the eclipse is 84% total (Hall et al. 1991). Typical eclipse lasts for 2-3 days.

- Hall, D. S. et al., 1991; "Worldwide photometry of the January 1989 Tau Persei eclipse", AJ, 101, 1821
- Demircan, O., Selam, S. O., 1992; "A long-period eclipsing binary Tau Persei", Astr. & Astroph., 259, 577
- Ake, T. B. et al., 1985; "Discovery of an Atmospheric Eclipse of tau Per", IBVS, 2847, 1

gamma Persei (23 Per)

Perseus; J2000: RA = 03h 04m 47.8s; DEC = +53d 30m 23.2s;
Mag.: 2.91 - 3.21 V; Period: 5346 d; Next eclipse: December 2019

Gamma Persei is a spectroscopic binary with a period of 14.6 years. It is even an eclipsing binary, where a small magnitude drop can be observed at the time of eclipse. The eclipse was first observed in September 1990 and lasted for two weeks (Griffin et al., 1994). The duplicity of Gamma Persei was first recognized by Miss Maury in 1897, based on the analysis of its spectrum.

- Griffin, R. F. et al., 1994; "The Eclipse of Gamma Persei", International Amateur-Professional Photoelectric Photometry Communication, 57, 31
- Pourbaix, D., 1999; "Gamma Persei: a challenge for stellar evolution models", Astr. & Astroph., 348, 127
- Popper, D. M.; McAlister, H. A., 1987; "Gamma Persei - Not overmassive but overluminous ", AJ, 94, 700

V0481 Persei (BD+49 1130) – *the chart is on the right*

Perseus; J2000: RA = 04h 13m 08.8s; DEC = +49d 42m 35.3s;
Mag.: 12.0 - 13.2 p; Period: 1496 d; Next eclipse: February 2015

V0718 Per (Herbig 187, IC 348)

Perseus; J2000: RA = 03h 44m 39.2s; DEC = +32d 07m 35.6s;
Mag.: 12.95 - 13.65 Ic; Period: 1716 d; Next eclipse: Feb-Mar 2015

Extremely interesting object. The remarkable pre-main-sequence object V718 Per (HMW 15, H187) in the young cluster IC 348 periodically undergoes long-lasting eclipses. The light curve is flat-bottomed and rather symmetric, with a depth of 0.66 mag. During eclipse, the system reddened by ~0.17 mag in R-I (Cohen et al., 2003), confirmed by Nordhagen et al. (2006). The duration of each eclipse is at least 3.5 yr, or ~75% of a cycle, verifying that this is not an eclipse by a stellar companion. It may be an eccentric binary in which a portion of the orbit of one member is currently occulted during some binary phases by a circumbinary disk. The star deserves sustained observational attention for what it may reveal about the circumstellar environment of low-mass stars of planet-forming age. (Nordhagen et al., 2006). Late 2004, V718 Per entered a second eclipse, in

shape and depth very similar to the first one. (Barsunova et al. 2005). More detailed observations by Nordhagen et al. (2006) show that V718 Per undergoes recurrent, 3.5 year long eclipses with a period of P = 4.7 ± 0.1 years (see also Grinin et al. 2006a). Thus, given the very long eclipse duration and its comparitively short period, this system is one of the most exotic eclipsing systems known.

- Grinin, V. et al., 2008; "The unusual pre-main-sequence star V718 Persei...". Astr. & Astroph., 489, 1233
- Grinin, V. et al., 2006; "On the nature of the unique eclipsing system H 187 (HMW 15)", Astr. Lett., 32, 827
- Nordhagen, S. et al., 2006; "The Recurrent Eclipse of an Unusual [..] Star in IC 348", ApJ, 646, 151
- Cohen, R. E. et al., 2003; "An Unusual Eclipse of a Pre-Main-Sequence Star in IC 348", ApJ, 596, 243

RZ Oph (HIP 92055)

Ophiuchus; J2000: RA = 18h 45m 46.4s; DEC = +07d 13m 12.3s;
Mag.: 9.65: - 10.42 V; Period: 261.9277 d; Next eclipse: August 2014

The long period Algol-type binary RZ Oph is known for more than a century. It was also observed in summer 1981 at the University Observatory in Brno. Analysis of the circumstellar Balmer emission lines indicates that the primary is surrounded by an extensive, highly flattened disk of nonuniform density (Baldwin, 1978).

- Baldwin, B. W., 1978; ApJ, 226, 937
- Olson, E. C., 1993; AJ, 106, 754
- Forbes, D. & Scarfe, C. D., 1984; PASP, 96, 737
- http://www.as.up.krakow.pl/o-c/data/getdata.php3?RZ%20OPH

OW Gem (SAO 95781)

Gemini; J2000: RA = 06h 31m 41.8s; DEC = +17d 04m 56.3s;
Mag.: 8.22 - 9.6 V; Period: 1258.59 d; Next eclipse: October 2015

This eclipsing binary consists of two supergiants: an F2 Ib-II primary and a a cooler, fainter giant companion G8 IIb secondary. Variability of the system was discovered by Kaiser in 1988. The AAVSO's eclipsing binary team has conducted a multi-filtered international campaign on OW Gem covering the primary and secondary eclipses in 1995 and 2002.

- Terrell et al., 2003; "The Double Supergiant Binary OW Gem", AJ 126, 902
- Kaiser, D.H. : 2002 (IBVS 5347), 1988 (IBVS 3233), 1988 (IBVS 3196)

NSV 10028 (USNO-B1.0 0943-0320829)

Ophiuchus; J2000: RA = 18h 01m 55.4s; DEC = +04d 22m 16.4s;
Mag.: 11.55 - 12.43 V; Period: 704 d; Next eclipse: June 2014

NSV 10028 is an orange star that seems to undergo 0.8-0.9 mag fadings. This may be a long period eclipsing binary, according to Hoffmeister's 1967 discovery and interpretation, but may be an RCB object as well. It takes more than 40 days for the star to recover. Very interesting object to follow, due to an almost 0.9 mag range. The question if the object is periodic is still open.

http://www.astrouw.edu.pl/cgi-asas/asas_lc/180156+0422.3

Remarkable objects from the South celestial hemisphere will be described in the second part. Generally, observations should be started at least a month prior to the predicted eclipse date, in order not to miss an event.

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