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CALL FOR OBSERVATIONS OF THE AZ Cas ECLIPSE AND PERIASTRON PASSAGE OF 2012-2014

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AZ Cas ($m_{\rm V}$=9.3) was discovered as a variable star by Beljawsky (1931). Ashbrook (1956) has found it to be an eclipsing binary of Algol type with very long orbital period ($P_{\rm orb}\approx$9.3yr). There are yet only a few eclipsing binary systems known to contain giant/supergiant stars, which have very long orbital periods, lasting decades. Eclipses in these systems are rare but if they occur they are very long and accompanied by interesting phenomena. A good example is VV Cep ($P_{\rm orb} \approx 20.3$ yr), in which the eclipses last for nearly 2 years. Its most recent eclipse in 1997 was delayed by 1% of the orbital period relative to the predictions (Graczyk et al. 1999). This system is the prototype of the group of variables consisting of an M or late K type supergiant and an early B type star, in whose spectra strong Balmer and [Fe] emission lines are present (Cowley 1969). AZ Cas belongs to this group. Among dozens of known VV Cep type binaries, only these two show eclipses.

The next spectacular event is about to begin in the AZ Cas system, which consists of two components with masses as high as about 30 $M_\odot$. The more massive component of the system is a supergiant of late K or early M spectral type ($T_{\rm eff} \sim 4000$ K), of which linear diameter may reach up to 1000 $R_\odot$. Its companion is a hot B star ($T_{\rm eff} \sim 21000$ K) with a diameter several tens of times smaller ($D \sim 30\,R_\odot$). Its total amount of emitted radiation equals to the supergiant and exceeds it many times in the ultraviolet. Due to the great difference in size and surface brightness between the components, photometrically only the primary eclipses can be observed, when the hot component is obscured. The depth of the eclipses differ strongly in different bands: reaches up to $\sim 2^{\rm m}_{.}1$ in U and decreases rapidly towards the red, being only $\sim 0^{\rm m}_{.}23$ in V (Fig. 1 a). The most interesting light variations appear during and near to the eclipses. In the $BV(RI)_{\rm C}$ photometric bands a gradual increase in the brightness of the system happens, reaching a maximum around phase 0.09, and then follows a relatively rapid decline. This is best seen in the V light curve (where the most numerous and accurate photometric data is available). There we can see the brightness drift starting already a bit before phase -0.05 (about half a year before the photometric eclipse) and the eclipse appears to be imposed on this (Fig. 1 b). The totality in the whole observed range has a convex bottom with an increasing maximum towards the shorter wavelengths (Fig. 1 b & c). A slow increase in brightness by about $0^{\rm m}\!.4$ over about 7-8 month after the egress in U band has been observed, for the first time with the 60 cm telescope at Piwnice Observatory (Fig. 1 c).

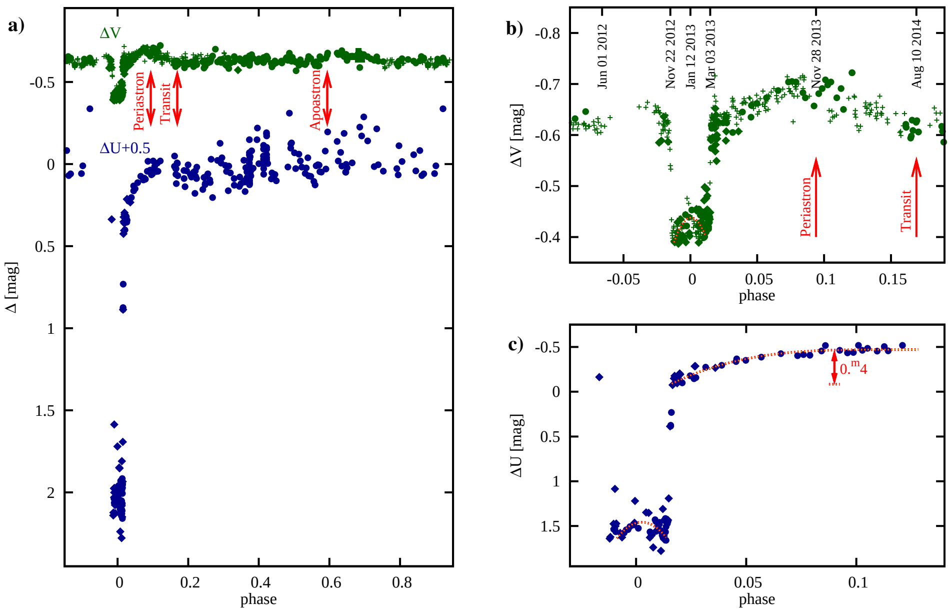

Figure 1. Left (panel a): U and V light curves obtained with the 0.6 m telescope at Piwnice Observatory since the last eclipse during 0.9 of orbital phase (points) are shown together with data obtained during the previous eclipses: Suhora and Kraków measurements (Mikolajewski et al. 2004) (diamonds) and older Larsson-Leander (1960) and Tempesti (1980) data (crosses). An expanded view of the curves around the eclipse and the periastron are shown on the right (panels: b & c): the V light curve with some dates of characteristic stages, predicted according to the ephemeris (Eq. 1) (top - panel b) and U light curve (bottom - panel c). The convex bottom and the long atmospheric eclipse are highlighted with dashed lines.

The unusual photometric behavior shown above is caused by the specificity of the orbit and the characteristics of the components. The orbit is highly eccentric (e = 0.55) and has a very special (close to zero) value of periastron longitude ($\omega = 4°$) (Cowley et al. 1977), so that the phase of occultation (primary eclipse) and transit are very close to the periastron (see Fig. 2). The supergiant has a huge diameter and furthermore it is surrounded by a very extended gaseous envelope formed as a result of an efficient mass loss process. When the components approach each other during the periastron passage then the equipotential surface is shrinking and the tidal forces lead to great deformation of the supergiant from the spherical symmetry. This phenomenon is responsible for the increase in brightness with maximum around the periastron. The maximum observed during the totality phase, seen as a convex bottom, could indicate the appearance of some additional, third light in the system. The increasing amplitude of this phenomenon towards the short wavelengths suggests that scattering effect could be responsible for that. In AZ Cas we observe probably for the first time such a strong scattering of the bright B stars radiation off particles in the extended envelope. More detailed studies of the brightening in the bottom shows that its maximum is shifted somewhat towards the end of the eclipse in agreement with the change in brightness profile generated by orbiting scattering particles (Galan 2009). The effect connected with scattering is strong during the occultation, while it seems absent or very weak during the transit, which suggests that the Mie scattering dominates on particles of significant size in proportion to the wavelength of radiation. Additional support for the scattering nature of the phenomenon is the behavior of the color changes during the eclipses. The supergiant is significantly less reddened during the eclipse than its companion what indicates the existence of radiation excess in the short wavelengths (Galan et al. 2011).

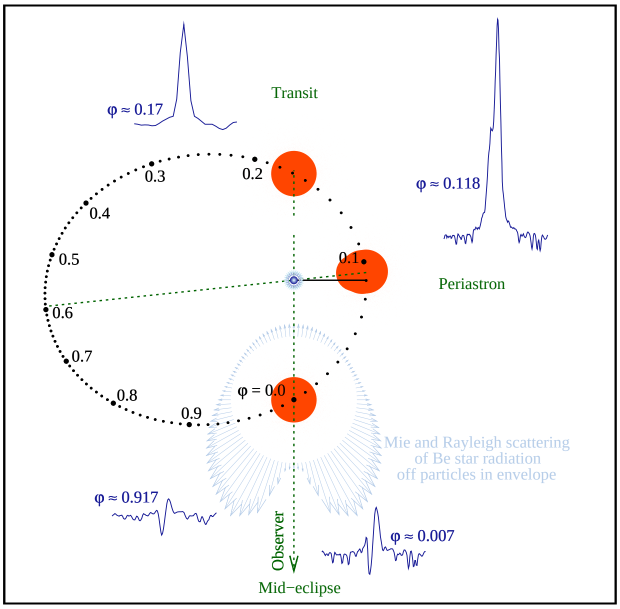

Figure 2. Schematic representation the supergiant and its extended envelope orbiting the B star. The special cases of mid-eclipse, periastron phase and transit are denoted. At the mid-eclipse position the scattering effect of the B star radiation off particles in the envelope is shown with blue arrows. During the periastron phase the supergiant is strongly distorted from the spherical symmetry as a result of ellipsoidal effect. The changes in the Hα profile ($FWZI \approx 13$Å) observed in the selected spectra obtained at Rozhen, Asiago, Piwnice and Terskol observatories at orbital phases: 0.007, 0.118, 0.17 and 0.917, respectively are shown.

The envelope causing the scattering can be responsible for the brightness increase after the egress in the U band. We interpret this as a result of the absorption by the envelope (extensive atmosphere) of the supergiant - a phenomenon analogous to that occurring in ζ Aurigae type eclipsing binaries - a class related to the VV Cep stars. If the proposed interpretation is correct, we should expect a similar "wing" caused by absorption which precedes the eclipse, and it should start in a short time. The last spectrum obtained in April 2012 at phase 0.917 shows a strong absorption component in the Hα line profile (Fig 2). This could indicate that the spectroscopic eclipse is already in progress.

An opportunity to observe and study in details the phenomena in AZ Cas system happens once in every 10 years. To exploit this opportunity, a dense coverage with photometric and spectroscopic observations is needed. The long time scales of changes in AZ Cas - the whole phenomenon will take more than 2 years - demands the involvement of a large number of observatories at different locations to reduce the dependency on the weather conditions and guarantee success during the important phases of the eclipse, which will be relatively short (e.g. ingress and egress). In addition an engagement of a large number of instruments in the observations should increase the accuracy of the obtained light curves. This is very important when some changes have an amplitude as small as few hundredths of a magnitude. To achieve these goals we organize an international campaign for observations of the 2012/13 AZ Cas eclipse similar to the very fruitful observational campaigns for another, unique eclipsing binary EE Cep (Mikolajewski et al. 2005 a & b, Galan et al. 2010, Galan et al. 2012 a). To support the campaign coordination and to help the observers, we have prepared a special webpage: `http://www.astri.uni.torun.pl/∼cgalan/AZCas`. All willing to participate in the observational campaign please contact the authors at `cgalan@astri.uni.torun.pl`. We invite both professional and amateur astronomers around the world. Multicolor photometry is especially desirable obtained in bands close to the standard Johnson or Johnson-Cousins $UBV(RI)_C$ and spectra with low and high resolution covering the whole wavelength ranges from UV to IR. Nevertheless, photometric observations obtained with photographic filters RGB (owned by many amateurs) could also be very valuable. Although they differ from the standard Johnson BVR filters, it is possible to transform them to standard bands. Unfiltered CCD observations should be useful as well for timing purposes, i.e. to determine the precise moments of minimum. However, because of the strong supergiant domination in the infrared, it will be better to use at least an UV-IR blocking filter.

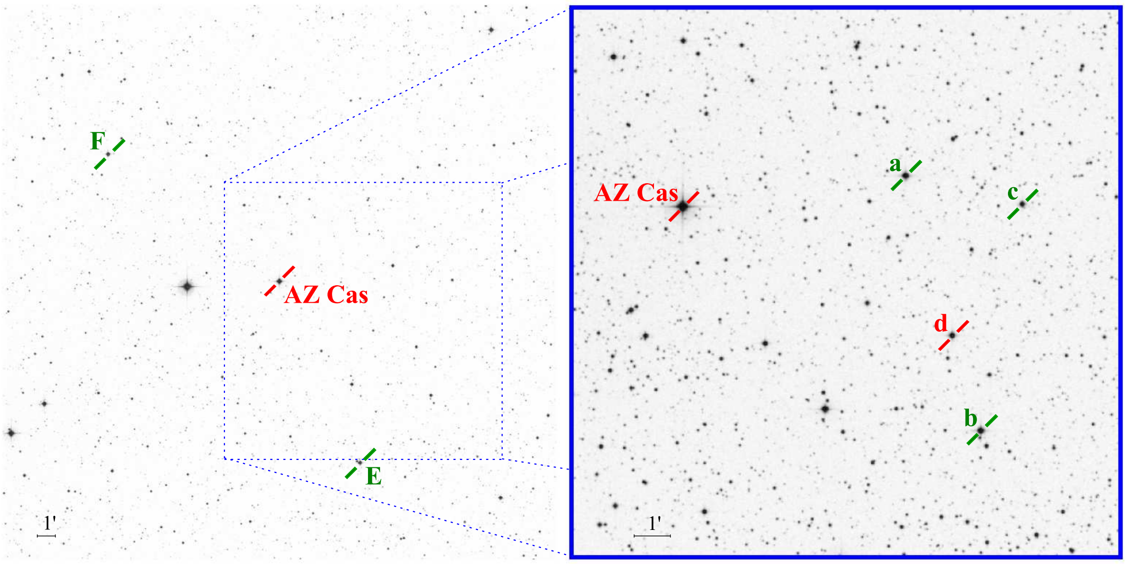

Figure 3. The sky area (30′ × 30′) around AZ Cas ($\alpha_{2000} = 1^{\mathrm{h}}\,42^{\mathrm{m}}\,17^{\mathrm{s}}$, $\delta_{2000} = +61^\circ\,25''\!.3$) (left) with expanded view of closer area (15′ × 15′) shown on the right. The comparison stars recommended for the CCD photometry are marked with green color (see Table 1 for details). Star "d" (TYC 4031-791-1) is variable (see the text).

BD+60°306 and BD+60°317 could be used as comparison stars. Both checked to be constant in V band within $0^{\mathrm{m}}\!.01$ (Tempesti 1980). We have used these objects for multicolor $UBV(RI)_C$ photometry of AZ Cas carried out by a single-channel diaphragm photometer with cooled Burle C31034 photomultiplier attached to the 60 cm Cassegrain telescope at Piwnice Observatory (53.0943 °N, 18.5532 °E) during the period August 2003 – November 2004. We have found these stars to be constant within $< 0^{\mathrm{m}}\!.01$ in $V(RI)_C$ bands and within $< 0^{\mathrm{m}}\!.02$ in UB. However the angular distance between AZ Cas and these stars (see Table 1) is too large. For the purpose of our CCD observations of AZ Cas carried out during the last 7 years using the SBIG-STL 11000 and SBIG-STL 1001 CCD cameras we established a new sequence of comparison stars: BD+60° 303, TYC 4031-437-1 and TYC 4031-125-1 (see Fig 3 and Table 1). We discovered that one of the brightest stars in our photometric field - TYC 4031-791-1 - is a previously unknown eclipsing binary of Algol type (Galan et al. 2012b). Using photometric Johnsons magnitudes published for BD+60°317 by Bern & Virdefors (1972), we have obtained UBV magnitudes for the stars mentioned above. They are shown in Table 1 together with the coordinates. We suggest to use star "a" (BD+60° 303) as main comparison star for the photometric measurements during the campaign. The simultaneous use of other comparisons (stars: "b", "c", "E", "F" in Table 1) is recommended. The variable star "d" is not suitable to be used as comparison, but campaign will provide a unique opportunity to obtain an accurate multicolor light curves for this object.

Table 1. The list of stars selected among those observed at Piwnice Observatory to establish the sequence of comparison stars.

Des.	Identifier	α_{2000} [h m s]	δ_{2000} [° ']	Dist.* [']	Brightness [mag] U $(3\sigma_U)$	B $(3\sigma_B)$	V $(3\sigma_V)$
a	BD+60° 303	1 41 24.9	61 25.76	6.2	11.30 (0.05)	11.09 (0.04)	10.60 (0.03)
b	TYC 4031-437-1	1 41 11.2	61 18.65	10.2	12.39 (0.05)	11.75 (0.04)	10.93 (0.03)
c	TYC 4031-125-1	1 40 58.5	61 24.79	9.3	12.67 (0.05)	12.41 (0.04)	11.80 (0.03)
d**	TYC 4031-791-1	1 41 16.4	61 21.31	8.2	11.66 (0.06)	11.71 (0.04)	11.16 (0.03)
E	BD+60° 306	1 41 44.8	61 15.25	10.7	11.68 (0.04)	10.95 (0.03)	9.90 (0.02)
F***	BD+60° 317	1 43 31.0	61 32.62	12.0	10.24 (0.03)	10.02 (0.02)	9.59 (0.01)

$\star$ The angular distance from AZ Cas in arcminutes.
$\star\star$ The eclipsing variable of Algol type discovered at Piwnice Observatory. The UBV magnitudes mean the average brightness outside eclipses in this case.
$\star\star\star$ UBV magnitudes by Bern & Virdefors (1972)

The most important moments during the campaign are marked in Fig. 1 b. To cover with observations the time interval in which we are interested, it is necessary to observe from June 2012 to August 2014. The complete lack of multicolor observations is particularly unfortunate in orbital phases preceding the eclipse. We emphasize the particular importance of filling this gap. It can contain the initial phase of the drift in brightness mentioned above and the atmospheric eclipse in U. The mid-eclipse, according to the ephemeris (Galan et al. 2011):

$$JD_{\mathrm{mid-ecl}} = 2432477.8 + 3403.85 \times E, \tag{1}$$

should occur on Jan 12, 2013. It will be important to intensify the observations by about one month around mid-eclipse because of the expected maximum in the convex bottom as well as during and around the rapid brightness changes occurring in ingress and egress. The mid-ingress is expected on Nov. 22, 2012 and mid-egress on Mar. 3, 2013. Because of the disparities in the components sizes, both of these stages are amazingly short. The expected duration of the ingress is 11 days while the egress should be about 4 days shorter due to the increasing orbital velocity of the system components when they approach the periastron. It would be also valuable to intensify observations around the periastron passage in November and December 2013 due to the presence of the ellipsoidal effect maximum, and the intriguing local minimum visible in the V light curve.

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