Report From the ε Aurigae Campaign in Greece

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Abstract We report the results of the Greek campaign to observe the 2009–2011 eclipse of ε Aurigae. We present the activities organized by the Hellenic Amateur Astronomy Association (HAAA) in order to publicize the event and to provide the necessary information and tools to both first-time and experienced observers. Although visual observations were the core method, we proposed and experimented with various techniques. In total, data from 21 observers were acquired combining different techniques: 302 visual, 95 CCD, and 11 DSLR observations, and 5 low-resolution spectra.

We were able to construct the light curve of the eclipse and extract some interesting results, in agreement with previous studies. The system's V-magnitude drops from ~3.0 to ~3.8 in 131 ± 21 days. The ingress date is estimated around the MJD 55087 ± 15d (August 12, 2009) and the system is exiting eclipse after the MJD 55797 ± 15d (August 23, 2011). We estimate the duration of the 2009–2011 eclipse to be 710 ± 21 days. A rather possible trend for mid-eclipse brightening exists only in the CCD/DSLR data, which show oscillations of 0.07 magnitude amplitude.

1. Introduction

The bright (~3 V-magnitude) binary system ε Aurigae (ε Aur, R.A. 05^h 01^m 58.1^s, Dec. +43° 49' 23.9", J2000) has been a long mystery since its discovery in early 1800s. The binary consists of a F0 Iab star and a cool, mysterious companion which eclipses the supergiant every 27.1 years for almost 2 years. Although the system has been used extensively as a test bed for many theories and observational methods (Carroll *et al.* 1991; Guinan and deWarf 2002, and references therein) the data obtained so far, which extend almost two centuries, have not been adequate to fully explain this system. Even after the last eclipse of 1982–1984, when an international campaign was launched, the mass and luminosity uncertainties remained strong, prohibiting the final solution (Stencel 1985). But all these data provide important constraints allowing two possible scenarios: (i) the high-mass model, where the F0 star is considered a young star of mass ~15 $M_{\odot}$ and radius ~200 $R_{\odot}$ and the eclipsing companion a cool, proto-stellar or proto-planetary disk with total mass of M ~13.7 $M_{\odot}$ and radius ~9.3 AU, (ii) the low-mass model, where the F0 star is an old solar mass post-AGB star and the disk is a remnant of accretion due to mass transfer with a total mass of ~5 $M_{\odot}$ and radius ~7 $R_{\odot}$. But both models have severe problems to fully interpret the observations, and, moreover, new data raise new questions (Hoard *et al.* 2010; Kloppenborg *et al.* 2010).

In 2009–2010 the system would undergo another eclipse, offering a great opportunity to acquire more information. Thus, another international campaign has been launched in order to coordinate, collect, and provide all the necessary material to perform scientific useful observations from both professional and amateur astronomers: the International ε Aur Campaign 2009–2011 (http://www.hposoft.com/Campaign09.html) organized by Jeff Hopkins and Robert Stencel, and the Citizen Sky project (http://www.citizensky.org) organized by the American Association of Variable Star Observers (AAVSO; http://www.aavso.org). The contribution of amateur astronomers is considered valuable since the system is bright enough to be observed by their equipment (even with unaided eye).

This fact motivated us, the Hellenic Amateur Astronomy Association (HAAA; http://www.hellas-astro.gr), to publicize this campaign in Greece. In HAAA our main goal is to promote the amateur astronomy performed using the necessary methodology in order to obtain scientifically valuable observations and contributing to pro-am collaborations. Thus, the contribution to such a project was considered as a unique opportunity to participate in and to promote it to the Greek amateur community.

This work reports the results of this campaign in Greece, including the aims and the activities organized, in section 2, a description of the methods used and the observations collected, in section 3, and a small discussion on the results, in section 4.

2. The campaign in Greece

2.1. Aims

The ε Aur campaign in Greece was directed by the HAAA with the help of the AAVSO/Citizen Sky staff. The main goals of this campaign were to: (i) inform the Greek community about the rarity and the importance of the ε Aur's eclipse, (ii) provide the necessary material for observations for both experienced and first-time observers, (iii) collect all observations by Greek observers, (iv) forward these to the AAVSO database, (iv) construct the light curve of the eclipse along with any interesting results.

2.2. Activities

In order to better promote the campaign, we have created the dedicated webpage "The observational program of ε Aur" (currently available in Greek at http://www.hellas-astro.gr/article.php?id=765&topic=variables&subtopic=&lang=el) in which we published related material. This included analytical guides on how to perform visual observations, maps, tips, news and updated information on the system, and a frequently updated plot of all observations collected.

This page has already been updated thirteen times and it will continue as new information and results will become available. Updates were mailed to the observers who have already submitted observations and were publicized at the two main fora of amateur astronomers in Greece, Astrovox (under the thread "epsilon Aur", http://www.astrovox.gr/forum/viewtopic.php?t=10578&highlight=\%C7\%ED\%DF\%EF\%F7\%EF\%F5) and AstroForum (under the thread "epsilon Aur", http://astroforum.gr/forum/viewtopic.php?t=3862&highlight=\%C7\%ED\%DF\%EF\%F7\%EF\%F5), with almost 5,000 reads each. At the same time, there was also a thread active in the forum (under the thread "Greek on-going visual observations", http://www.citizensky.org/forum/greek-going-visual-observations) of the Citizen Sky project, which was informing the international campaign about the progress in Greece.

A formal call for observations was made during a talk at the 6th Panhellenic Conference on Amateur Astronomy held in Alexandroupolis, Greece, on September 26, 2009 (Maravelias 2009), with more than 500 participants. The talk was also accompanied by a practical mini-workshop during the night, in which volunteers tried the visual observing technique on the system. In addition, two of the regular meetings of the HAAA were dedicated to ε Aur, regarding the progress of the observations and of the eclipse along with new results obtained. Numerous informal discussions took place at the meetings and via the mailing list.

ε Aur was presented in all talks and workshops related to variable stars that took place after the initialization of the campaign in March 2009. We took advantage of every event to publicize the need for observations and the campaign itself (that is, the Panhellenic Astroparties of 2009 and 2010, at Anavra-Fthiotida and Mt. Parnonas, respectively, and the "Sun and Variable Stars Meeting" at the University of Athens in 2010). Especially in the cases of workshops we offered the opportunity for hands-on experience of visual and digital observations.

Although we did not circulate any press releases about the ε Aur eclipse, there was one article, to the best of our knowledge, published in a national circulation newspaper dedicated to this event ("Vima Science," January 17, 2010). The author referred to both historical and new data about the system and did not fail to refer to the Citizen Sky project and the Greek campaign.

3. Observations

The campaign in Greece was heavily based on visual photometric observations. However, we still experiment with other kind of observations, including DSLR photometry (GM was a member of the DSLR Documentation and Reduction team of the CitizenSky project (http://www.citizensky.org/teams/dslr-documentation-and-reduction, responsible to develop observational methods and tutorials), CCD photometry (IMS was an official member of the International Epsilon Aur Campaign 2009 (http://www.hposoft.com/Campaign09.html)), and low-resolution spectroscopy. The observations will be web-archived and made available through the AAVSO ftp site at ftp://ftp.aavso.org/public/datasets/gmaraj402.txt. We present each method and observations obtained in the following sections.

3.1. Visual

Visual observations are all observations that are obtained using the eye as a photometer, either unaided or through an optical system (that is, binoculars or a telescope). Since ε Aur is a bright object the majority of the observations were made using unaided eye and binoculars.

The method used for visual observations is simply based on the comparison of the target star (ε Aur) with two reference (comparison) stars, usually η Aur with 3.2 V-magnitude (in visual observations all magnitudes are rounded to the first decimal place), ζ Aur with 3.8 V-magnitude (actually it is an eclipsing binary of ~3.75 V-magnitude with a drop of ~0.1 during eclipse, every 2.7 years with eclipse duration ~40 days, but it is considered as non-variable during the major part of the ε Aur eclipse except for the period November–December 2009 when it was in eclipse—during that time it was avoided as a comparison star), or 58 Per with 4.3 V-magnitude. By comparing our target with a fainter and a brighter star, we were able to place it between the two magnitudes. Usually the error of these measurements is not given, and an accuracy of a few tenths of magnitude is assumed with the most experienced observers going down to 0.1, although a subject of controversy (Price *et al.* 2006). In some cases we were able to go down to 0.05 magnitude error, partly due to the small difference between ζ Aur and 58 Per (when ε Aur was in-between) and partly to the growing experience and confidence with the field.

By applying this method we were able to collect 302 observations from twenty-one persons, presented in Table 1.

3.2. CCD

The CCD observations were performed by using an ATik 16 IC monochrome camera, equipped with a Zenit 55 mm *f*/2.8 lens, and a Johnson V photometric filter with the whole setup mounted on an equatorial mount. The reduction procedure followed is the standard one for CCD observations: (i) create the master-dark, the master-bias, and the master-flat images (usually twenty-five images were combined for each master image), (ii) subtract master-dark and master-bias from each science image, (iii) divide each of these by the master-flat, (iv) align and stack images of each set (usually ten sets of thirty science images each), (v) perform photometry using the MaxIm DL software.

The comparison stars used were η Aur and ζ Aur. Since the latter is an eclipsing binary the V-magnitude to use was provided each week by Jeff Hopkins (coordinator of the International ε Aur Campaign 2009). The reduction and the photometry were performed according to the guidelines of the International Campaign.

Using this technique we collected 95 CCD observations, all acquired by a single observer. Details are presented in Table 2.

3.3. DSLR

DSLR photometry refers to the use of a normal Digital Single-Lens Reflex camera (DSLR) or any digital photography camera which: (i) can produce images in a RAW data format, (ii) can focus semi-manually, (iii) is able to manually select a shutter speed/exposure time of several seconds, (iv) has a wide enough field-of-view to get a variable star and a comparison star in the image. In order to obtain the images needed, the camera is usually mounted on a simple tripod with a typical lens of 50–90 mm and exposures of some seconds to capture the bright stars (Kloppenborg *et al.* 2012, in this volume).

The data reduction of DSLR observations follows that of the CCD. In our case though, bias and flat fields were not available, so a slightly different process was followed: (i) the master-dark was created as normal (from dark images), (ii) using three science images we created the master-flat (median combine of the images), (ii) subtract the master-dark from science images, (iii) divide each of these by the master-flat, (iv) align and stack images of each set (usually around eight images), (v) separate stacked images to their RGB Bayer pattern, and keep only the Green channel (closer match to the V filter passband), (vi) perform photometry.

The DSLR Documentation and Reduction team of the Citizen Sky project has developed standard guides (http://www.citizensky.org/content/dslr-documentation-and-reduction) for some widely used software packages within the amateur astronomer community (IRIS, AIP4WIN, MAXIMDL) in order to present easy ways to reduce data and perform photometry. In this work we used IRIS (free software) for image reduction and photometry, along with the spreadsheets provided for this purpose at the Citizen Sky site. We used η Aur as a comparison star while others (that is, ζ Aur, λ Aur, ο Aur, and 58 Per) were used for color and airmass correction. Two of the DSLR observations were analyzed with the MaxIm DL software, where η Aur and ζ Aur stars were used as comparison stars.

Using this technique we manage to collect eleven observations from three persons. The observers and the systems used are presented in Table 2.

3.4. Spectra

3.4.1. 80-mm refractor

As low resolution spectroscopy is available to amateur astronomers, a sample was obtained with a Sky Watcher 80-mm Apochromatic refractor equipped with an ATiK 16 IC camera (640 × 480 px) and a Baader Blaze Grating Spectroscope (207 lines/mm grating with a dispersion of 1267 Å/mm and wavelength coverage ~ 3800–6800 Å).

The spectra extraction was performed through the RSPEC software. Using the standard libraries, an A7V spectral type star profile was selected for the identification of the Balmer lines as well as for the wavelength calibration. From the calibrated spectrum, the Balmer lines were removed, leaving only a featureless spectrum composed of the continuum emission of the star and the instrumental response of the system. By dividing this result by the instrumental response we obtained the final normalized spectrum.

Using this method we collected four spectra, obtained by a single observer (Table 3). One of these spectra is presented in Figure 1.

3.4.2. 1.3-m reflector

We were also able to use the slit spectrograph mounted on the 1.3-m telescope at Skinakas Observatory (http://skinakas.physics.uoc.gr/en/) to acquire one spectrum of ε Aur during its eclipse, on 30 September, 2010. The telescope is equipped with a slit spectrograph (1302 lines/mm with a dispersion of 70.44 Å/mm and wavelength coverage ~ 5210–7280 Å) and a 2000 × 800 ISA SITe CCD.

The data reduction performed in IRAF included: (i) bias subtraction, (ii) flat-fielding, to correct pixel-to-pixel variations across the chip, and (iii) wavelength calibration. The final correction would be to remove the continuum with the help of a standard star. Since no standard was observed that night and no good one was available we decided to leave the spectrum uncorrected. Although present, the continuum does not prohibit us from identifying basic features in the spectrum.

Only one spectrum was obtained with this setup (Table 3) and is presented in Figure 2.

4. Discussion

4.1. Statistics

The main aim of the campaign in Greece was to collect all the observations made by Greek observers during the 2009–2011 eclipse (Figure 3). A total of twenty-one individuals managed to obtain 302 visual observations. Out of the twenty-one observers, only three were not engaged with the campaign run by the HAAA and their observations were acquired through the AAVSO International Database. However, the majority of the observers (~86%) were participants of this campaign (that is, they submitted their observations directly to HAAA) and provided almost all the observations (93%). It is interesting to point out that thirteen participants (~72%) were first-timers in visual observations of variable stars, but only three of them observed more than a couple of times. Although we were expecting a larger contribution, we hope that the new observers will continue observing other variable stars. In total the vast majority of the data (255 observations, almost 84% of the total sample) came from only four persons, already experienced observers.

Out of the eighteen participants of the campaign, six were not members of the HAAA, which means that actually there was a number of people outside the HAAA interested in the campaign. In addition, seven of the participants were already AAVSO observers (that is, they had an AAVSO observer code).

Although the campaign was heavily biased towards the visual observations (74% of the whole sample), there had been systematic work with digital observations (DSLR/CCD). Only three people observed using digital systems (two DSLR users and one using both). One of our team (IMS) used a CCD camera as part of the International ε Aur Campaign 2009, producing the majority of the digital results (almost 90% of all digital observations).

Spectroscopic observations were also attempted by two observers (ISM and GM), but mainly as tests. Experience and time availability was limited to fully exploit the powerful tool of spectroscopy for ε Aur, but the knowledge gained could be used in future projects.

4.2. Visual observations

In Figure 4 we present all the visual observations obtained (indicated as the "raw data" in the figure). It is obvious that we were completely successful in following the 2009–2011 eclipse of ε Aur. The number of observations is not sufficient to extract solid conclusions but some interesting results can be presented.

In order to perform a basic reduction of the observations we used bins of 15 days. Bins with fewer days are close to the sampling period, as the observations were obtained once per week or ten days. Bins with more days tend to smooth too much the light curve, as it is not realistic for the star to be constant in a time span of 20 to 30 days or more. For each bin the median value and the standard deviation (σ) were calculated. In the cases where only one observation was obtained, an error of 0.1 magnitude was assumed (corresponding to the best case scenario—experienced observers). Then all the data which were within the $3 \times \sigma$ range were kept (indicated as the "reduced data" in Figure 4). We used these data to obtain the median value and its corresponding error for each bin (represented as the "median" line in the same figure). By visual inspection of the final result some interesting features of the eclipse can be identified.

The V-magnitude of the system before entering eclipse was ~3.0. The small drop of 0.1 magnitude after the MJD 55050 (August 6, 2009) cannot identify the beginning of the eclipse (due to the 0.1-magnitude oscillations of the system (Carroll 1991; Hopkins *et al.* 2008). Only later, within MJD 55077–55097, we have a clearer indication of the ingress, which could be placed around the MJD 55087 (August 12, 2009), with an error equivalent to the bin size (that is, ±15 days). The date is within the predicted range of dates (Hopkins *et al.* 2008).

Only after MJD 55218 (February 2, 2010), ε Aur seems to have reached its faint state (totality) at magnitude ~3.8, losing almost 0.8 magnitude in 131±15 days, in agreement with the values of 137 days for the 1982–1984 eclipse and 135 days for the 1955–1957 eclipse (Carroll *et al.* 1991). There was a small trend of brightening after MJD 55261 (March 5, 2010), which could tempt us to credit it to the mid-eclipse brightening. However, since the errors are large, the brightening is not statistically significant. Moreover, during this period ε Aur was getting lower on the horizon and after passing behind the Sun (June 2010), it was again low on the horizon, when the observations were resumed. This position definitely affected the observations due to the airmass.

After the MJD 55376 (June 28, 2010) we notice a scatter of values around magnitude ~3.7–3.75. There can be no estimation when the system passed from the third contact (start of engress) due to the data scatter. Only after MJD 55797 (August 23, 2011) we can accept that ε Aur was totally out of the eclipse with a V-magnitude ~3.1. Using the previously estimated date of ingress (MJD 55087) we calculate the duration of the 2009–2011 eclipse to be 710±21 days, which is actually within 2–3σ from the previous eclipse durations, 647 days in 1982–1984 and 670 days in 1955–1957 (although there is a trend for decreasing duration (Carroll *et al.* 1991).

4.3. CCD and DSLR observations

We present the digital data (DSLR and CCD observations) in Figure 5. All observations were obtained within MJD 55128–55545 (October 23, 2009–December 14, 2010), when ε Aur was already in eclipse, with the majority of the data obtained during totality. Thus, there are no additional data to allow for the determination of ingress or engress. Nevertheless, we observe modulations of ~0.07 magnitude, in agreement with previous results (Hopkins *et al.* 2008; Carroll *et al.* 1991). The faintest value, within errors, that ε Aur reached was magnitude 3.789 ± 0.003. Moreover, the oscillations displayed in Figure 5, with maxima near MJD 55285, 55400, and 55470, probably reflects the 67- and 123-day periods identified by Kim (2008).

After MJD 55305 (April 18, 2010) and up to MJD 55335 (May 18, 2010), the system seems to have brightened, with a resulting change in V-magnitude of 0.13 magnitude. It is interesting to observe that this time period coincides with the possible trend observed in the visual data (see Figure 4). Although, the errors are large in visual observations, preventing us from definitely identifying the brightening, the CCD observations are more accurate and they are corrected for the airmass. Thus, this trend in the CCD observations is more realistic and could be attributed to the mid-eclipse brightening.

4.4. Spectra

As there have been only a few tests with spectroscopy, we present the best spectra obtained in Figures 1 (spcA) and 2 (spcB). The observations were obtained during the eclipse of ε Aur and, as such, its spectrum would be a composite of the main star and the disk. Thus, it is out of the scope of this work to present a classification or any spectral results regarding with the nature of the objects, but rather to present a sample of the observations performed and the lines identified.

There is an overlap of the two spectra in the range 5200–6700 Å, where the most prominent features are the NaI Doublet λλ5890,5896 lines (characteristic feature of F- to M-type stars (Montes *et al.* 1999)) and the Hα λ6563 line. Both of these lines are variable during the eclipse, revealing properties for both the disk and the primary star (Barsony *et al.* 1986; Chadima *et al.* 2011). Outside this region in spcA all Balmer lines are evident with some additional features around λλ4040, 4480, and 5050 but we were unable to resolve which lines they are (though the λ4480 line could be the MgII line at λ4481 Å). However, in spcB we were able to identify numerous metallic lines. The most abundant metal is iron with lines such as FeII λλ5235,5274,5316,5363,6148,6238, and 6247 lines and FeI λλ5226,5325,5657, and 5780 lines. Also present are the NiIII λ5534 line and the SiII λλ6347,6371 lines (Chadima *et al.* 2011). In this case, the NaI Doublet is also nicely resolved to its two separate absorption lines (λλ5890,5896, see inset graph in Figure 2).

5. Conclusions

The current work is a report of the results obtained from the Greek campaign dedicated to the observation of the 2009–2011 eclipse of ε Aur. We have been successful in informing the Greek amateur astronomical community about the eclipse and its importance. Furthermore, we publicized the event and the appropriate material for both experienced and first-time observers, by using internet resources (dedicated webpage, threads in well-known fora) and talks/workshops at major astronomical events. We managed to collect 413 observations (302 visual estimates, 95 CCD, and 11 DSLR measurements, 5 low-resolution spectra) from 21 Greek individuals, which have been submitted to the AAVSO International Database.

We were able to construct the light curve of the eclipse and, even under some limitations of the data, to extract some interesting results. By visual examination of the light curve we noticed the system's V-magnitude dropped from ~3.0 to ~3.8, in 131 ± 21 days, in agreement with Carroll *et al.* (1991). We estimated the ingress date around the MJD 55087 ± 15 days (August 12, 2009), within the predicted range of dates, and the exit of the eclipse after the MJD 55797 ± 15 days (August 23, 2011). The duration of the 2009–2011 eclipse was found to be 710 ± 21 days, within the error margins of previous eclipses (Carroll *et al.* 1991). Although we cannot confirm the mid-eclipse brightening by the visual observations, the CCD/DSLR data presented a rather possible indication. Moreover, 0.07-magnitude oscillations were present in the CCD/DSLR data in agreement with previous observations (Hopkins *et al.* 2008; Kim 2008). In addition, we presented our first attempts at spectroscopic observations of ε Aur, which resulted in the identification of the NaI Doublet λλ5890,5896 lines, the SiII λλ6347,6371 lines, and numerous FeI and FeII lines (Barsony *et al.* 1986; Chadima *et al.* 2011).

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References

Barsony, M., Lutz, B. L., and Mould, J. R. 1986, *Publ. Astron. Soc. Pacific*, **98**, 637.
Carroll, S. M., Guinan, E. F., McCook, G. P., and Donahue, R. A. 1991, *Astrophys. J.*, **367**, 278.
Chadima, P., *et al.* 2011, *Astron. Astrophys.*, **530A**, 146.

Guinan, E. F., and DeWarf, E. 2002, in *Exotic Stars as Challenges to Evolution*, eds. C. A. Tout and W. Van Hamme, ASP Conf. Ser. 279, Astron. Soc. Pacific, San Francisco, 121.

Hoard, D. W., Howell, S. B., and Stencel, R. E. 2010, *Astrophys. J.*, **714**, 549.

Hopkins, J. L., Schanne, L., and Stencel, R. E. 2008, in *The Society for Astronomical Sciences 27th Annual Symposium on Telescope Science, Held May 20-22, 2008 at Big Bear Lake, CA*, Society for Astronomical Sciences, Rancho Cucamonga, CA, 67.

Kim, H. 2008, *J. Astron. Space Sci.*, **25**, 1.

Kloppenborg, B., Pieri, R., Eggenstein, H.-B., Maravelias, G., and Pearson, T. 2012, *J. Amer. Assoc. Var. Star Obs.*, **40**, 815.

Kloppenborg, B., *et al.* 2010, *Nature*, **464**, 870.

Maravelias, G. 2009, In *Proceedings of the 6th Panhellenic Conference on Amateur Astronomy, Alexandroupolis, Greece, 25–27 September 2009*, 143 (in Greek).

Montes, D., Ramsey, L. W., and Welty, A. D. 1999, *Astrophys. J., Suppl. Ser.*, **123**, 283.

Price, A., Foster, G., Skiff, B., and Henden, A. 2006, *Bull. Amer. Astron. Soc.*, **38**, 1126.

Stencel, R. E. 1985, in *1982–1984 Eclipse of Epsilon Aurigae* , ed. R. E. Stencel, NASA Conf. Publ. 2384, NASA, Washington, D.C., v.

Table 1. Visual observations obtained by Greek observers during the 2009–2011 eclipse of ε Aur.

Name	*Number of Observations*	*Participant*[1]	*HAAA Member*[2]	*AAVSO Code*[3]
Douvris, Athanasios	1	yes	no	DXA
Flemotomos, Nikos	1	yes	no	—
Georgalas, Byronas	1	yes	yes	—
Gkionis, Dimitris	5	yes	yes	—
Kardasis, Manos	44	yes	yes	KMO
Kottaridis, Panagiotis	5	yes	yes	KPAA
Krikis, Manolis	1	yes	no	—
Manousos, Dimitris	4	yes	no	MUQ
Maraki, Eleni	1	yes	no	—
Maravelias, Grigoris	64	yes	yes	MGK
Ntovolos, Serafim	1	yes	yes	—
Panourakis, Kostas	1	no	no	PKO
Paschos, Dimitris	1	no	no	PDIA
Stefanopoulos, Giorgos	41	yes	yes	STF
Strikis, Iakovos-Marios	106	yes	yes	SIAK
Takoudis, Vasilis	1	yes	yes	—
Tsouloucha, Andromachi	2	yes	no	—
Vakalopoulos, Lefteris	1	yes	yes	—
Vithoulkas, George	19	no	no	VGK
Voutiras, Giorgos	1	yes	yes	—
Voutiras, Orfeas	1	yes	yes	—
Totals *(persons/observations)*				
21	302	18	12	10

[1] *Defined as an observer who submitted his/her observations directly to the HAAA (in "no" cases the data were retrieved from the AAVSO International Database).* [2] *Member of the Hellenic Amateur Astronomy Association (HAAA).* [3] *Observer who submits his/her observations to the AAVSO has a unique observer code—this is given when applicable.*

Table 2. DSLR and CCD observations obtained by Greek observers during the 2009-2011 eclipse of ε Aur.

Name	*Filter**	*Camera*	*Lens*	*f-ratio*	*Exposure(s)*	*No. Obs.*
Gkionis, Dimitris	Green	Canon 300D	Nikon 200mm	2.8	5	1
Gkionis, Dimitris	Green	Canon 300D	Tamron 300mm	5.6	5	1
Kardasis, Manos	Green	Canon 300D	Canon 17–85mm (@ 85mm)	5.6	10	7
Strikis, Iakovos-Marios	Green	Canon EOS 5D Mrk II	Tamron 24–105mm (@ 105mm)	4.5	5	1
Strikis, Iakovos-Marios	Green	Canon EOS 350D Rebel XTI	Tamron 24–105mm (@ 105mm)	4.5	5	1
Strikis, Iakovos-Marios	V	ATiK 16 IC monochrome	Zenit 55mm	2.8	2–5	95

* *Green corresponds to the Green channel of the Bayer pattern (RGB) for DSLR cameras, V corresponds to the Johnson V photometric filter, used for CCD photometry.*

Table 3. Log of spectroscopic observations obtained by Greek observers during the 2009–2011 eclipse of ε Aur.

Name	*Date*	*Telescope*	*Camera*	*Grating (lines/mm}*	*Wavelength (Å)*	*Dispersion (Å/mm)*
Strikis, Iakovos-Marios	2 Jan 2010	ED 80mm	ATiK 16 IC (640 × 480)	BBG* (207)	3800–6800	1267
Strikis, Iakovos-Marios	30 Jan 2010	ED 80mm	ATiK 16 IC (640 × 480)	BBG (207)	3800–6800	1267
Strikis, Iakovos-Marios	1 Feb 2010	ED 80mm	ATiK 16 IC (640 × 480)	BBG (207)	3800–6800	1267
Strikis, Iakovos-Marios	27 Aug 2010	ED 80mm	ATiK 16 IC (640 × 480)	BBG (207)	3800–6800	1267
Maravelias, Grigoris	30 Sep 2010	Skinakas' 1.3m	ISA SITe (2000 × 800)	1302	5210–7280	70.44

* *Baader Blaze grating.*

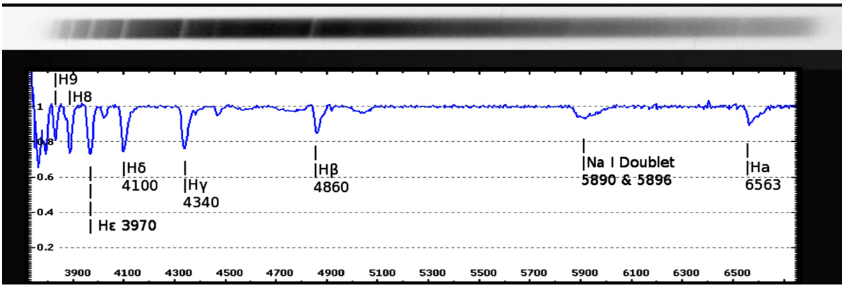

Figure 1. Low-resolution spectrum of ε Aur obtained on August 27, 2010. A Sky Watcher 80-mm Apochromatic refractor was used equipped with an ATiK 16 IC (mono) and a Baader Blaze grating (see section 3.4.1). Characteristic Balmer lines are shown along with the NaI Doublet lines. Spectrum obtained by IMS, reduced by Robin Leadbeater.

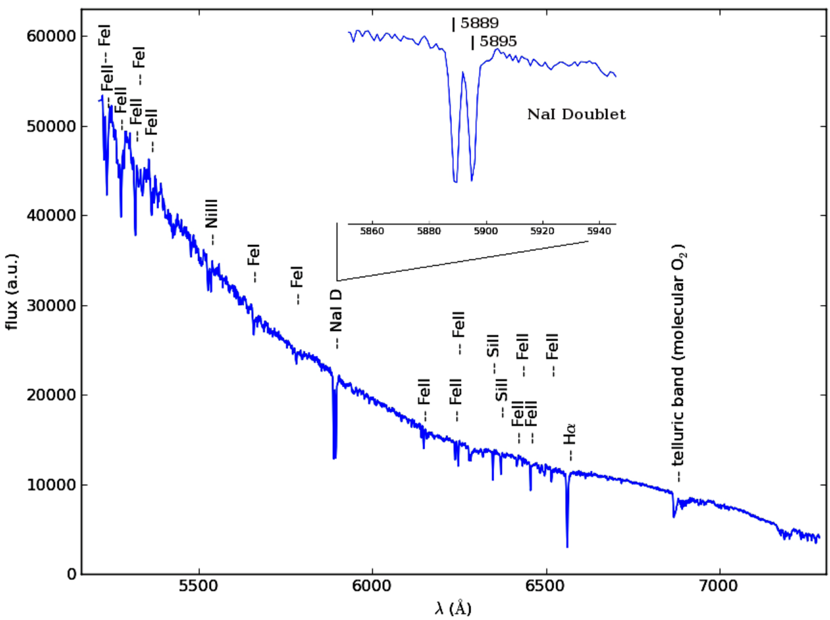

Figure 2. Low-resolution spectrum of ε Aur obtained on September 30, 2010. Skinakas' 1.3-m telescope was used, equipped with an ISA SITe and a slit spectrograph (see section 3.4.2). The Hα and NaI Doublet lines are prominent along with a series of FeI and FeII lines, and SiII lines. Spectrum obtained by GM with the help of Pablo Reig, and reduced by MK.

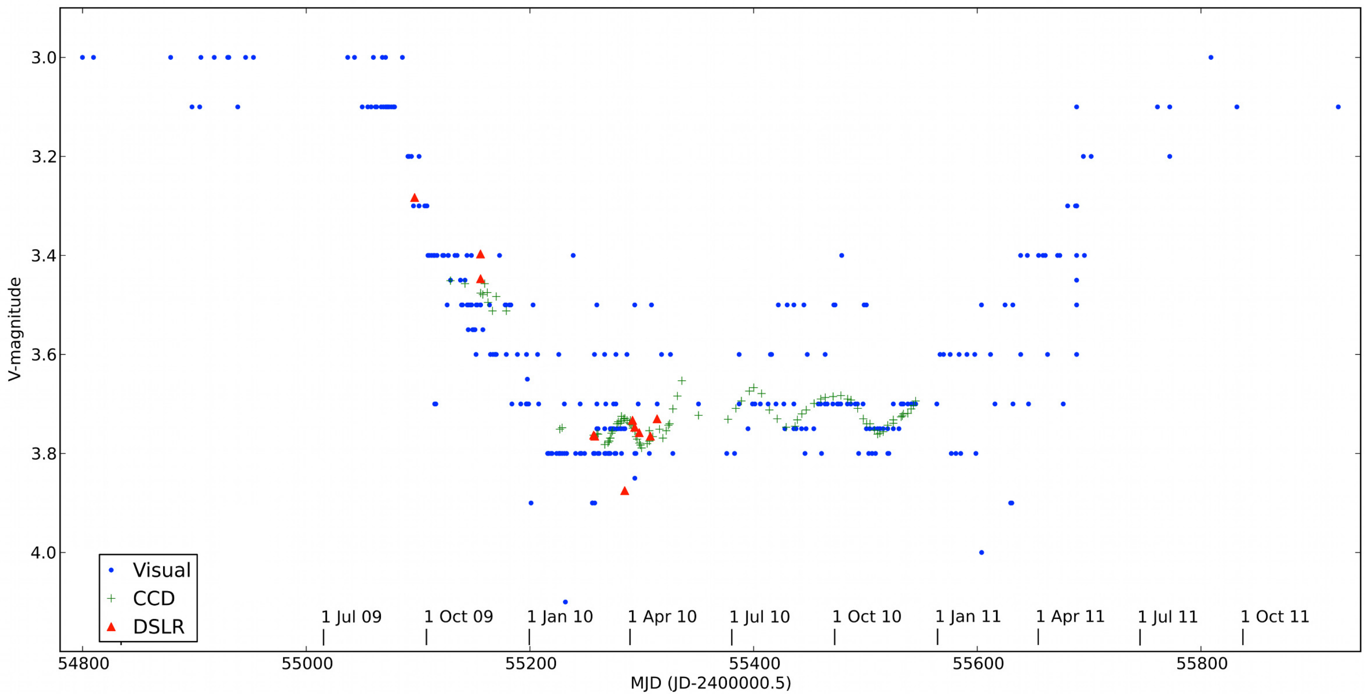

Figure 3. The 2009–2011 eclipse of ε Aur as derived from observations (visual is indicated with a dot, CCD is indicated with a cross, DSLR is indicated with a triangle) obtained by Greek observers, members or not of the Hellenic Amateur Astronomy Association (the list of contributors is presented in Tables 1 and 2).

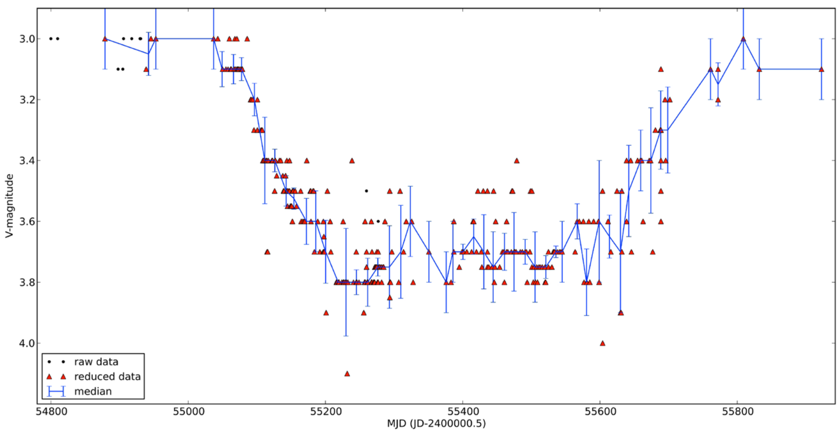

Figure 4. Plot of visual observations along with the median values of the binned data (15 days). From the initial data (indicated as "raw data") values outside the $3 \times \sigma$ were removed and we binned the remaining ones (indicated as "reduced data") providing the median value and its corresponding standard deviation σ (indicated as "median line"). Interesting results are presented in section 4.2.

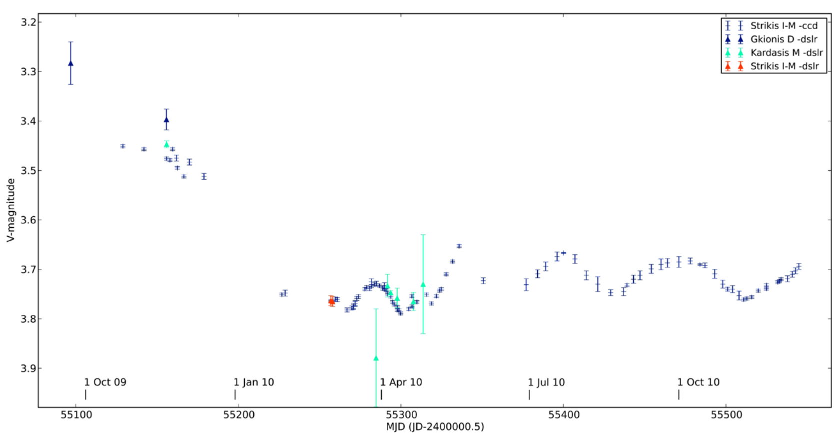

Figure 5. Plot of the digital (DSLR identified as triangles, and CCD identified as crosses) observations during the 2009–2011 eclipse of ε Aur (see section 4.3 for details). The DSLR point just before April 1st, 2010, is a poor result probably due to the presence of thin clouds.