Epsilon Aurigae Eclipse 2009 - Ingress

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ABSTRACT

The mysterious star system epsilon Aurigae undergoes an eclipse every 27.1 years that lasts nearly two years. The most recent eclipse started during the late summer of 2009. An international campaign for observing this eclipse was created in 2006, with a web site for information and, to-date, 17 periodic newsletters for details, as well as a Yahoo forum List for immediate announcements and comments. Photometric data in the UBVRIJH bands have been submitted. Ingress occurred with first contact in the V band estimated at the second week of 2009 August and second contact estimated at 2010 mid-January. Spectroscopic data were also obtained during ingress. Spectroscopic data have been provided in the potassium I region, hydrogen alpha and beta regions and sodium D line region of the star system's spectrum. In this paper we describe details of observations and preliminary analysis during ingress and second contact. We introduce the observers and discuss plans for observing throughout totality and the end of the eclipse in 2011.

1. Introduction

During the 1982-1984 eclipse of epsilon Aurigae, an international Campaign was started. The Hopkins Phoenix Observatory was the focal point for that campaign. Thirteen Newsletters were published and distributed around the world. At the conclusion of the campaign, a NASA-sponsored workshop was held in Tucson, Arizona, in conjunction with the June 1985 American Astronomical Society meeting, resulting in published proceedings (Stencel, 1985).

Now 27 years later, epsilon Aurigae is back in eclipse between 2009 August and 2011 May. A new international campaign was started in 2006. The campaign consists of professional and advanced amateur observers from around the world who have contributed high-quality and valuable spectroscopic and photometric data on the epsilon Aurigae star system. This paper discusses the ingress and second contact portion of the current eclipse as well as providing information on the observers who have contributed data for this period. For reference we include Figure 1 which shows a system schematic using the "High Mass" model which was the prevailing model for most of the 20th century.

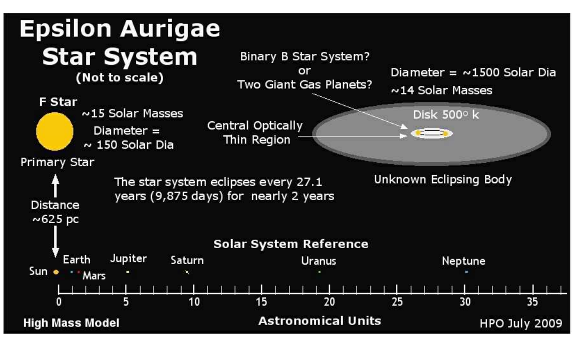

Figure 1. Epsilon Aurigae system schematic.

2. Campaign Communication

During the previous eclipses and campaigns, communication was limited to in-person meetings, telephone calls and postal mail. With observers located around the world, meetings were extremely difficult and expensive. Telephone calls were also expensive and not efficient for getting news to many people. The use of postal communication was much more efficient, but very slow. A month or more went by between newsletters. With the advent of the Internet, we now have near instantaneous communication around the world. In addition, newsletters are created more easily and published on the Internet in high quality PDF format that includes data lists, diagrams, and photographic images. These newsletters can be downloaded by anyone. A very popular and powerful feature of the Internet is the use of on-line forums. People can post a message and receive comments near instantaneously as well as sharing images and data.

In 2006 May, the Hopkins Phoenix Observatory created a web site devoted to epsilon Aurigae and the current campaign. We have published 17 newsletters for this campaign. They are available free as PDF-format files. There is also a vast amount of reference material on the site. In the fall of 2009, a Yahoo forum was created to allow near instantaneous communication with all those interested in the campaign and epsilon Aurigae. The web site URL is

http://www.hposoft.com/Campaign09.html

One can sign up for the forum at

http://tech.groups.yahoo.com/EpsilonAurigae/

3. Campaign Equipment

During the 1982-1984 eclipse, personal computers were just becoming available. The Internet, affordable CCD and DSLR cameras did not yet exist, and spectroscopy by a small observatory was unheard of. This eclipse is benefiting from many technological advances. Many smaller observatories are contributing spectroscopic data. In addition to the single channel photometers, e.g., PMT-based photon counters, and PIN diode-based SSP-3 and SSP-4, CCD photometers are also making valuable contributions. What is even more astounding are the contributions from observers using Digital Single Lens Reflex (DSLR) cameras, without a telescope and just mounted on a tripod. Excellent V band data are being provided by those using the DSLR cameras. For spectrometry, the Lhires III spectrograph has proven affordable and an excellent tool for the small observatory.

4. Photometric Data

Full resolution images of the following plots can be seen on-line at the following links:

http://www.hposoft.com/Plots09/VFall09.jpg
http://www.hposoft.com/Plots09/UBFall09.jpg
http://www.hposoft.com/Plots09/RIFall09.jpg

Figure 2 shows a plot of composite V band photometric data contributed by 18 observers. The plot covers slightly before first contact to just after second contact.

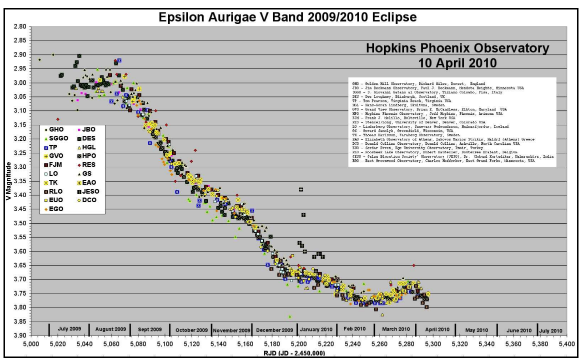

Figure 2. V Band composite photometric data.

Figure 3 shows a plot of composite U and B band photometric data contributed by 6 observers. The previous season's data showing the out-of-eclipse (OOE) variations are included. A significant step or knee can be seen in the data during ingress with it being more pronounced in the U band.

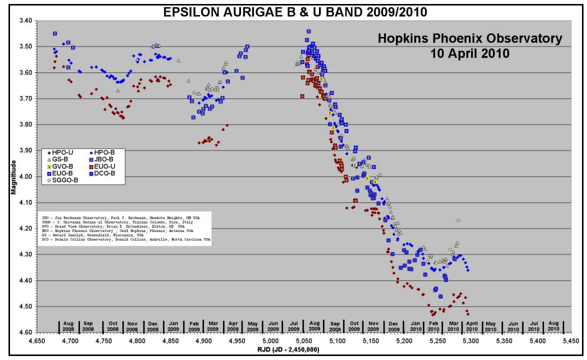

Figure 3. U and B band composite photometric data.

Figure 4 shows a plot of composite Rj, Rc, Ij and Ic band photometric data contributed by 5 observers.

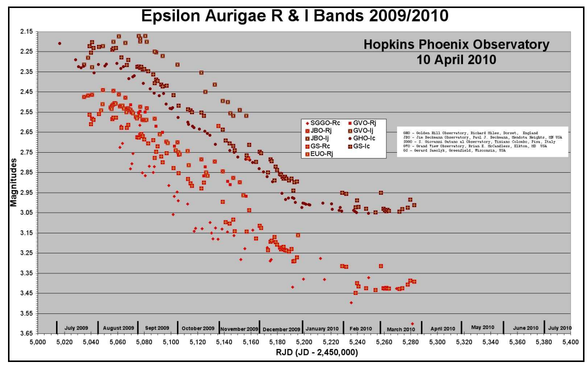

Figure 4 R and I band composite photometric data.

5. Photometric Analysis

The goal of our eclipse photometry is to be able to better define times of contact, that is, the start of partial and total eclipse. Clearly the light curve has additional light variation superimposed on it that complicates the analysis. The OOE variations were described in a poster paper presented at the American Astronomical Society meeting in 2010 January by Brian Kloppenborg, Robert Stencel, and Jeffrey Hopkins:
http://adsabs.harvard.edu/abs/2010AAS...21541938K

All tables are presented at the end of this paper.

Examining the photometric record created by Lou Boyd and Jeff Hopkins spanning the interval between eclipses, it appears that the OOE are more pronounced in the years nearer eclipses and less marked in-between. As seen in Figure 5, the OOE max in V band near RJD 5150 appears to correlate with a smallest (bluest) U-B color. Further study will be needed to determine the role of periastron passage, secondary minimum and/or circumbinary material in contributing to the OOE variations.

The OOE variations are present during the ingress and throughout the eclipse and will cause problems whenever a precise magnitude is needed. Because these variations appear to be random in timing and amplitudes, it is not possible to predict their effect with any degree of accuracy. For the average UBV magnitudes OOE, the several years of pre-eclipse UBV data obtained at the Hopkins Phoenix Observatory were used (Table 1). For the average during totality, the average UBV values from totality during the 1982 -1984 eclipse were used (Table 2).

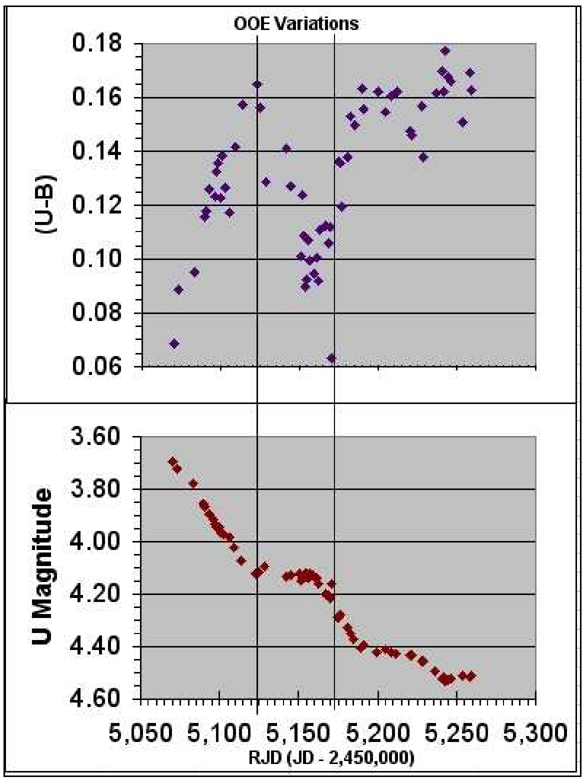

Figure 5. OOE-like variations during ingress.

There are insufficient data for the R and I bands to determine contact times. There was essentially very little pre-eclipse data in these bands and data from the 1982-1984 eclipse have very little coverage in these bands. Table 3 lists the first contact times from the 1982-1984 eclipse. Table 4 lists a summary of the first and second contact times, ingress slopes, ingress times and periods along with the differences between the current eclipse and the 1982-1984 eclipse. These data were calculated using Hopkins Phoenix Observatory UBV data.

Table 5 lists a summary of the first and second contact times, ingress slopes, ingress times and periods along with the differences between the current eclipse and the 1982-1984 eclipse. These data were calculated using current campaign's composite data.

5.1 Determination of Average Contact Points

To determine the contact points, ingress times and periods, the two sets of data, HPO and composite, were averaged. Table 6 shows the results. After having determined the timings for first and second contact, then the orbital velocities are critical values for determining sizes in the star system. Since the F star and eclipsing body orbit a common center of gravity, they have their own orbits. The F star orbital or translational velocity during ingress 2009 was 15.42 ± 0.42 km/sec (Kloppenborg et al., 2010). The velocity measured with interferometry was 25.10 ± 4.65 km/s. This means the eclipsing body's orbital velocity is the difference between that sum value and the F star's 15.42 km/s velocity, or 9.68 km/s (see Figure 7). Similarly, when the mid-eclipse brightening occurs, using the eclipsing body's velocity allows a rough estimate of the size of the opening.

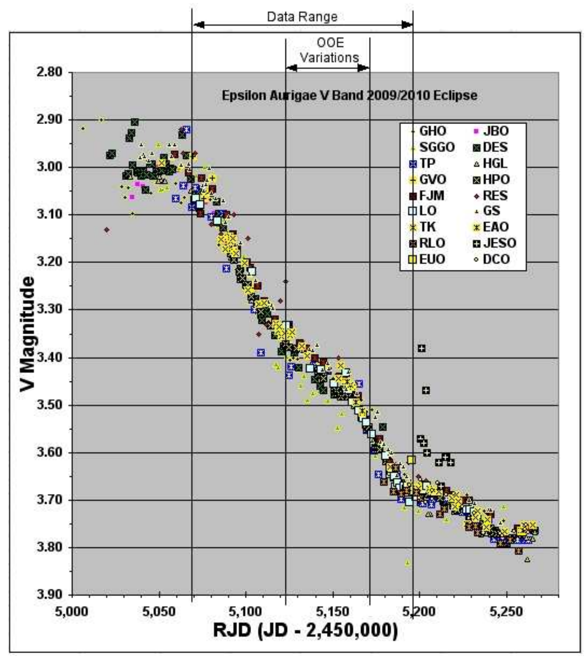

Figure 6. Ingress linear regression data ranges.

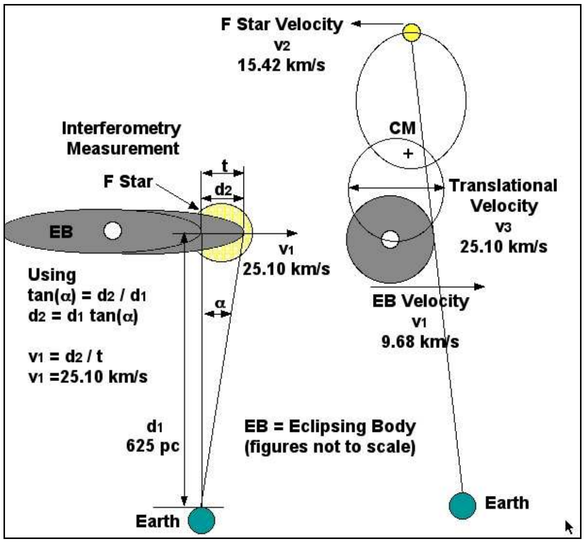

Figure 7. Interferometry measurement.

Table 7 shows the system size for both velocities. These calculations assume a circular orbit with approximate constant velocities (neither of which is true) and are just first approximations.

Others have determined the combined size of the orbits to be 19 AU. Using this instantaneous orbital speed results in a system size of 22.8 AU (14.0 + 8.8 AU), but this is presented simply for comparison.

For a simple eclipsing binary involving two spheres, duration of ingress would yield information on the size of the star being eclipsed, assuming the eclipser is the larger object. Other measurements have shown the F star to have a diameter of 1.4 AU. Table 8 shows the F star size in different bands. Sizes are calculated using the eclipsing body's ingress time and calculated translational velocity during ingress. The non-agreement implies that either the F star diameter is different or that the eclipser is not a simple spherical object. While we cannot exclude the possibility of an extended atmosphere of the F star as described by Cha et al. (1994) and Kemp et al. (1986), the interferometric image of the disk makes it clear that more careful study of the light curve production with non-spherical shapes is needed.

Table 9 shows the original pre-eclipse predicted first contact times with the difference between the average and predicted dates.

To estimate the time of the start and end of the mid-eclipse brightening for the current eclipse, the times between second contact and those points during the 1982-1984 eclipse were calculated and added to the second contact dates for the UBV bands of the current eclipse. Table 10 shows the result of those calculations and the predicted times for the start and end of the mid-eclipse brightening in the UBV bands.

To estimate 3rd and 4th contact points for the current eclipse, times between the second contact point and these points during the 1982-1984 eclipse were calculated and added to the second contact point for each UBV band, Table 11 show the results of those calculations and the resulting predicted 3rd and 4th contact points for the current eclipse.

6. Spectroscopic Data

A directory of epsilon Aurigae spectra has been set up. Robin Leadbeater is coordinating the submissions and maintaining the directory. Information on how to submit and view spectra can be found on the Campaign Web site at

http://www.hposoft.com/EAur09/Robin.html

The past few years has seen an increasing number of amateurs equipped for sub-Angstrom resolution spectroscopy, capable of resolving line profiles and allowing radial velocities to be measured with high precision. This has led to a number of professional-amateur collaborations on bright objects of which the epsilon Aurigae campaign is a typical example. Other examples are the ongoing Be star monitoring project ARAS BeAm and the periastron of colliding wind binary WR140 project in 2008/9 .

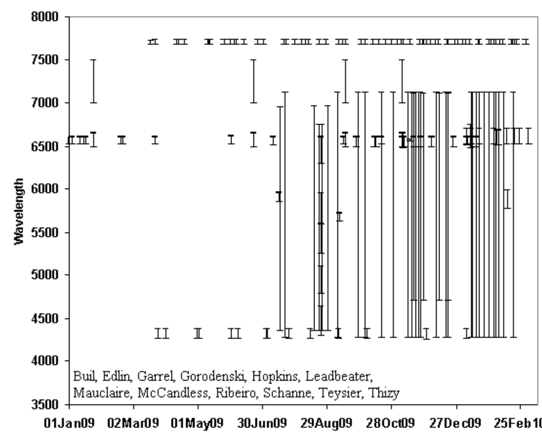

Figure 8. Spectroscopic coverage of epsilon Aurigae obtained by amateur observers during ingress.

Figure 8 shows the spectroscopic coverage achieved by amateur observers during this campaign from 2009 January to 2010 March including ingress. A full list of spectra contributed to the campaign to date can be accessed on-line. There were over 250 as of 2010 March.

Most participants are limited to either a wide wavelength range at low resolution or a narrow range at high resolution for any given measurement. Note, however, that two observers are now equipped with Echelle spectrographs capable of simultaneous high resolution coverage over a wide range of wavelengths.

As the eclipse progresses, absorption lines from the eclipsing object are superimposed on the F star and interstellar spectrum. Changes were first seen in the neutral potassium line at 7699A in the IR by one observer (Leadbeater) as early as the end of 2009 May, several months before any drop in brightness. In 2009 July, CBET 1885 was issued based on these data. The development of this line and others (H-alpha, sodium D) during this eclipse is shown in Figures 9, 10, 11 and has generally followed the trends seen in previous eclipses with the eclipsing object component appearing red shifted during ingress.

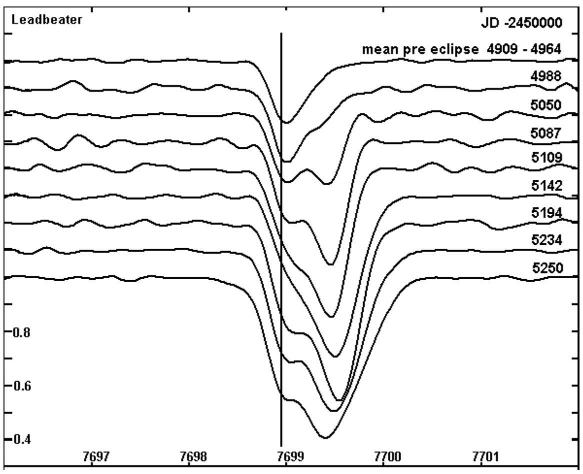

Figure 9. Potassium 7699A line evolution during ingress.

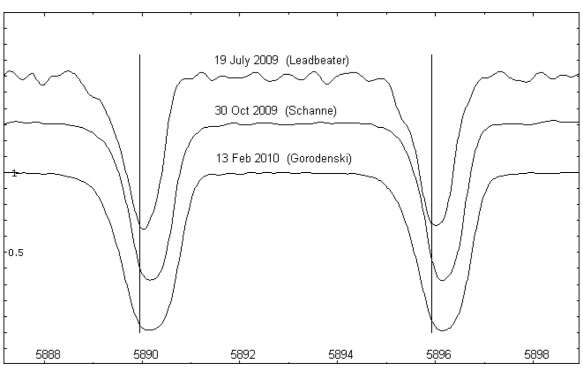

Figure 10. Sodium D line evolution during ingress.

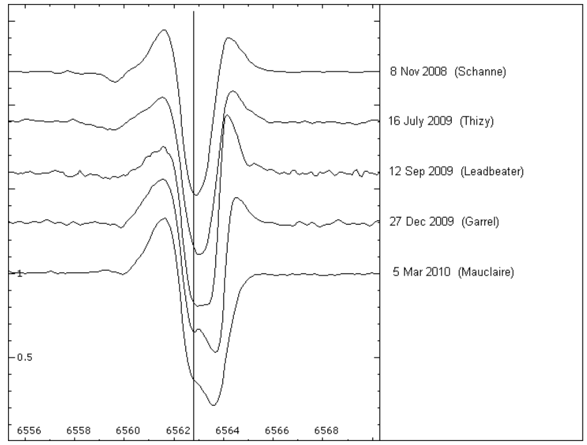

Figure 11. Hydrogen-alpha line evolution during ingress.

The increase in strength of other metallic lines in the H-gamma region (designated the "shell spectrum" by Ferluga) is shown in Figure 12.

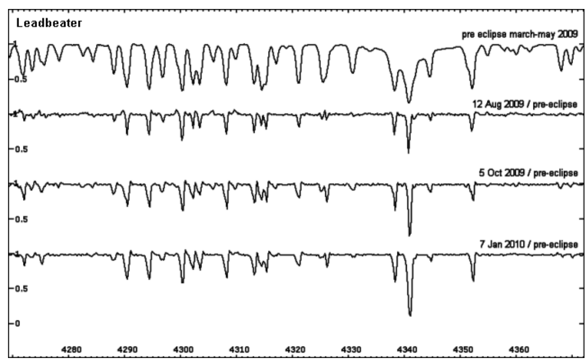

Figure 12. Spectra in the Hydrogen-gamma region taken during ingress divided by the mean pre eclipse spectrum to reveal narrow shell lines from the eclipsing object.

The increased coverage during this eclipse has revealed variations within the overall trend not previously detected. Buil has used his Echelle spectrograph to detect subtle variations in both intensity and radial velocity in various lines not previously studied. (Figure 13). It is possible that these may hold clues to the origin of the additional variations in brightness of the system seen both inside and outside eclipse.

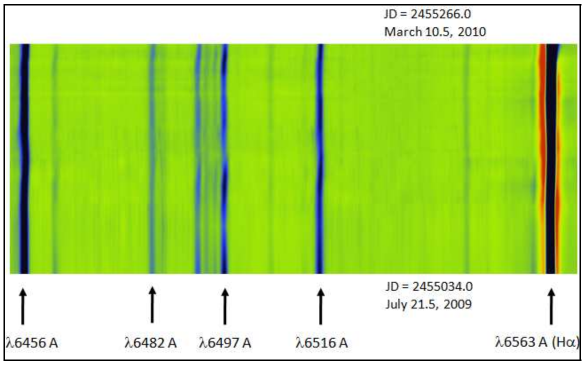

Figure 13. False color image showing variations in intensity and radial velocity with time in lines adjacent to Hydrogen α

7. Spectroscopic Analysis

A detailed study of variations in the development of the potassium 7699A line by Leadbeater has revealed variations during ingress consistent with ring like structures within the eclipsing object. (Leadbeater and Stencel, 2010). Figure 14 shows a time dependence of the excess equivalent width of the potassium I 7699A profile, minus the interstellar contribution, versus RJD, showing step functions during eclipse ingress and the start of totality.

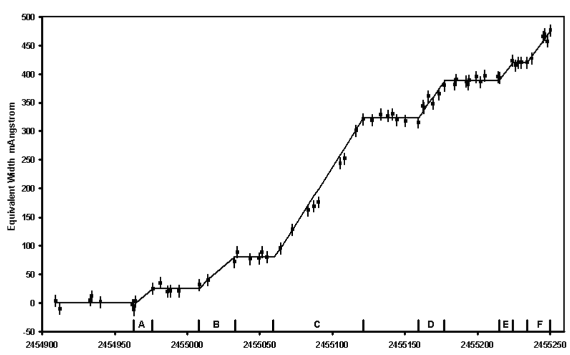

Figure 14. Time dependence of the excess equivalent width of the potassium I 7699A profile

8. Observers

The following are brief biographies of people who contributed data for this paper.

Jeffrey L. Hopkins, Hopkins Phoenix Observatory, Phoenix, Arizona USA

I have a BS in Physics from Syracuse University with graduate work at the University of Wyoming, University of Arizona, and Arizona State University. I was involved with the 1982/1984 epsilon Aurigae campaign where I coordinated the photometry section and produced the campaign newsletters. I have been doing UBV photon counting photometry since the early 1980's using a home made 1P21 photomultiplier tube based photometer on a Celestron C-8 telescope in a slide-off roof backyard observatory. I have also done BVRI CCD photometry using a Meade DSI Pro CCD camera with filters and a 50-mm camera lens. I used a SSP-4 to obtain pre-eclipse JH band infrared photometry data using my 0.30-m LX200 GPS telescope in a second backyard observatory with a roll-off roof. Later I used a Lhires III on the 0.3-m telescope to do high resolution spectroscopy of the hydrogen alpha and sodium D line regions of epsilon Aurigae. Email: phxjeff@hposoft.com

Robert E. Stencel, University of Denver, Denver, Colorado, USA

I am privileged to be the William Herschel Womble Professor of Astronomy at Denver University. Following graduate study in astronomy at the University of Michigan, I worked at NASA Headquarters in Washington DC where I teamed up with Jeff Hopkins to co-chair the 1982-85 eclipse campaign. I joined Denver University in 1993, where I teach astronomy and astrophysics, and am Director of the DU Observatories: Chamberlin and Mt. Evans. Our most productive telescopes for epsilon Aurigae have been the CHARA Array at Mt.Wilson and the Spitzer Space Telescope. My campaign support web page is http://www.du.edu/~rstencel/epsaur.htm along with the site:www.twitter.com/epsilon_Aurigae. Email: rstencel at du.edu.

Robin Leadbeater, Three Hills Observatory, Cumbria, England

I am a British physicist with more than 30 years industrial research and development experience. Now retired, I am enjoying contributing to astronomical research projects through pro-am collaborations. My main interest lies in astronomical spectroscopy and I am the contact point for amateurs contributing spectra to the epsilon Aurigae campaign. I use a Celestron C11 telescope with Star Analyser and Lhires III Spectrographs and an ATIK 16ICS camera.

Paul J. Beckmann, Jim Beckmann Observatory, Mendota Heights, Minnesota, USA

I have a BA in Physics from St. Mary College in Winona, MN. I earned my MS in Biophysics from the University of Minnesota, Minneapolis, under Otto H. Schmitt of Schmitt Trigger fame. My PhD is in Cognitive and Biological Psychology from UMN-TC where I worked under Gordon E. Legge measuring and modeling the optical and photoreceptor differences between central and peripheral vision. I now work as an adjunct professor in Biological Psychology and a Research Associated with Legge on projects related to low-vision access to building interiors. After my father's unexpected death in 1984, I used a modest inheritance to purchase a Meade 0.20-m SCT (2080 LX3) to peer into the heavens. I was advised to craft a "program of observation" and expanded JBO's capability with the purchase of an Optec SSP-3 and BVRI filters. I joined the AAVSO soon after but knew how scientific publication worked and wanted to be more intimately involved with the analysis and publication of my data, something not typically championed by that organization. I discovered IAPPP and worked diligently to wrap my mind around reduction of SSP-3 photometric data with no success. With the help of Jeffrey Hopkins in 2009, I was able to move forward and finally make BVRI observations with an Optec SSP-3a with near-millimagnitude standard errors. While I continue to observe with the 2080 optics, I have upgraded to an LXD55 GOTO mount that I Hypertuned. I have 2 positions for observations but no observatory, a real hardship in -30F wind chill conditions!

Christian Buil, Castanet-Tolosan, France

I use a 0.28-m telescope (Celestron 11) + eShel spectrograph (R = 11000) + QSI532 CCD camera (CCD KAF3200ME). Processing is done with standard échelle pipeline (Reshel software V1.11). H2O telluric lines are removed (division by a synthetic H2O spectrum).

Donald Collins, Warren Wilson College, Ashville, North Carolina USA

I teach physics at Warren Wilson College in the Blue Ridge Mountains of North Carolina. I have been here 40 years since receiving my PhD in physics. Our astronomy facilities include an 0.20-m SCT with an SBIG-7 CCD on a portable mount with R, V, B, and H-Alpha filters. We carry it out each night of observing, align it, and get deep sky objects. I have done time-series of variable stars, especially cataclysmic variables for Joe Patterson and the Center for Backyard Astrophysics. I use DSLR techniques and I can make an observation of a bright star such as epsilon Aurigae or beta Lyrae in 5 minutes. The processing and analysis require much more effort. I've been working all last fall on developing ways to measure atmospheric extinction, and I am beginning to beat that.

Tiziano Colombo, S. Giovanni Gatano al Observatory, Pisa, Italy

I'm 57 years old with a degree in physics, specialized in atmospheric physics. I am the head of climate division of Italian Meteorological Service. I observe epsilon Aurigae both in my observatory in the town of Pisa, central northern Italy, and near Rome where I work. I use a Meade DSI Pro CCD camera fitted to a Pentax K 28-mm lens through a Mogg's adapter mounted on a Purus Astromechanik clock allowing a 30 sec. to 1 minute equatorial tracking. I use Astrodon photometric filters in three bands: Red (Cousin), Visual and Blue. The software used to elaborate the images is Autostar from Meade. My photometric measurements are transformed using calibrations with M67 and Hyades.

Thierry Garrel, Observatoire de Foncaude, Juvignac, France

I was born in the French Alps in 1968, growing on the snow, before my parents left the mountains to go to the Mediterranean Sea. I got in the University of Montpellier, the oldest of Europe, with a beautiful botanic garden and an amazing anatomy museum. Now I'm general dentist in Montpellier, married, with two kids. My interest in astronomy began with an observation of the Moon with my grandfather's binoculars when I was 10. I was very surprised to see craters, valleys, and mountains on this white, seemly flat body. A long course to discover the Universe began, with a lot of different telescopes, observing with my keen eyes and various CCD. I realized soon that nothing can be done in astronomy alone. Searching for companions was difficult in these early times as there was no Internet or cellular phones or even micro-computer; the scientific society didn't easily accept a very enthusiastic young man. Now I'm not so young but still enthusiastic to participate in the epsilon Aurigae campaign. I'm involved in different pro-am programs and also in the local astronomy society. For the next year I would like to complete my observatory instrumentation with some photometric abilities which fits very well and compliments my spectroscopic observations. I use a CN212 Takshashi, 212 mm, 12,4/3,99 Cassegrain/Newtonian telescope with a Lhires III 2400 l/mm, and Star Analyser100 with a Atik 314L+, cooled camera based on sony285 CCD

Stanley Gorodenski, Blue Hills Observatory, Dewey, Arizona USA

I obtained my B.S. and M.S. at Arizona State University, not in the physical sciences but instead in Zoology, and my Ph.D. at North Carolina State University at Raleigh was in Genetics and Statistics. However, I have always had an interest in doing research in astronomy. My goal had been to do photometry with a Starlight-1 photometer I own, but for many years my resources, time, and work was devoted toward building a dome and observatory near Prescott, Arizona. For a number of years it housed a

0.31-m Dall-Kirkham telescope built by a machinist friend until it was replaced in 2007 by a Meade 0.40-m LX200R. I have always been interested in doing spectroscopy and by the time I finished the observatory and equipped it with a telescope that can do scientific work, CCD technology made it possible and the LHIRES III had came out.

Email: stanlep@commspeed.net

Snaevarr Gudmundsson, Lindarberg Observatory, Hafnarfjordur, Iceland

I was born 1963 and am director of Stjornuverid (Planetarium), which uses mobile Digital Starlab for presentations of the night sky and the cosmos. I'm also finishing a BSc in Geography and Geology from the University of Iceland. I have written two books and many articles about mountaineering, climbing, and astronomy. I qualified as mountain guide in 1985 and have also worked occasionally as a nature photographer. I have been an amateur astronomer since 1988, with special interest in our home galaxy, ranging from binaries and variables to star clusters and nebulas. My observing site is located at outskirts of Hafnarfjordur in Iceland. The observatory is elevated at 60 m (above sea-level) on a hill with reasonable light pollution towards north and west (from Reykjavik), but very little light pollution towards east and south. Weather is usually unpredictable in the long term, but when it clears up the sky is usually without mist or much pollution. Auroras are frequent sights from Iceland, but has been unusually quiet during this winter. These conditions have been helpful for this project. I built my observatory in 2000. It has two telescopes: Meade LX 200 0.30-m Schmidt-Cassegrain telescope f/10 and Williams Optic FLT-110 refractor which is mostly used for astrophotography. Since 2005, I have used SBIG's STL-11000M CCD camera and Astrodon's narrowband filters for astrophotography. I also had invested in an Optec SSP-3, used for single channel V photometry (since 2003) of variable stars and eclipsing binaries.

Thomas Karlsson, Varberg Observatory, Varberg, Sweden

I've been an active variable observer for two years but have been interested in astronomy since I was a kid. Now I'm 45 years old and work with IT as a network technician. For epsilon Aurigae, I do V measurements. I use a Canon 450D DSLR camera with an EF 35-80 mm objective on a camera tripod. I usually shoot 4 or 5 series of 10 photos with 5 second exposure time at ISO800, slightly defocused. I process the raw pictures with dark and flat frames, align and stack each series of 10 pictures before measuring them. For the photometric measurement, I have 20 non-variable stars around epsilon I use for calibrating each stacked picture. For each session I also compute each star's air mass. I then use regression analysis to get the two coefficients in the formula. Finally, I compute the average and standard deviation from the 4-5 series to get a final V value for epsilon. For image processing I use Iris, for photometry TeleAuto, and for analys, Excel.

Dr. Mukund Kurtadikar, Jalna Education Society Observatory, Maharashtra, India

The JESO was established in 2001 January with the installation of a 0.30-m Meade LX200 Telescope with SSP-3A Optec photometer as the backend instrument. The instrument was funded by Department of Science and Technology , Govt. of India.

JESO Staff

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S.K. Pandit: Teaching Faculty Member in the Department of Physics, B.R. Barwale College, Jalna 431 203, Maharashtra State, India. He is a member of JESO for Eps Aur campaign.

A.D. Dashrath: Teaching Faculty Member in the Department of Physics, High-Tech Polytechnic and Engineering College, Waluj, Aurangabad, Maharashtra State, India. He is a member of JESO for Eps Aur campaign.

R.S. Yannawar: Teaching Faculty Member in the Department of Physics, Milind Science College, Aurangabad 431 005, Maharashtra State, India. He is a member of JESO for Eps Aur Campaign.

Hans-Goran Lindberg, Kaerrbo Observatory, Skultuna, Sweden

I live in Sweden 60 deg north, 16d 24 m east and have an observatory with 254-mm Schmidt-Newtonian f/4, 254-mm Newtonian f/5.1, and 180-mm f/10 Intes-Micro Maksutov-Cassegrain telescopes. Starlight EXpres CCD camera HX-516 mono as I use on epsilon Aurigae with a 50-mm fl camera lens from Meyer optik. I am section leader for The Swedish Amateur Astronomer Association (Svensk Amator Astronomisk Forening, SAAF) section for variable stars. I started with astronomy as a young boy 7 years old in 1948 and have observed variable stars since 1993. For the past 5 years during the summer time, I images Venus in UV-light. I have helped develop a database with Swedish observations of variable stars starting in 1720: http://var.astronet.se/

Des Loughney, Edinburgh, Scotland

I observe from suburban Edinburgh, Scotland. I use a 450D Canon DSLR with an 85-mm lens mounted on a tripod. The settings are exposure 5 seconds, f/4.5 and ISO 200. Each estimate is arrived at after analyzing 5 sets of ten images using AIP4WIN (v 2.1.10). For each image a green channel image is isolated and used to compare epsilon with eta Aurigae. A transformation coefficient has been worked out for the 450D DSLR. This is used to determine V magnitude from the green channel estimate. In good conditions, V estimates have a standard deviation of less than 0.01 mag. I have a BSc MA and am an amateur astronomer with scientific training. I am the Eclipsing Binary Secretary of the British Astronomical Association Variable Star Section and also a member of the Astronomical Society of Edinburgh.

Benji Mauclaire, Observatoire du Val de I'Arc, Bouches du Rhone, France

I have been observing the sky for more than 20 years. I am a professor of physics near Aix-en-Provence, South of France. I started with visual observation of deep sky objects with a 0.43-m Dobson telescope, especially planetary nebulae challenges. Stellar evolution is one of my favourite astrophysics subjects. From my own remote observatory, my main purpose is the spectral analysis of targets from Be stars to planetary nebulae. I use a 0.30-m SCT with a LHIRES III spectrograph under a country sky which provides a good environment for long time survey projects such as epsilon Aurigae. I created a software program for a high-rate production of spectra's reduction and analysis with powerful pipelines called SpcAudace

http://bmauclaire.free.fr/spcaudace/

that gives time for astrophysics reading and analysis, and public conferencing. Today, my main research program is Be stars study in collaboration with professional astronomers that leads to burst detection and publications in international revues.

Brian E. McCandless, Grand View Observatory, Elkton, Maryland USA

I have been an astronomer since the 1960's. I earned my degree in astronomy from the University of Maryland at College Park in 1980. I am an associate scientist with the Institute of Energy Conversion at the University of Delaware, where I research thin film photovoltaic devices. My wife Julie and I operate their Grand View Observatory from sites in Tidewater, Maryland and the Blue Ridge Mountains in Virginia. The observational focus is single channel photometry and spectroscopy of long-period variables and novae. Photometric observations are carried out in Johnson BVRI, wing narrow band-pass, and infrared JH systems using Optec solid state photometers. Spectrographic measurements are made using an SBIG SGS spectrograph with ST7-XME CCD camera. The primary telescope is a Celestron 0.36-m SCT on a CGE mount.

Frank J. Melillo, Holtsville, New York USA

I have a Celestron 0.20-m and a Meade 0.25-m telescope. I became interest in photoelectric photometry in 1983 when I purchased the SSP-3 OPTEC photometer, which I still have today. I caught the last partial eclipse of epsilon Aurigae in the spring of 1984. Afterward, I concentrated more on minor planets photometry to monitor their brightness as they rotate. I did photometry on Uranus and Neptune to take measurements in the near-infrared where methane absorbs the most. I use the 0.20-m telescope to monitor epsilon Aurigae photoelectrically with a SSP-3 OPTEC photometer.

Email: Frankj12@aol.com

Richard Miles, Golden Hill Observatory, Dorset, England

I am a 58 year old retired research scientist working in physics and chemistry. I have been an amateur astronomer since I was a kid. My special interests are in photometry, occultations, asteroids and comets. I began by building my own photometers using PMTs in 1981. I have been a member of the British Astronomical Association since 1966 and am Past President 2005-2007. I am keen on participating in pro-am collaboration and have been a member of IAPPP since 1982 I have recently begun making increased use of robotic telescopes to gather observations with a view to publishing new insights into the nature of some comet nuclei. I use a 0.06-m Takahashi F860C refractor telescope with a Starlight Xpress SXV-H9 CCD camera with V and Ic band filters.

Robert T. (Tom) Pearson, Virginia Beach, Virginia USA

Although I've enjoyed amateur astronomy for many years, I'm a relative newcomer to variable star observing. I became intrigued when I heard that DSLR cameras could be used to do accurate photometry. When I first read about the "mystery star" last summer, I thought the coming eclipse would be a perfect opportunity to do real research by combing two hobbies, photography and astronomy. I am currently imaging epsilon Aurigae from my backyard in Virginia Beach, VA, using a Canon 20D DSLR with a 70-mm lens. During each observing session I take 30 star images, 10 dark frames, 10 flats and 10 flat darks. Exposures are 5 seconds at f/4 and ISO 800.

Gerard Samolyk, Greenfield, Wisconsin USA

I have been a variable star observer for more than 35 years (both visual and CCD). I worked with the AAVSO Eclipsing Binary committee and RR Lyr committee for 30 years, publishing an annual ephemeris and times of minimum. Currently I'm co-chair of the AAVSO Eclipsing Binary Section and the Short Period Pulsator Section. I have been the Observatory Directory for the Milwaukee Astronomical Society since 1980. I use an ST9XE CCD camera with 50-mm lens for BVR photometry.

Lothar Schanne, Hohlstrasse 19, D-66333, Völklingen, Germany

My astronomical equipment consists of a: C14 + autoguided Lhires III spectrograph + self-build echelle spectrograph + sigma 1603ME (CCD) in a Sirius 2.3 m dome. My interest is spectroscopy of hot stars. I have 5 years experience with spectroscopy. I have web sites at www.astrospectroscopy.eu and www.spectrosphere.de

Iakovos Marios Strikis, Elizabeth Observatory of Athens, Haldrf (Athens), Greece

I was born on 1985 May 15. My profession is a photo-journalist. I am the current President of the Hellenic Amateur Astronomy Association. Until 1998 I had many different hobbies (coin collections, mineral collections, microscopy imaging, etc.). All of them had a terminal point because of the expenses to find some rare parts of my collections. When I found about astronomy I was stunned, soon I realized that with not huge budget I could do some serious job in contributing in the knowledge of astronomy. That is the time when I got my first telescope. From 1999 until 2004 I did more than 980 sunspot drawings and more than 300 planetary observations by drawing Jupiter, Saturn, Venus and Mars. In 2004 I started to get involved with the digital imaging with the new cheap web-camera from Philips. This had opened a brand new world to my eyes. I always wanted to get involved in CCD photometry and imaging. This came to life at 2008 when I got my CCD camera (one of the cheapest models) from a friend who got a new one and wanted some money. I started to observe and recorded many stars such as RR-Lyrae and i Boo because they had quick light curves. Then I started to observe globular clusters with Rodney Howe and others. When a friend told me about the epsilon Aurigae project, I started to observe almost every clear night but, as it has always been, the Sun is my first priority doing almost every day observations of the Sun in H-alpha line and also doing spectroscopy during total solar eclipses. I use a ATIC CCD camera with 55-mm lens at f/6.3. You can find my astronomy work and observations at: www.hellas-astro.gr, www.elizabethobservatory.webs.com and www.dailysolar.weebly.com

François Teyssier, Yogurt Pot Observatory, Rouen, France

I use a Lhires III spectrograph with a low resolution, 150 line/mm, grating and Starlight SXV-H9 CCD camera.

Olivier Thizy, Shelyak Instruments, Revel, France

I started astronomy more than 30 years ago with a 0.12-m telescope. I have always been an active observer, watching stars being one of the most exciting experiences! I am now observing from my home in the Alps or with one of the two 0.60-m public telescopes in France. I participated to the development of Lhires III high resolution spectrograph within AUDE association and worked on some professional spectrographs (MuSiCoS, NARVAL). In 2006, I co-founded Shelyak Instruments, a company specialized in spectroscopy for astronomy proposing the first commercial optical fiber echelle spectrograph. I am also actively involved in promoting scientific projects for amateur astronomers such as participation in pro/am collaboration on Be stars.

9. Conclusion

The system's mid-eclipse is predicted to be 2010 August 4, with third contact predicted for 2011 March, and fourth contact for 2011 May 13. During the late spring and summer observing season (Northern Hemisphere) the star system can be seen from higher latitudes early evening and just before sunrise. While the system is observable, the air mass through which the observations must be made is very high. Some of the most interesting and important data could be obtained during these times so it is worthwhile to put the extra effort into the observing. High air mass photometry requires careful correction of extinction. Ideally, nightly extinction coefficients should be determined.

The campaign is archiving photometric and spectroscopic data. The photometric data will be archived as text files and available for download from the campaign web site. The web site will also continue to host the spectroscopic data. A paper including the campaign's photometric data is planned for the IBVS.

10. Acknowledgments

We would like to thank Brian Kloppenborg for helpful comments during the development of this paper as well as the efforts of all the worldwide observers not included here who also are contributing data to this eclipse campaign.

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Leadbeater, R., Stencel, R. (2010). "Structure in the disc of epsilon Aurigae: Spectroscopic observations of neutral potassium during eclipse ingress." http://arxiv.org/abs/1003.3617

URLs

The ARAS BeAm Be star monitoring program:
http://arasbeam.free.fr

The periastron of colliding wind binary WR140 2008/9:
http://www.stsci.de/wr140/index_e.htm

The International Epsilon Aurigae Campaign list of amateur spectra:
http://www.threehillsobservatory.co.uk/epsaur_spectra.htm

CBET 1885 27 July 2009 epsilon Aurigae:
http://www.cfa.harvard.edu/iau/cbet/001800/CBET001885.txt

Tables 1-5

	U Band	B Band	V Band
Avg Mag	3.7264	3.6050	3.0360
Max Mag	3.5369	3.4897	2.9289
Min Mag	3.9207	3.7168	3.1235
Δ	0.3838	0.2271	0.1946

Table 1 Out-of-Eclipse Data from the Hopkins Phoenix Observatory, 2003 December through 2009 April.

	U Band	B Band	V Band
Avg Mag	4.516	4.305	3.746

Table 2 Average Totality Magnitudes during 1982-1984 Eclipse

	U Band	B Band	V Band
JD	2,445,180	2,445,170	2,445,158

Table 3 First Contact Times for the 1982-1984 Eclipse

	U Band		B Band		V Band	
	1982/84	2009/11	1982/84	2009/11	1982/84	2009/11
1st Contact	45,180	55,062	45,170	55,058	45,158	55,059
2nd Contact	45,300	55,214	45,305	55,204	45,300	55,205
Depth Mag(Avg)	0.84	TBD	0.73	TBD	0.91	TBD
Δ	TBD		TBD		TBD	
Slope (m/d)	0.0066	0.0052	0.0052	0.0048	0.0050	0.0049
Δ	-0.0014		-0.0004		-0.0001	
Ingress Time	120d	152d	135d	146	142d	146d
Δ	+32d		+11d		+04	
Period	9,885d	9,882d	9,875d	9,888d	9,863d	9,901d
Δ	-03d		+13d		+38d	

Table 4 Ingress data from the Hopkins Phoenix Observatory Data. Contact Dates are Reduced Julian Date (RJD), RJD = JD - 2,400,000. First and Second Contact Point Estimates using selected HPO UBV Data (27 sets of observations, JD 2,455,069 - 2,455,199). To try to stay on the linear portion of the ingress, data used for the linear regression were after the estimated first contact (JD ~2,455,054) and before estimated second contact (~JD 2,455,199). Data during the assumed OOE variation during mid-ingress (~JD 2,455,122 - 2,455,171) was not used. See Figure 6. Linear regression was performed on the Ingress data.

	U Band		B Band		V Band	
Eclipse Years	1982/84	2009/11	1982/84	2009/11	1982/84	2009/11
1st Contact	45,180	55,073	45,170	55,070	45,158	55,063
2nd Contact	45,300	55,209	45,305	55,204	45,300	55,207
Depth Mag(Avg)	0.84	TBD	0.73	TBD	0.91	TBD
Δ	TBD		TBD		TBD	
Slope (m/d)	0.0066	0.0058	0.0052	0.0052	0.0050	0.0049
Δ	-0.0008		0.0000		-0.0001	
Ingress Time	120d	136d	135d	136d	142d	144d
Δ	+16d		+01d		+02d	
Period	9,885d	9,893d	9,875d	9,900d	9,863d	9,905d
Δ	+08d		+25d		+42d	

Table 5 Ingress Data from the Composite Data, Contact Dates are Reduced Julian (RJD), RJD = JD - 2,400,000. First and Second Contact Point Estimates using selected Composite UBV Data (307 observations, JD 2,455,069 - 2,455,199). To try to stay on the linear portion of the ingress, data used for the linear regression were the same dates as used for the HPO data Obvious flyer data that departed significantly from the average data were not included in the analysis. Linear regression was performed on the Ingress data.

Tables 6-9

Band	Period	
V	9,903d ± 02d	
B	9,894d ± 06d	
U	9,888d ± 06d	
First Contact		
Band	**JD**	**UT Date**
V	2,455,061 ± 02d	17 August 2009
B	2,455,064 ± 06d	20 August 2009
U	2,455,068 ± 06d	24 August 2009
Second Contact		
Band	**JD**	**UT Date**
V	2,455,206 ± 01d	09 January 2010
B	2,455,204 ± 00d	07 January 2010
U	2,455,211 ± 03d	14 January 2010
Band	**Ingress Time**	
V	145d ± 01d	
B	141d ± 05d	
U	144d ± 08d	

Table 6 Averaged Periods, Contact and Ingress Times

Orbits		F Star V= 15.42 km/s		Eclipsing Body V=9.68 km/s	
Band	**Period**	**Circumference**	**Radius**	**Circumference**	**Radius**
V	9,903d ± 02d	88.19 AU	14.04 AU	55.36 AU	8.81 AU
B	9,894d ± 06d	88.11 AU	14.02 AU	55.31 AU	8.80 AU
U	9,888d ± 06d	88.06 AU	14.02 AU	55.28 AU	8.80 AU

Table 7 Orbital Velocity versus Star System Size

Translational V= 25.10 km/s		
Band	**Ingress Time**	**F Star Diameter**
V	145d ± 01d	2.10 AU
B	141d ± 05d	2.04 AU
U	144d ± 08d	2.09 AU

Table 8 Translational Velocity versus F Star Size

Band	JD	UT Date	Δ
V	2,455,043	30 July 2009	+18d
B	2,455,055	11 August 2009	+09d
U	2,455,065	21 August 2009	+03d

Table 9 Original Pre-eclipse Predicted First Contacts Dates

Tables 10-11

	Start		Mid-Point		End	
Band	RJD	UT Date	RJD	UT Date	RJD	UT Date
V	55,325	08 May 2010	55,405	27 July 2010	55,485	15 October 2010
B	55,319	02 May 2010	55,399	21 July 2010	55,479	09 October 2010
U	55,334	17 May 2010	55,414	05 August 2010	55,494	24 October 2010

Table 10 2010 Mid-Eclipse Brightening Prediction Dates

	3rd Contact		4th Contact	
Band	RJD	UT Date	RJD	UT Date
V	55,654	02 April 2011	55,719	06 June 2011
B	55,641	20 March 2011	55,712	30 May 2011
U	55,664	12 April 2011	55,719	06 June 2011

Table 11 2010 Eclipse 3rd and 4th Contact Points Prediction Dates