

GEOS meeting

EE CEP in 2014

An international observational campaign

Laurent Corp



Association T60



SOCIÉTÉ ASTRONOMIQUE DE FRANCE
COMMISSION DES ÉTOILES DOUBLES



Contents

- Epsilon Aurigae : Evolution of the models
- The participants in the campaign 2014
- Star EE CEPhée
- Some results
- Conclusion - Questions



Epsilon Aurigae
Evolution of the models

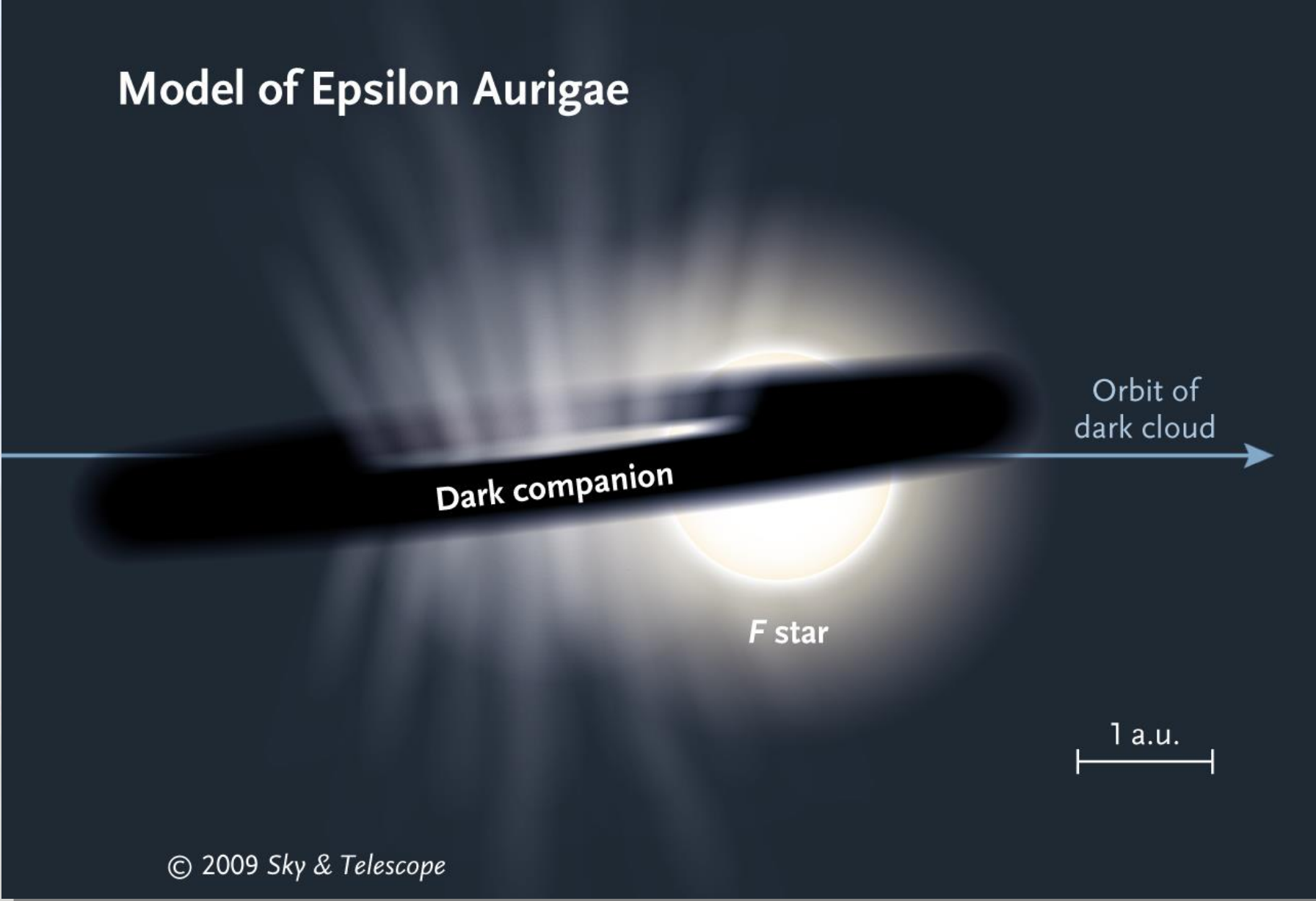
Model of Epsilon Aurigae

Dark companion

Orbit of dark cloud

F star

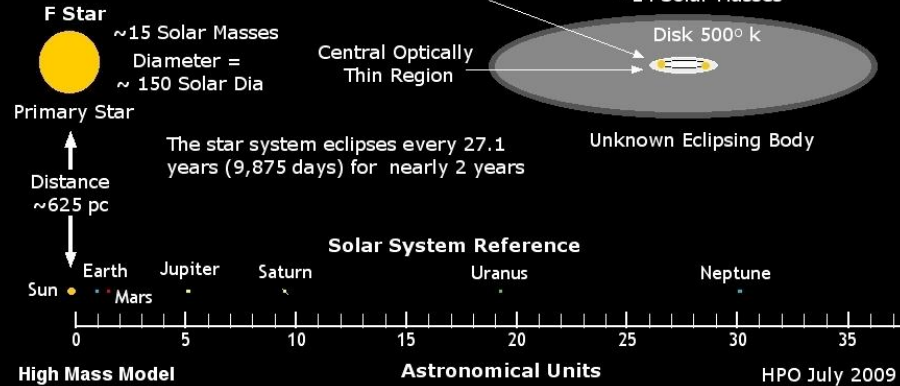
1 a.u.



Epsilon Aurigae – Evolution of the models

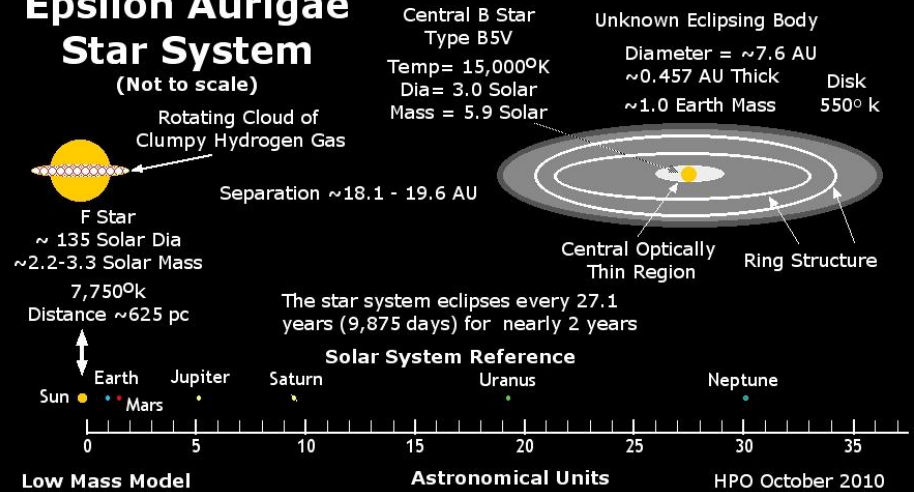
Epsilon Aurigae Star System

(Not to scale)



Epsilon Aurigae Star System

(Not to scale)



Epsilon Aurigae – Evolution of the models

Epsilon Aurigae Star System

(Not to scale)

F Star



~15 Solar Masses
Diameter =
~ 150 Solar Dia

Primary Star

Distance
~625 pc

Sun • Mars

The star system eclipses every 27.1
years (9,875 days) for nearly 2 years

Central Optically
Thin Region

Binary B Star System?
or
Two Giant Gas Planets?

Diameter = ~1500 Solar Dia
~14 Solar Masses

Disk 500° k

Unknown Eclipsing Body

Solar System Reference

Earth Jupiter Saturn Uranus Neptune



High Mass Model

Astronomical Units

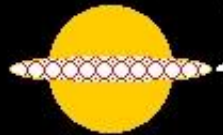
HPO July 2009

Epsilon Aurigae – Evolution of the models

Epsilon Aurigae Star System

(Not to scale)

Rotating Cloud of Clumpy Hydrogen Gas



F Star
~ 135 Solar Dia
~ 2.2-3.3 Solar Mass

7,750°K

Distance ~625 pc

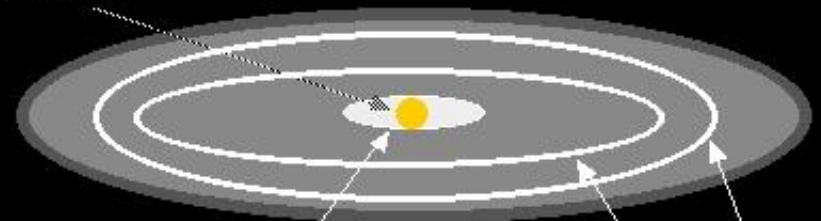
Separation ~18.1 - 19.6 AU

Central B Star
Type B5V
Temp = 15,000°K
Dia = 3.0 Solar
Mass = 5.9 Solar

Unknown Eclipsing Body

Diameter = ~7.6 AU
~0.457 AU Thick
~1.0 Earth Mass

Disk
550° K

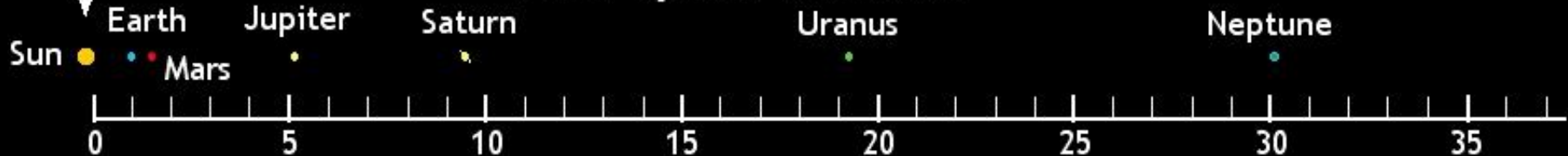


Central Optically Thin Region

Ring Structure

The star system eclipses every 27.1 years (9,875 days) for nearly 2 years

Solar System Reference



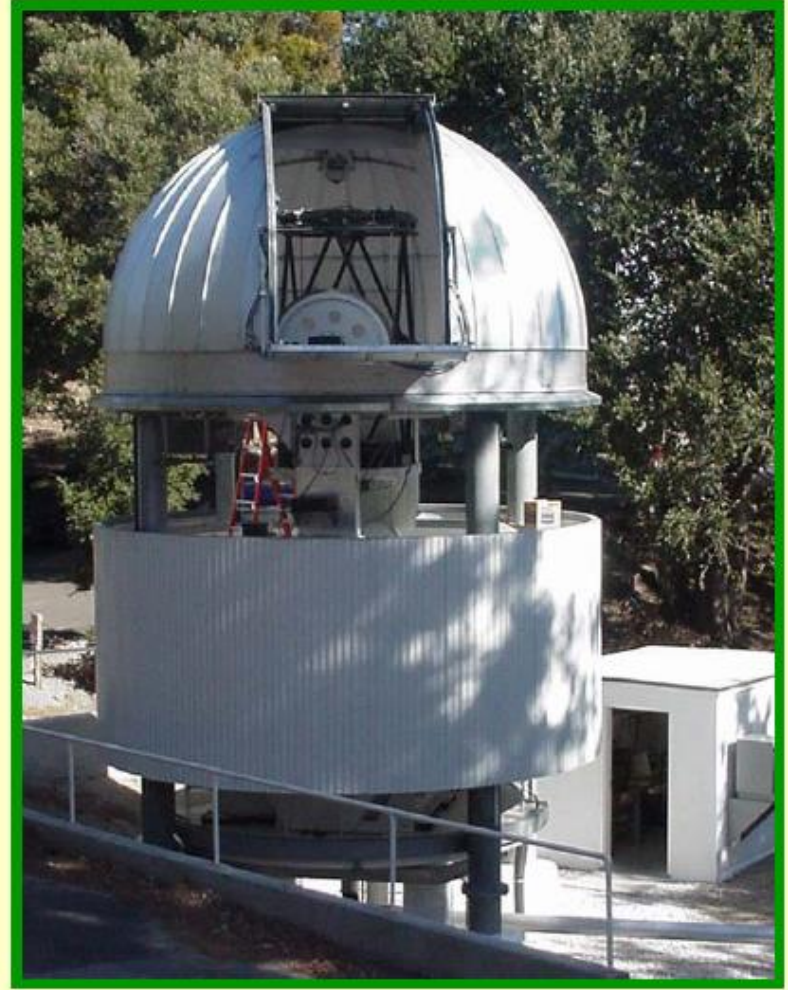
Low Mass Model

Astronomical Units

HPO October 2010

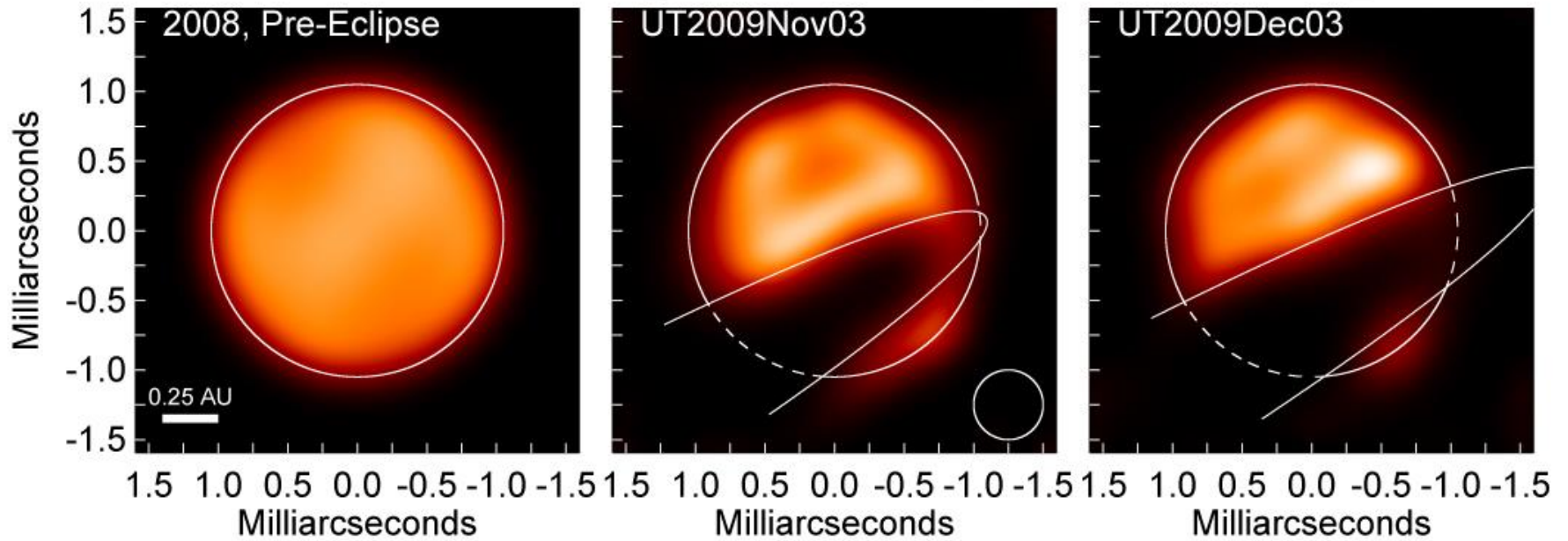
Telescope Enclosures


In Their Opened and Closed Configurations



Pictures of CHARA

Epsilon Aurigae Eclipse (CHARA-MIRC)





*The participants in the
campaign 2014
(before the D-day)*

47 participants in the campaign 2014

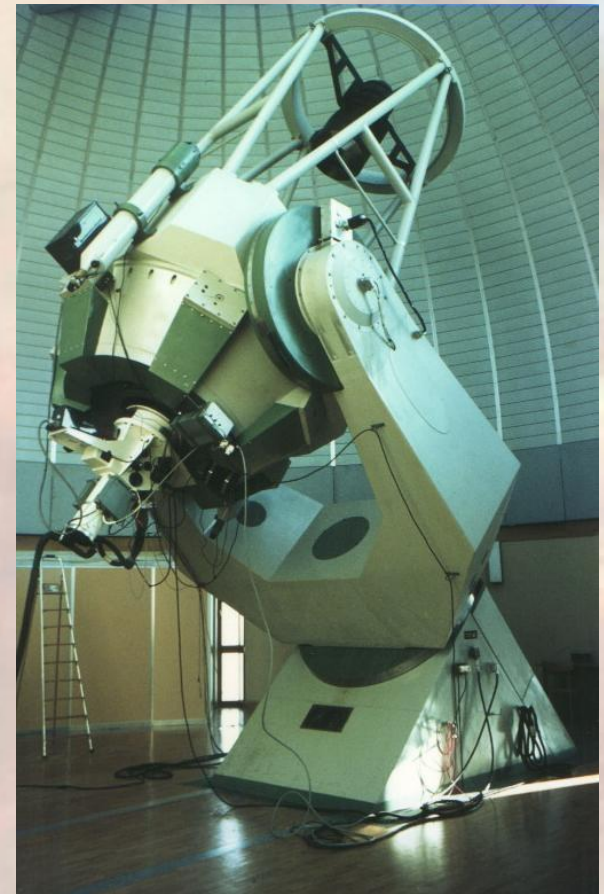
- Countries:
 - Pologne
 - Grèce
 - France
 - USA
 - Italie
 - Espagne
 - Canada
 - Royaume Uni
 - Slovaquie
 - Brésil
 - Belgique
 - Bulgarie
 - Inde

47 participants in the campaign 2014

- Professionals and amateurs
 - *Warsaw University Observatory, Al. Ujazdowskie 4, PL-00-478, Warszawa, Poland*
 - *Institute of Astronomy and National Astronomical Observatory, BAS, Sofia, Bulgaria*
 - *Hellenic Amateur Astronomy Association*
 - *AstroCamp Observatory, Nerpio, Spain (MPC I89)*
 -

47 participants in the campaign 2014

- Scope: 20 to 200cm



- Photometry :
 - B V Rc Ic
- Spectroscopy :
 - $R = 1000$
 - $R > 21000$ de 3650 à 7700 Ang

Quelques logiciels pour la photométrie

Gratuits

- AIP4WIN 2.4.8

- CCDSoft 5.xx

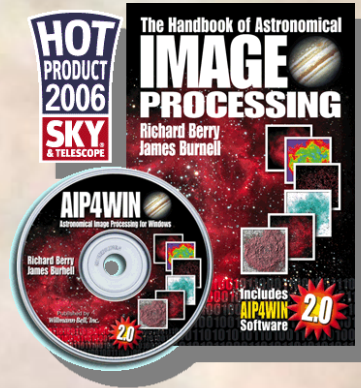
- ASTROART 5.0

- PRISM 6 ... à 10

- MPO Canopus 9.4.0.3

- Mira

- MaximDL 6.13



- IRIS 5.54

- AudeLA 2.1.0

- Teleauto 4.4

- Muniwin 2.xx

- IRAF et Sextractor

- Fotodif 3.5

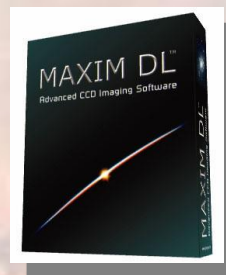
- A.P.T. 2.6.4

- AstrolmageJ 3.6.2

- LeevesAstro

- SIPS

-





Star EE Cephée

Campaign EE CEP – Historique

- First detection like variable star – 1952 - $E=0$ (Romano G., *Coelum*, 24, 135 (1956))
- Identification like Eclipsing Binary in July 1958 (Romano G. & Perissinotto M., *Memorie della Societa Astronomia Italiana*, 37, 255 (1966))
- Spectral type : B6III et $B-V : 0.52$ (Barbier M. et al., *Astronomy and Astrophysics*, 27, 421 (1973))
- Périod : 2050 days soit 5.62 yrs and spectral type B5II-III (Meinunger L., *Mitteilungen uber Veranderliche Sterne*, 7, 97 (1976))
- 5 eclipses observed between 1956 and 1980 with minima :
variation between 0.6 to 0.2 mag
(Meinunger L., *Mitteilungen uber Veranderliche Sterne*, 7, 97 (1976)), Baldinelli L. & Ghedini S., *Societa Astronomica Italiana, Memorie*, 48, 91 (1977), Baldinelli L. et al., *Information Bulletin on Variable Stars No. 1939* (1981))

Campaign EE CEP – Historic

- Model Epsilon Aurigae (Mikolajewski M. & Graczyk D., Mon. Not. R. Astron. Soc., 303, 521 (1999):
 - 10 rayons solaires
 - Distance : 2.75kpc ()
 - Spectral type B5III
 - Température 14500 K
- Après exploitation des mesures des éclipses de 2003 (E= 9) et 2008/9 (Galan C. et al., Astronomy & Astrophysics, 544, A53 (2012))
 - Disque obscur occultant
 - Disque de poussière
 - Etoile de faible masse
 - Etoile contact en faible rotation
 - Invisible en photométrie et spectro

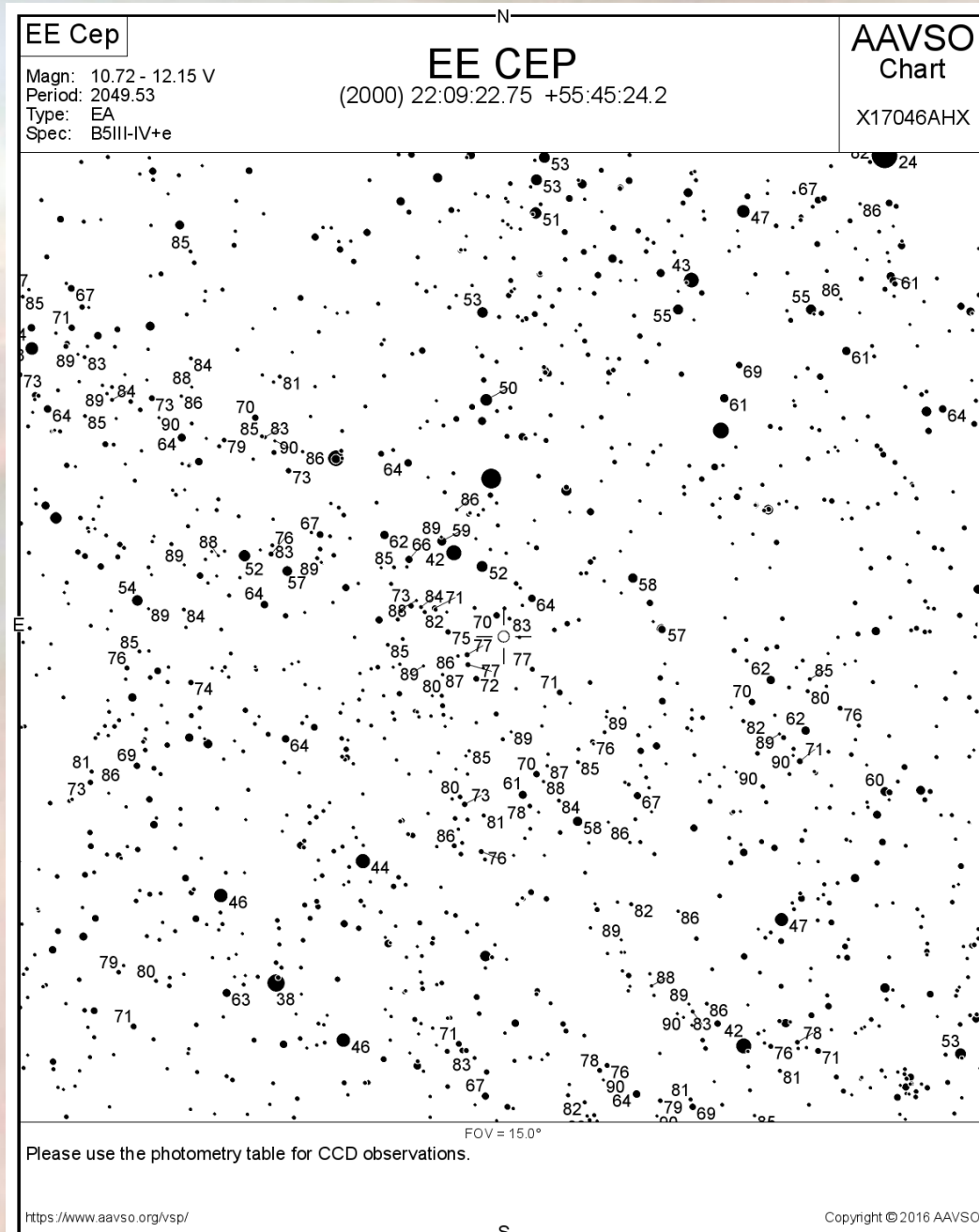
Campaign EE CEP – Historic

- Prediction of the minima de 2014 (Scott E. L. et al., accepted for publication in the Astrophysical Journal, <http://arxiv.org/abs/1410.7678v1>, Galan C. et al., Information Bulletin on Variable Stars No 6111 (2014))
 - Profondeur du minima : 2 mag
 - 23 August 2014
 - $E = 11$

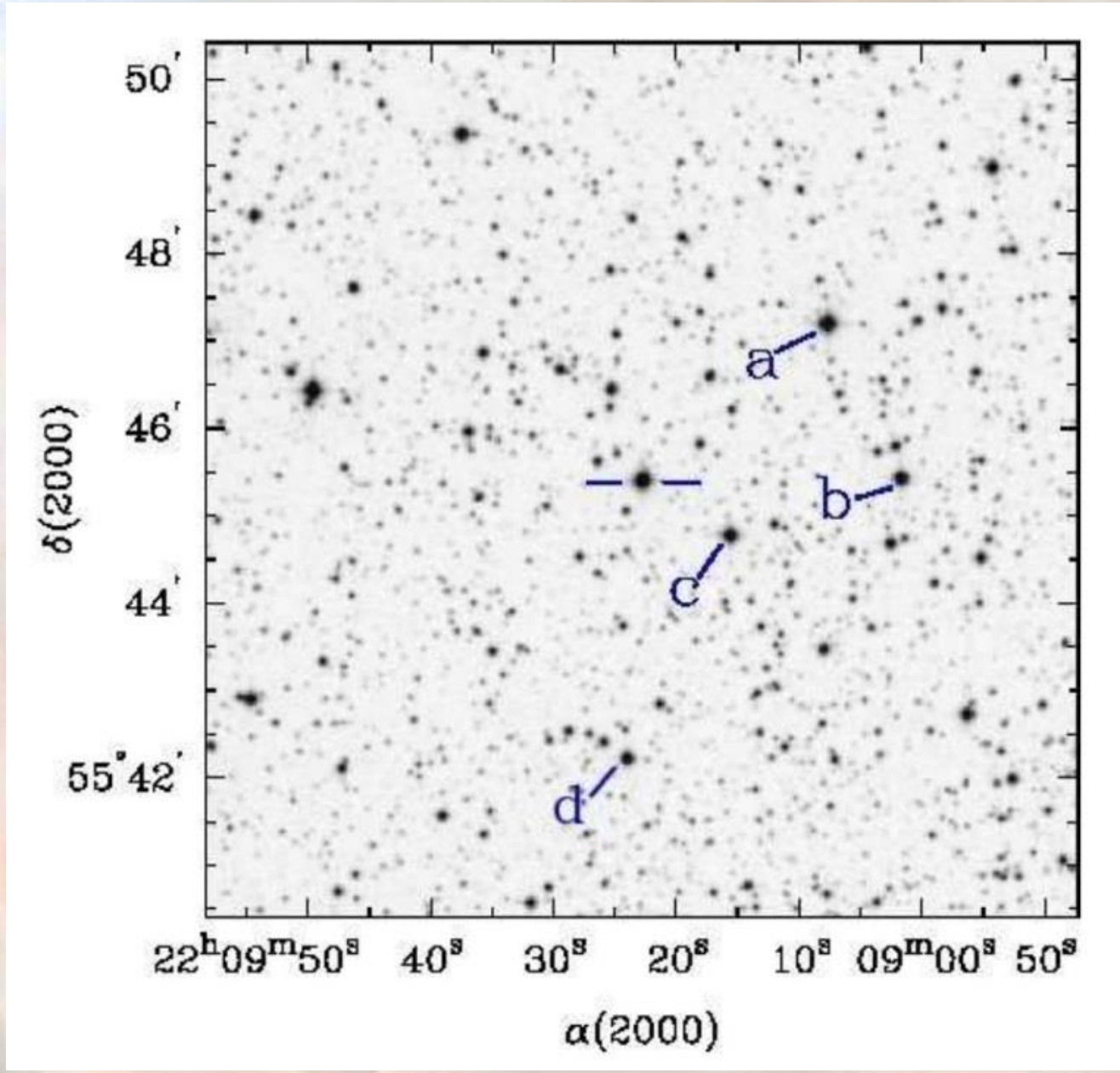
Campaign EE CEP – field of view



Campaign EE CEP – field of view 15°



Campaign EE CEP – field of view 10'



Campaign EE CEP – appel à contribution

COMMISSIONS 27 AND 42 OF THE IAU INFORMATION BULLETIN ON VARIABLE STARS

Number 6111

Konkoly Observatory
Budapest
28 June 2014

HU ISSN 0374 – 0676

THE 2014 ECLIPSE OF EE Cep: ANNOUNCEMENT FOR A THIRD INTERNATIONAL OBSERVATIONAL CAMPAIGN

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³ Institute of Astronomy and NAO, Bulg. Acad. Sc., 72 Tsarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria
e-mail: dinko@astro.bas.bg (DD)

Campaign EE CEP – Light curves

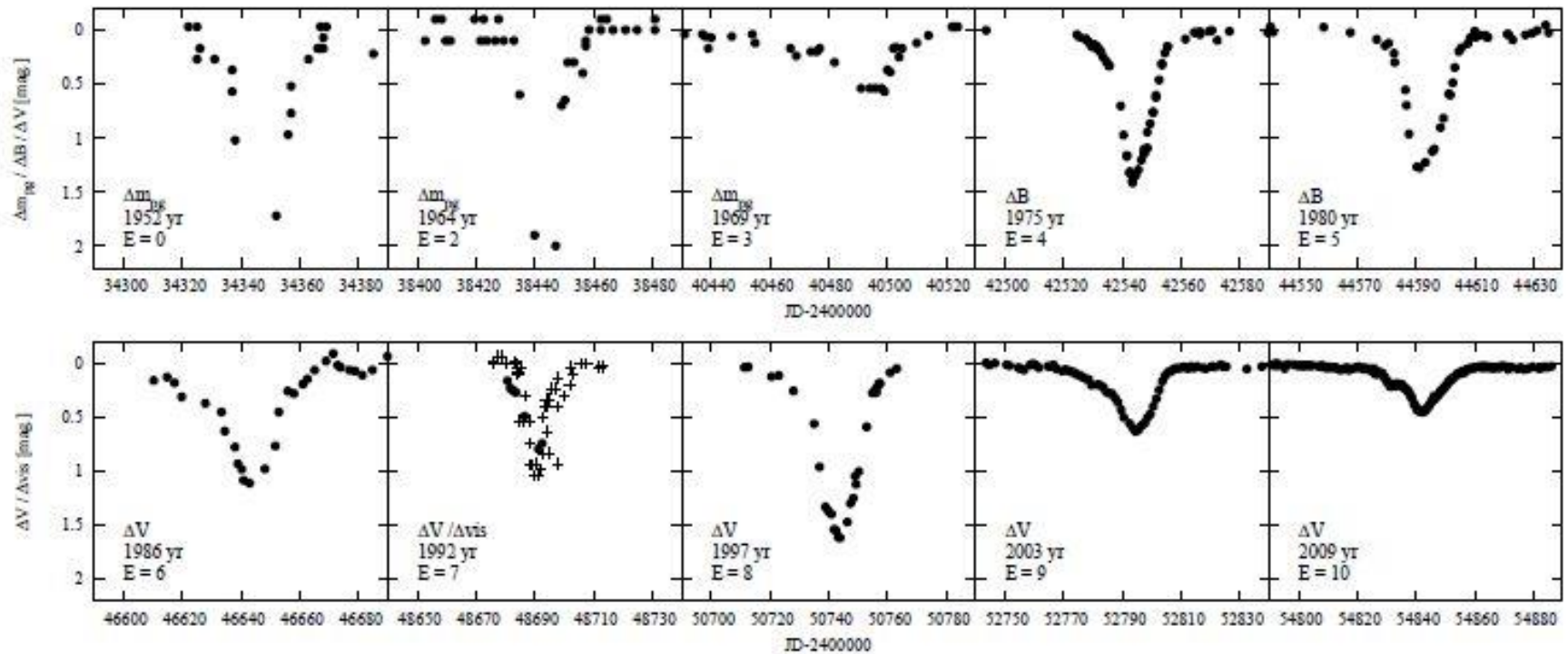
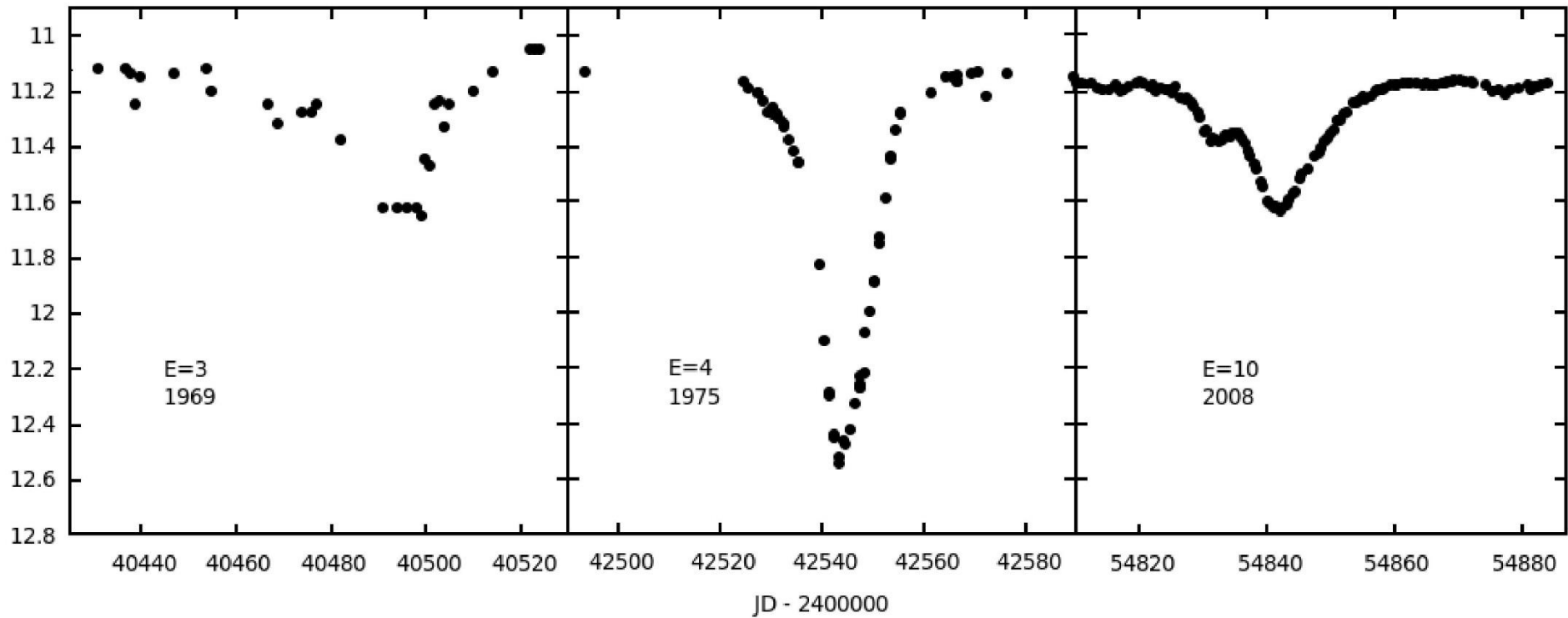
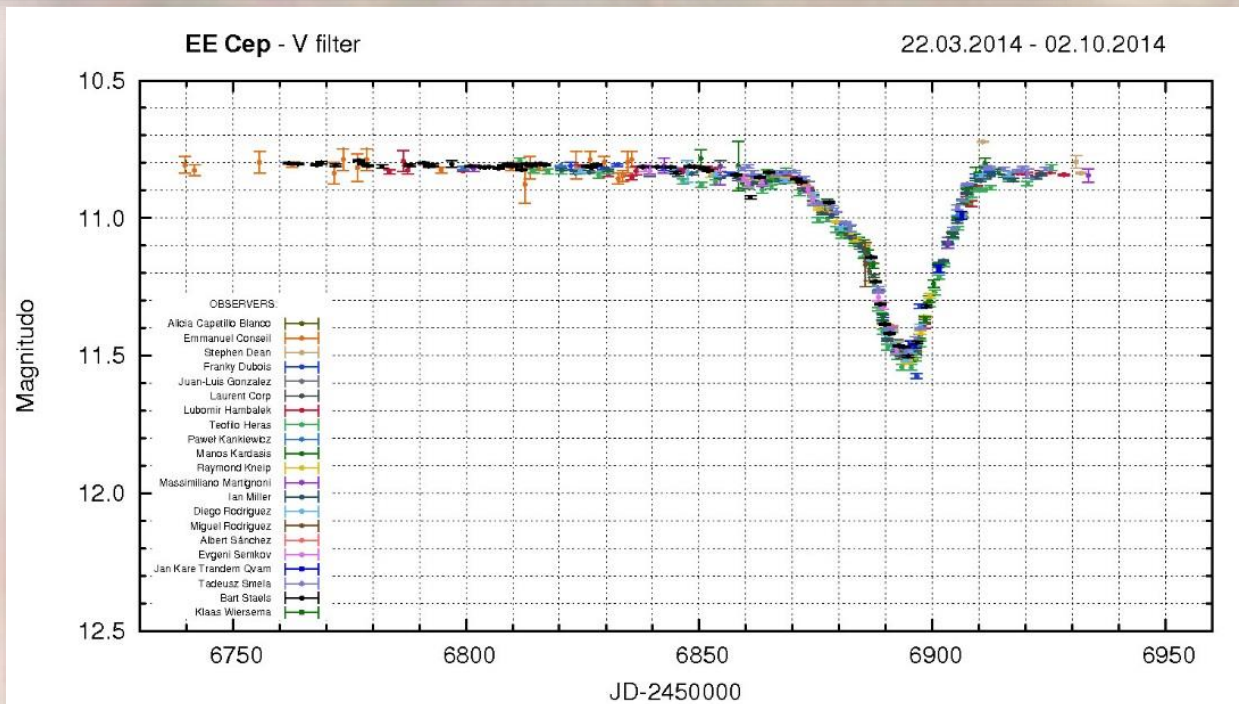
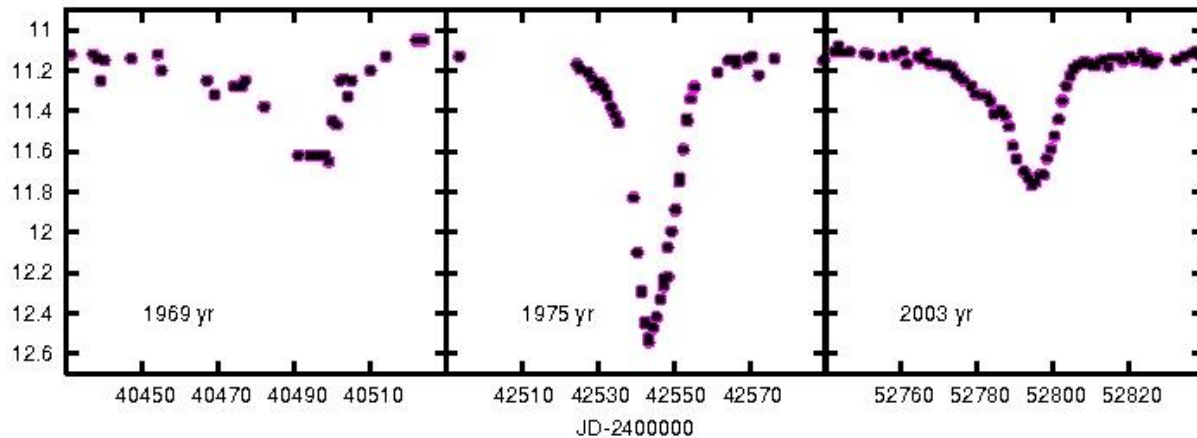


Figure 1. The light curves of ten among the eleven eclipses of EE Cep observed since 1952 are shown. The mean values of Halbach's (1992) visual observations of the 1992 eclipse are marked with crosses.

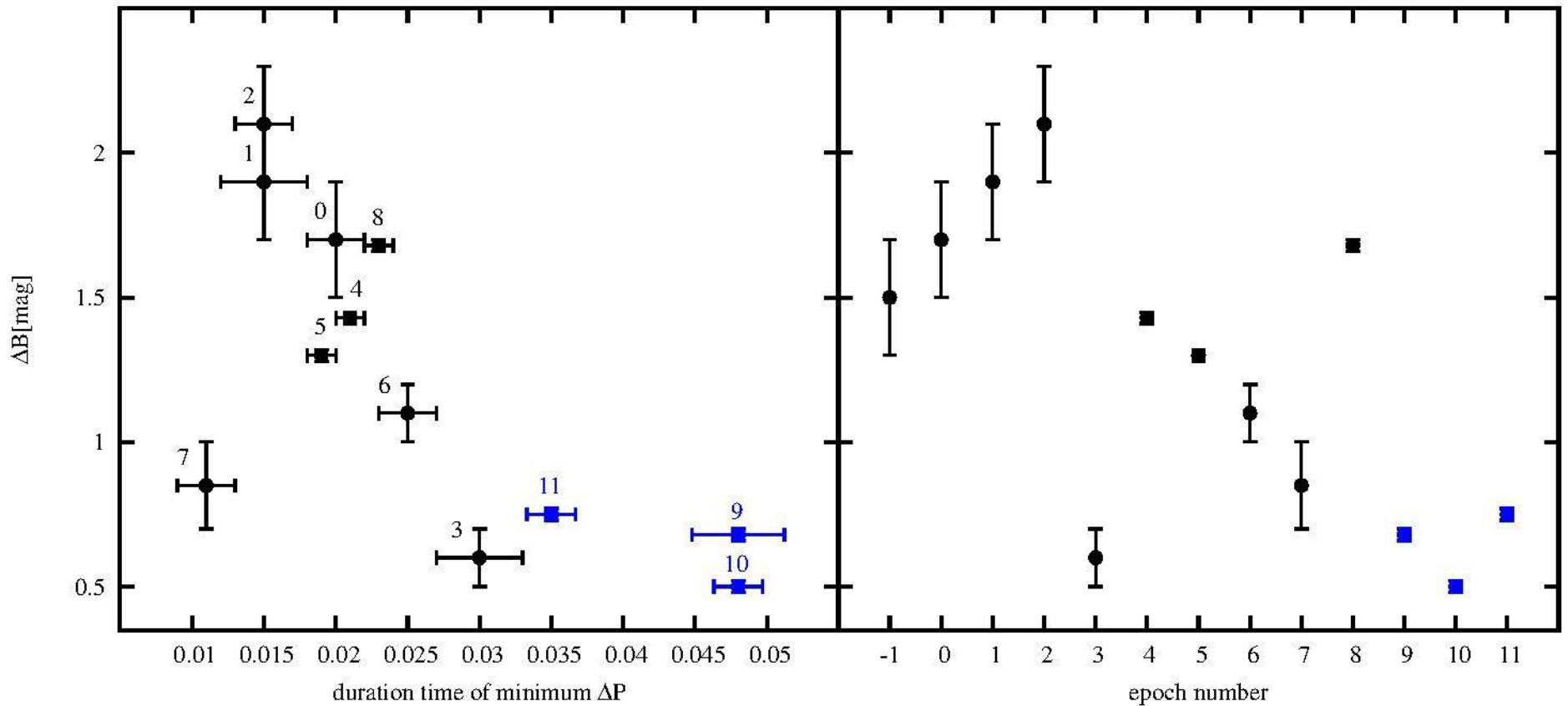
Campaign EE CEP – Light curves



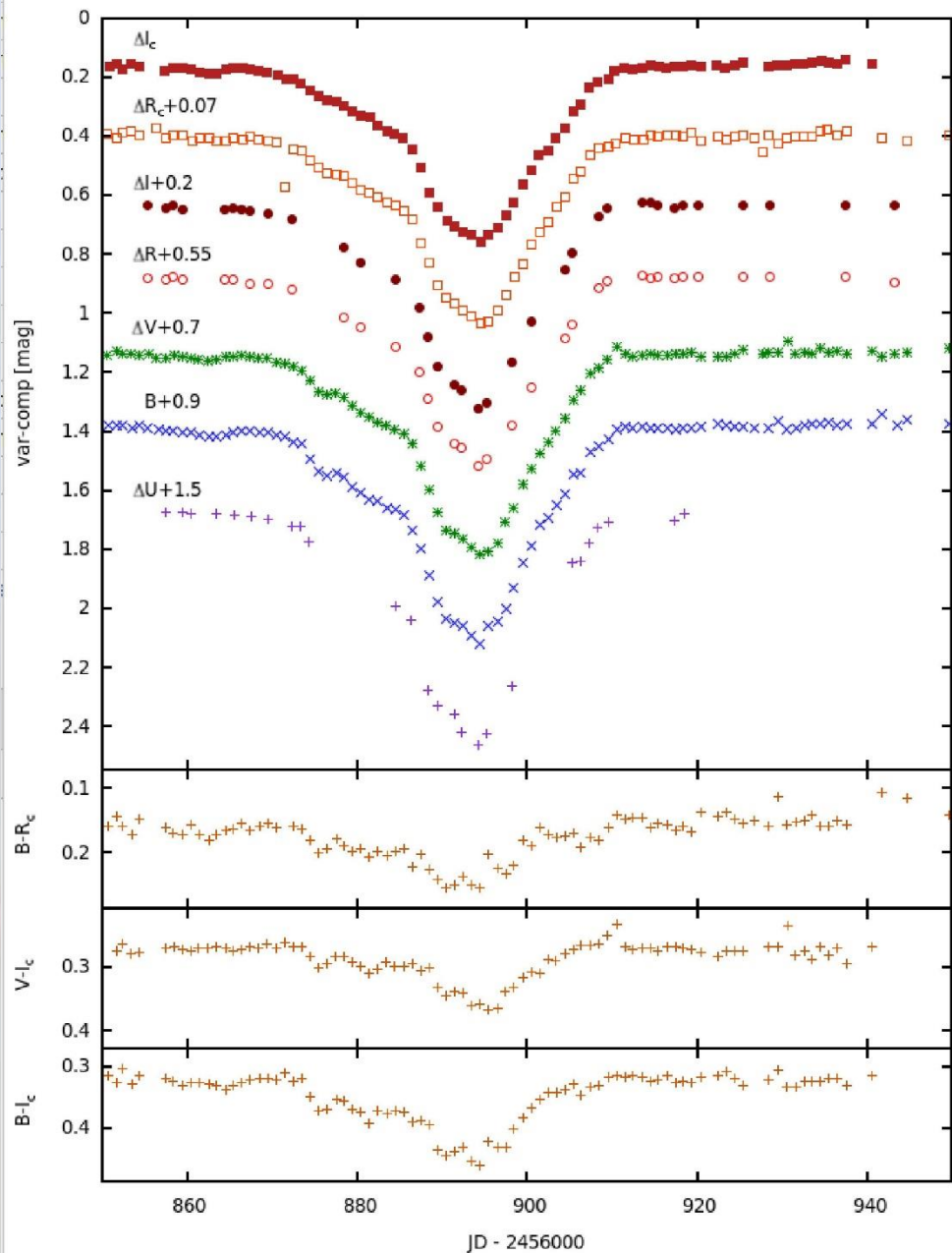
Campaign EE CEP – Light curves



Campaign EE CEP

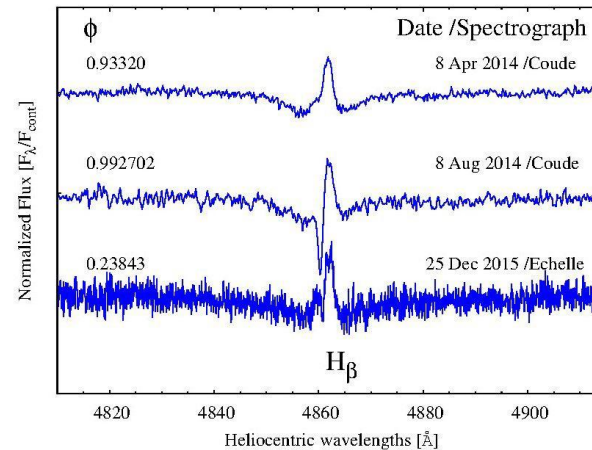
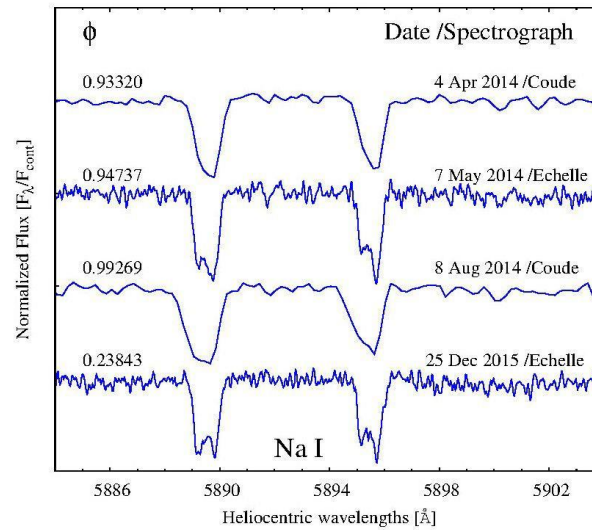
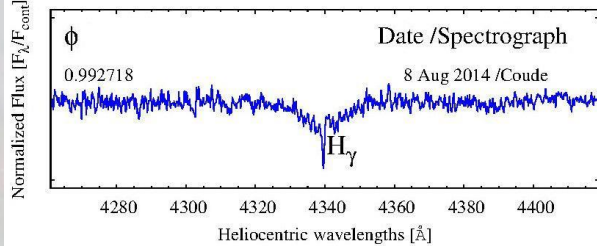
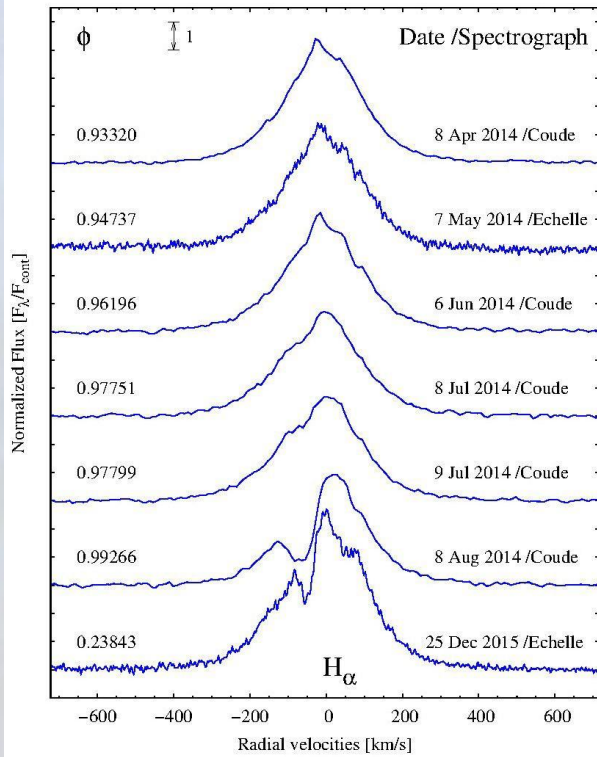


Campaign EE CEP – Light curves



2000 points
27 instruments
between 22 march
and 20 november
2014 soit 243 days

Campaign EE CEP

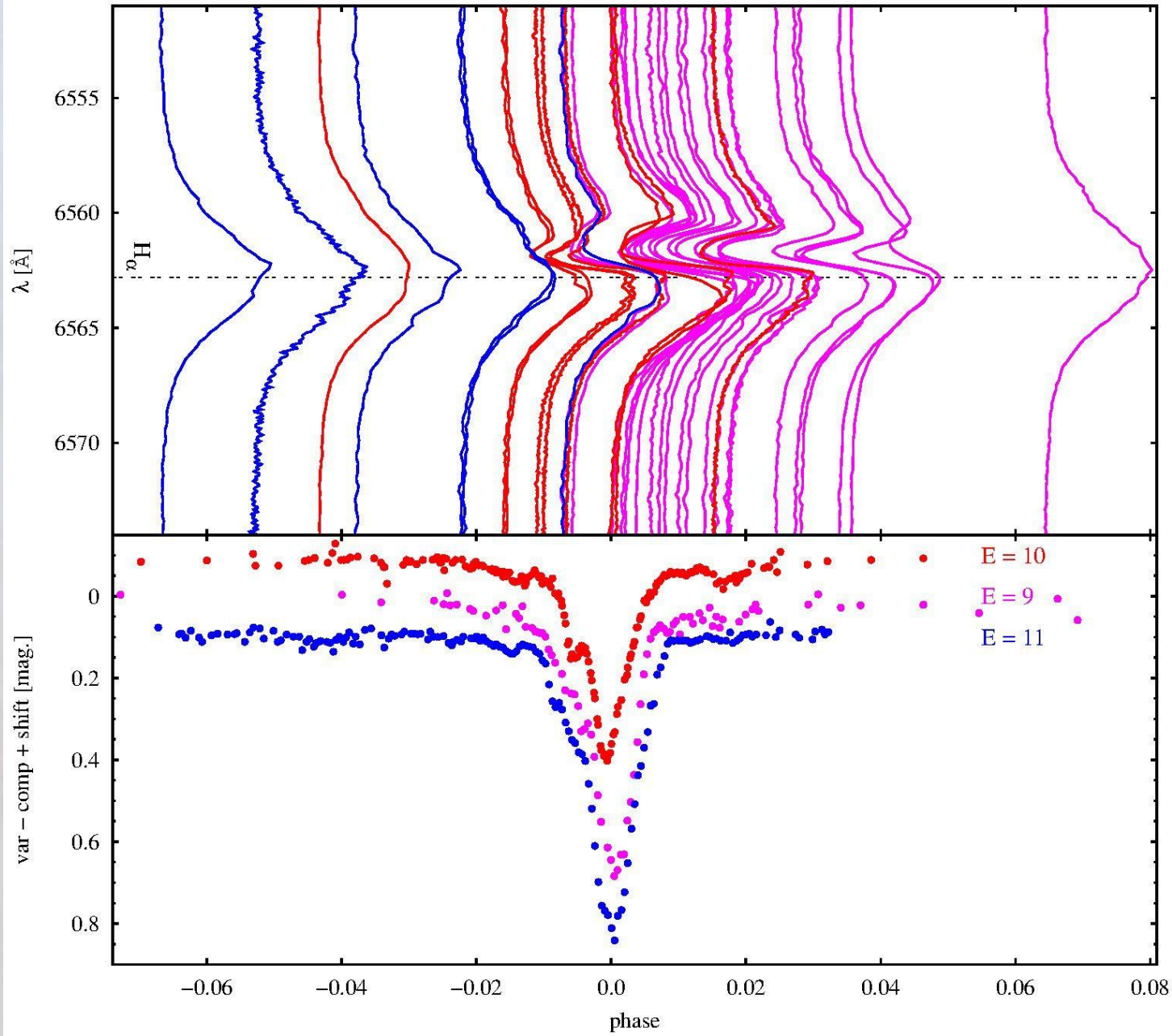


Spectro. haute resolution :
2-m Ritchey–Chretien–
Coude (RCC) telescope au
Rozhen Observatory,
Bulgaria.

Deux spectres ($R \sim 30000$)
 $\sim 4000\text{-}9000\text{\AA}$ avec ESpeRo
(Bonev et al., in preparation).

Dix spectres ($R \sim 16000$)
($\sim 200\text{\AA}$) avec le
spectrograph Coude

Campaign EE CEP



Evolutions :
Raie Ha
photométrie
en B durant
les époques 9,
10 et 11

Campaign EE CEP - modelling

Astronomy & Astrophysics manuscript no. EECep`AaA`120417
September 27, 2012

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International observational campaigns of the last two eclipses in EE Cep: 2003 and 2008/9 *

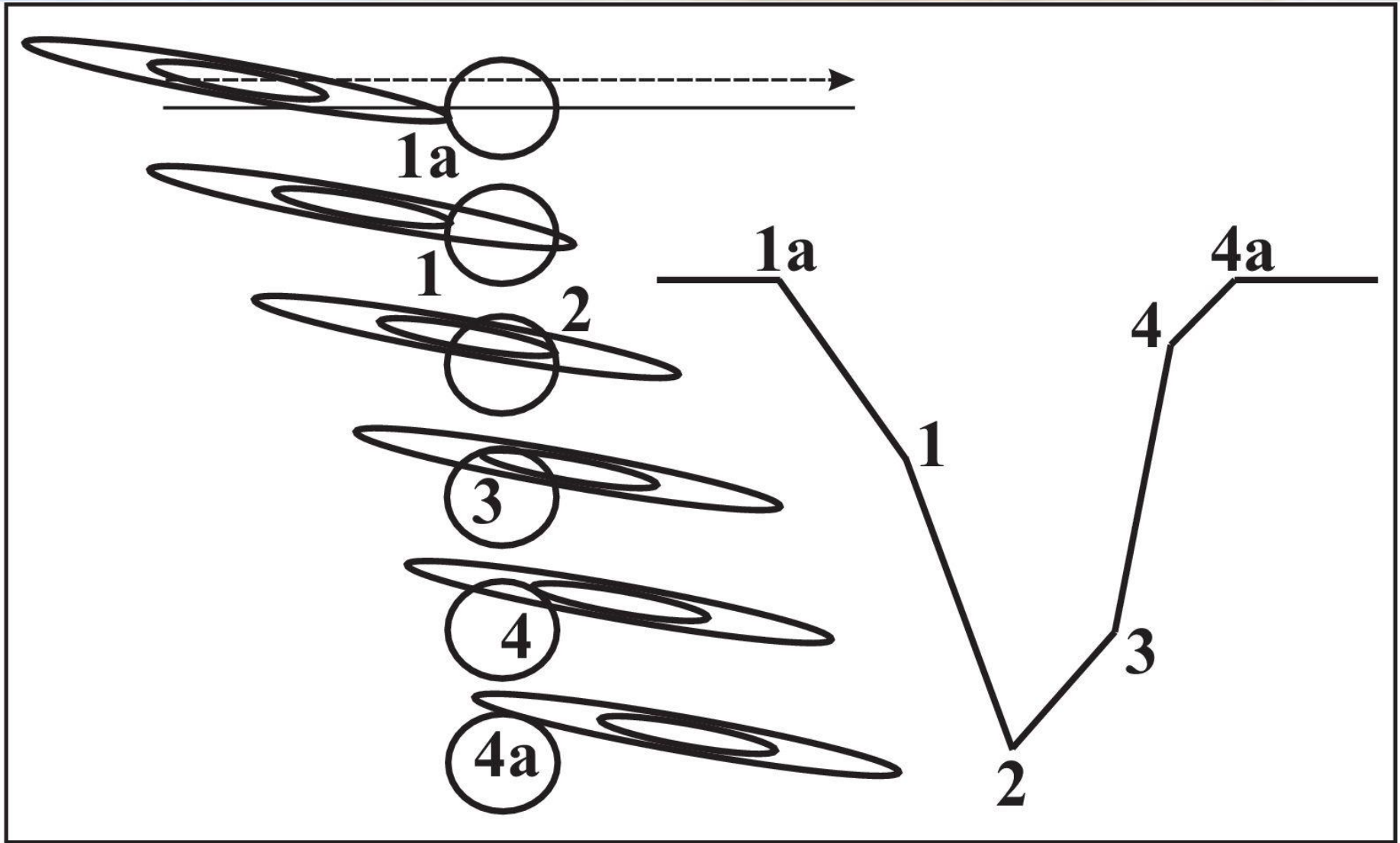
C. Gałan^{1,2}, M. Mikołajewski¹, T. Tomov¹, D. Graczyk³, G. Apostolovska⁴, I. Barzova⁵, I. Bellas-Velidis⁶, B. Bilkina⁵, R.M. Blake⁷, C.T. Bolton⁸, A. Bondar⁹, L. Brát^{10,11}, T. Brożek¹, B. Budzisz¹, M. Cikała^{1,12}, B. Csák¹³, A. Dapergolas⁶, D. Dimitrov⁵, P. Dobierski¹, M. Drahus¹⁴, M. Drózd¹⁵, S. Dvorak¹⁶, L. Elder¹⁷, S. Frąckowiak¹, G. Galazutdinov¹⁸, K. Gazeas¹⁹, L. Georgiev²⁰, B. Gere²¹, K. Goździewski¹, V.P. Grinin²², M. Gromadzki^{1,23}, M. Hajduk^{1,24}, T.A. Heras²⁵, J. Hopkins²⁶, I. Iliev⁵, J. Janowski¹, R. Kocián²⁷, Z. Kołaczkowski^{3,28}, D. Kolev⁵, G. Kopacki²⁸, J. Krzesiński¹⁵, H. Kučáková²⁷, E. Kuligowska²⁹, T. Kundera²⁹, M. Kurpińska-Winiarska²⁹, A. Kuźmicz²⁹, A. Liakos¹⁹, T.A. Lister³⁰, G. Maciejewski¹, A. Majcher^{1,31}, A. Majewska²⁸, P.M. Marrese³², G. Michalska^{3,28}, C. Migaszewski¹, I. Miller^{33,34}, U. Munari³⁵, F. Musaev³⁶, G. Myers³⁷, A. Narwid²⁸, P. Németh³⁸, P. Niarchos¹⁹, E. Niemczura²⁸, W. Ogłóza¹⁵, Y. Ögmen³⁹, A. Oksanen⁴⁰, J. Osiewała¹, S. Peneva⁵, A. Pigulski²⁸, V. Popov⁵, W. Pych⁴¹, J. Pye¹⁷, E. Ragan¹, B.F. Roukema¹, P.T. Różański¹, E. Semkov⁵, M. Siwak^{15,29}, B. Staels⁴², I. Stateva⁵, H.C. Stempels⁴³, M. Stęślicki²⁸, E. Świerczyński¹, T. Szymański²⁹, N. Tomov⁵, W. Waniak²⁹, M. Więcek^{1,44}, M. Winiarski^{15,29}, P. Wychudziński^{1,2}, A. Zajczyk^{1,24}, S. Zoła^{15,29}, and T. Zwitter⁴⁵

(Affiliations can be found after the references)

Received xxxxx xx, xxxxx; accepted xxxxx xx, xxxxx

RJ 26 Sep 2012

Campaign EE CEP - modelling



Asymétrie de la CDL (Galan et al. 2012)

Campaign EE CEP - modelling

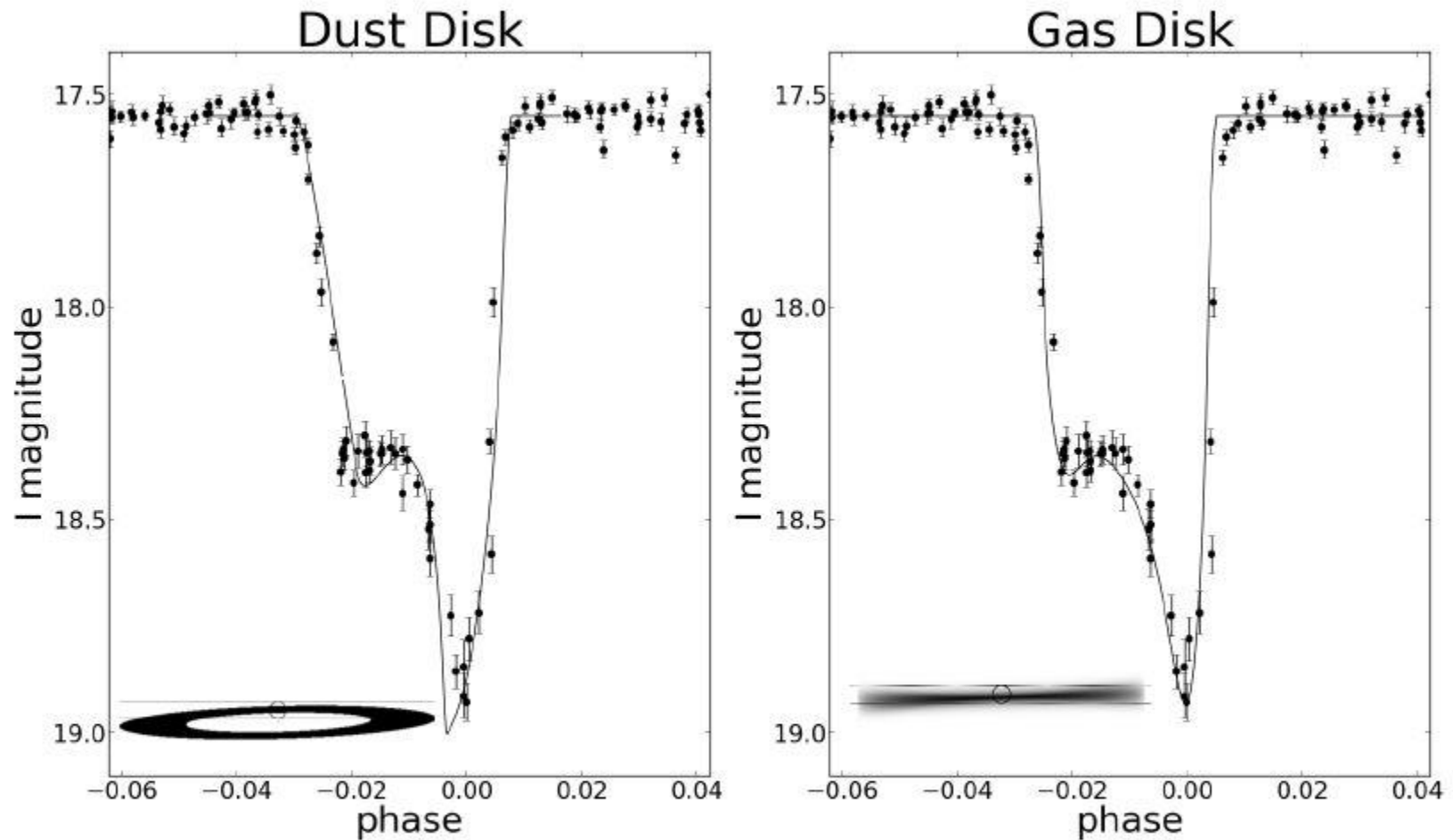


Figure 2. Phase-folded light curve for OGLE 11893 with best-fit synthetic light curves for (*left*) an infinitely thin dusty debris disk, and (*right*) flared gas-rich disk. Parameters of best fit synthetic light curves are compiled in Table 2.

Campaign EE CEP – preliminary results

- The minima calculated by Mikołajewski & Graczyk in 1999 is true.
- Le décrochage au 9^{ème} jour
- La chute de magnitude en U est de 0.81 et de 0.61 en I est moins « forte » que prévu, les raisons :
 - L'orbite du disque !!!
 - La densité du disque !!!
 - Le diamètre du disque : 150 R_{solaire} ???

Tout reste encore à faire (observer et modéliser) pour comprendre

Campaign EE CEP - modelling

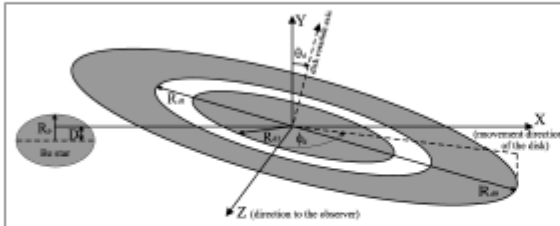


Fig. 12. Schematic explanation of the geometrical parameters in the special case when the precession axis of the disk (the symmetry axis of the conical surface over which the rotation axis of the disk moves cyclically with the precession period P_{prec}) is parallel to the Y axis of the coordinate system (i.e. it is perpendicular to the orbital plane). Our code allows this axis to be inclined by angles θ_{prec} and ϕ_{prec} in a similar way to the inclination of the rotation axis.

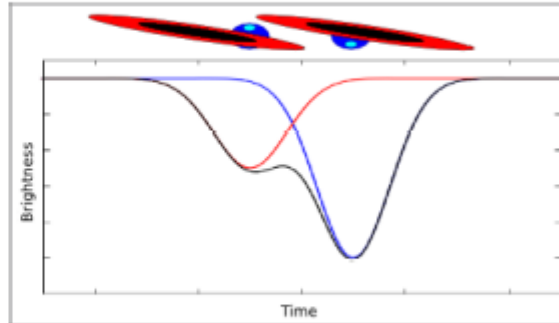


Fig. 13. Schematic explanation for the formation of the bump in the light curves. The configurations of the star and the disk at the first and second minima are shown at the top.

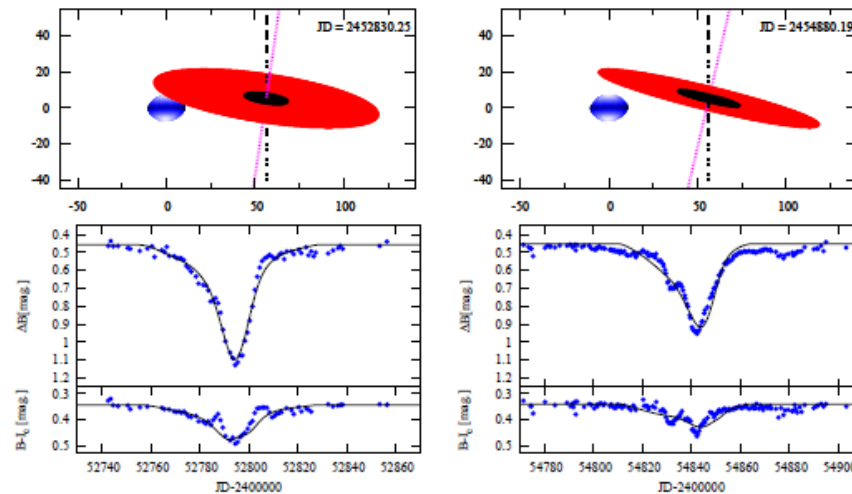


Fig. 14. Modelling of the eclipses of a rapidly rotating Be star by a solid disk, considering both the 2003 (left) and 2008/9 (right) eclipses. The precession period is a free parameter. The top panels show projections of the system onto the plane of the sky. The polar (hot) and equatorial (cool) areas of the star are shown by changing shades. The inner (opaque) and outer (semi-transparent) areas of the disk are shown by dark and light shades, respectively. The sizes are expressed in solar radii. The lower panels show the B light curve (middle) and the $B - I_C$ colour index (bottom) together with the synthetic fits (lines). The Julian day in the upper right corner represents the moment at which (according to the model) the spatial configuration of the system is the same as shown in the relevant panel.



Publications

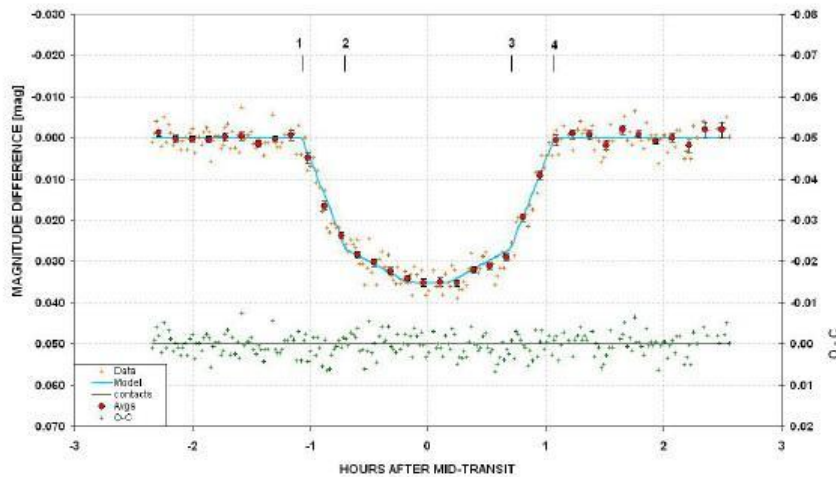
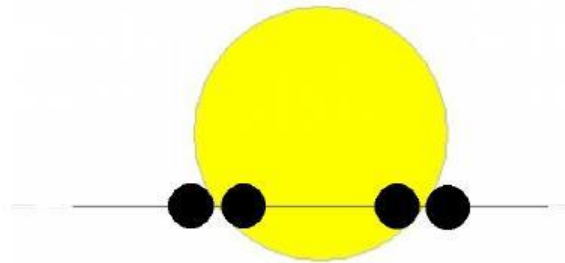


**Cela s'appelle un
« livre » !
Je ne sais pas
comment on le
recharge !**

Books

EXOPLANET OBSERVING FOR AMATEURS

Second Edition



Bruce L. Gary

A PRACTICAL GUIDE TO

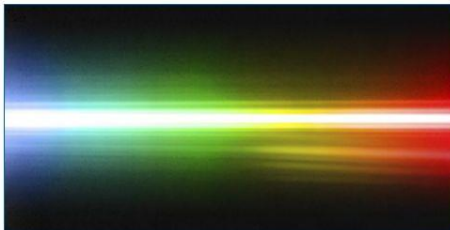
Lightcurve Photometry and Analysis

BRIAN D. WARNER

 Springer

Astronomie collaborative

Inventaire et analyse des programmes
professionnels-amateurs en astronomie observationnelle
identifiés en France



Binaires à éclipses

Connaître les heures des minima (et les maxima)

Coordination: CORP Laurent



F. Aves/Ciel et Espace Photos

Effectuer une multitude d'images CCD d'étoiles binaires à éclipses afin de déterminer des séries temporelles permettant de construire des courbes de lumière.

Réaliser des courbes de lumière sous forme de fichiers donnant les informations temporelles et lumineuses sur chaque saisie.

Les amateurs réalisent tout le protocole.

Nombre de personnes actuellement impliquées : 5

Échelle temporelle :

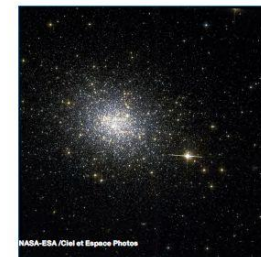
- 1 - Prédiction (logicielle et catalogues, recoupement).
- 2 - Observation d'une étoile pendant 4 h mini.
- 3 - Réduction des données (logicielle)



RR Lyrae

Recherche des maxima

Coordination: CORP Laurent



MASA-ESA/Ciel et Espace Photos

Effectuer une multitude d'images CCD d'étoiles binaires à éclipses afin de déterminer des séries temporelles permettant de construire des courbes de lumière.

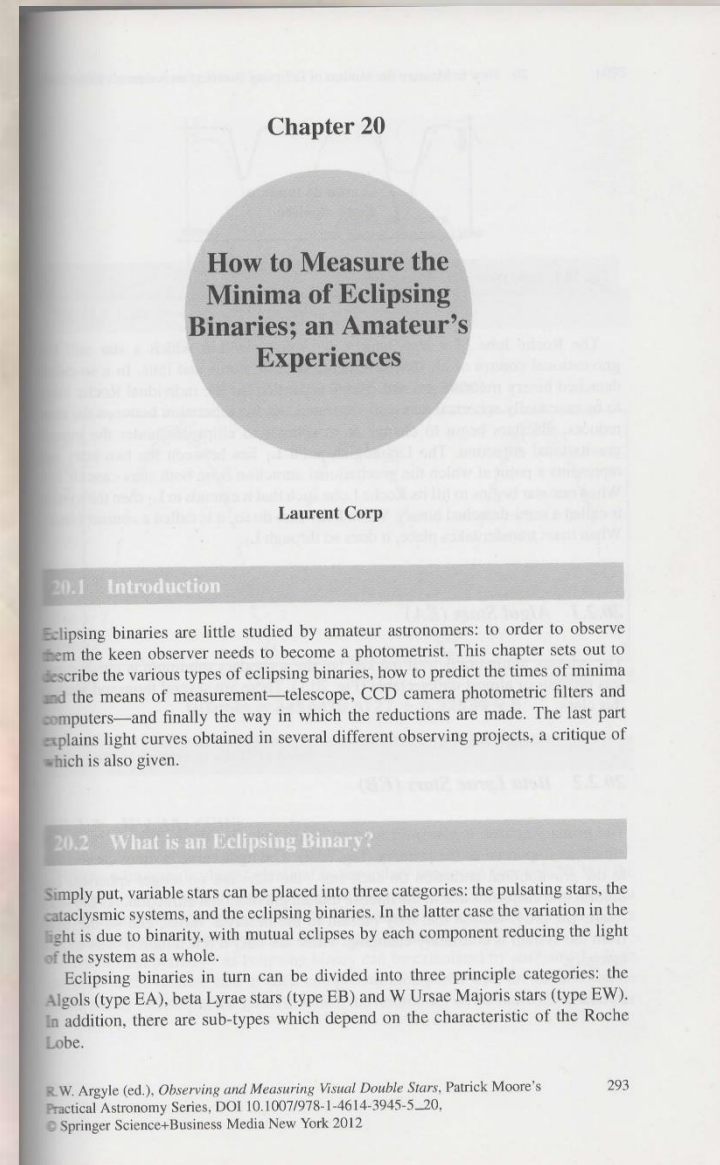
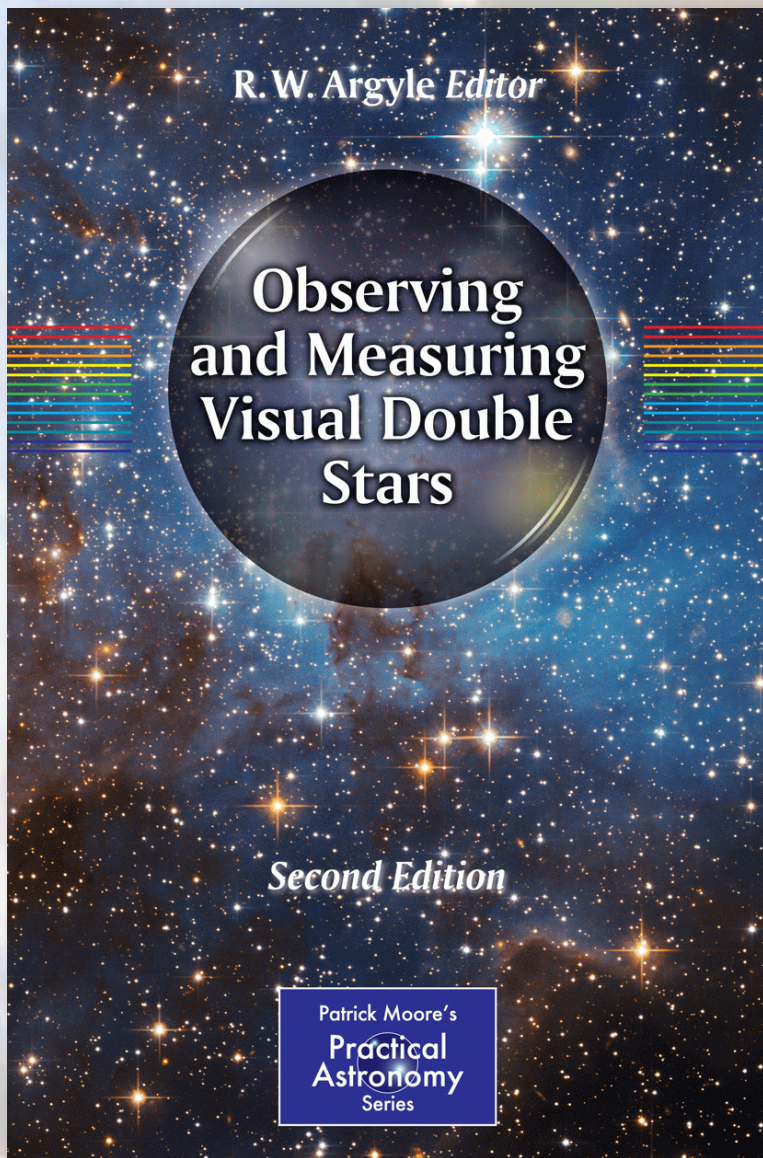
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- 2 - Observation d'une étoile pendant 4 h mini.
- 3 - Réduction des données (logicielle)



Fin décembre 2012 - 16 auteurs – 423 pages – voir chapitre 20

<http://www.springer.com>

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M 07266 - 2014 - F. 7,50 € - RD



OBJECTIF

Mieux comprendre la physique des étoiles

MÉTHODE

Réaliser des mesures photométriques des étoiles variables

GUETTEZ LES ÉTOILES VARIABLES

En relevant les variations d'éclat de certains astres changeants, vous pouvez contribuer à mieux comprendre le destin des étoiles.

Laurent Corp



Cette image de Hubble montre l'étoile variable de type céphéide RS Puppis, dont l'éclat varie d'un facteur 5 sur une période de 40 jours.

The Society for Astronomical Sciences

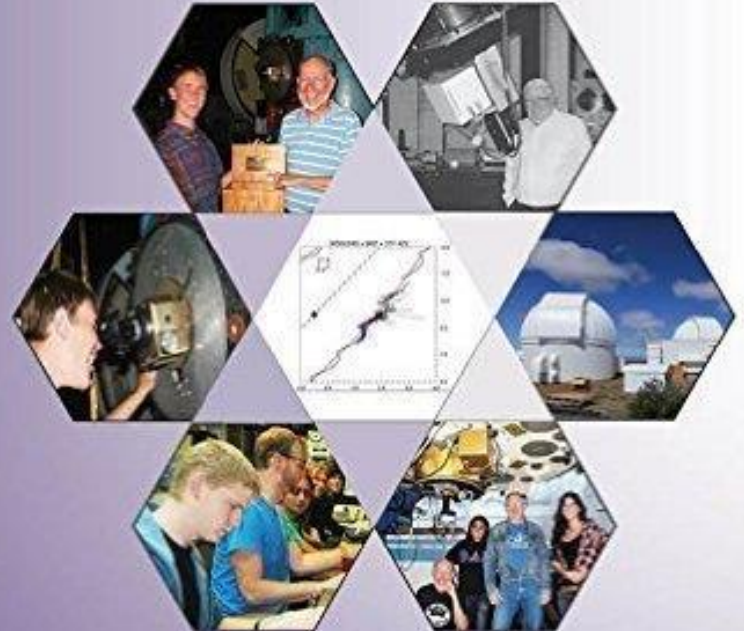
Proceedings for the 34th Annual
Symposium on Telescope Science

2015 June 11-13



Pages 199-202

DOUBLE STAR ASTROMETRY COLLABORATIONS, IMPLEMENTATIONS, AND ADVANCED TECHNIQUES



Editors:



Pages 139-141

Thank you for your
attention



Have you got
any question ?