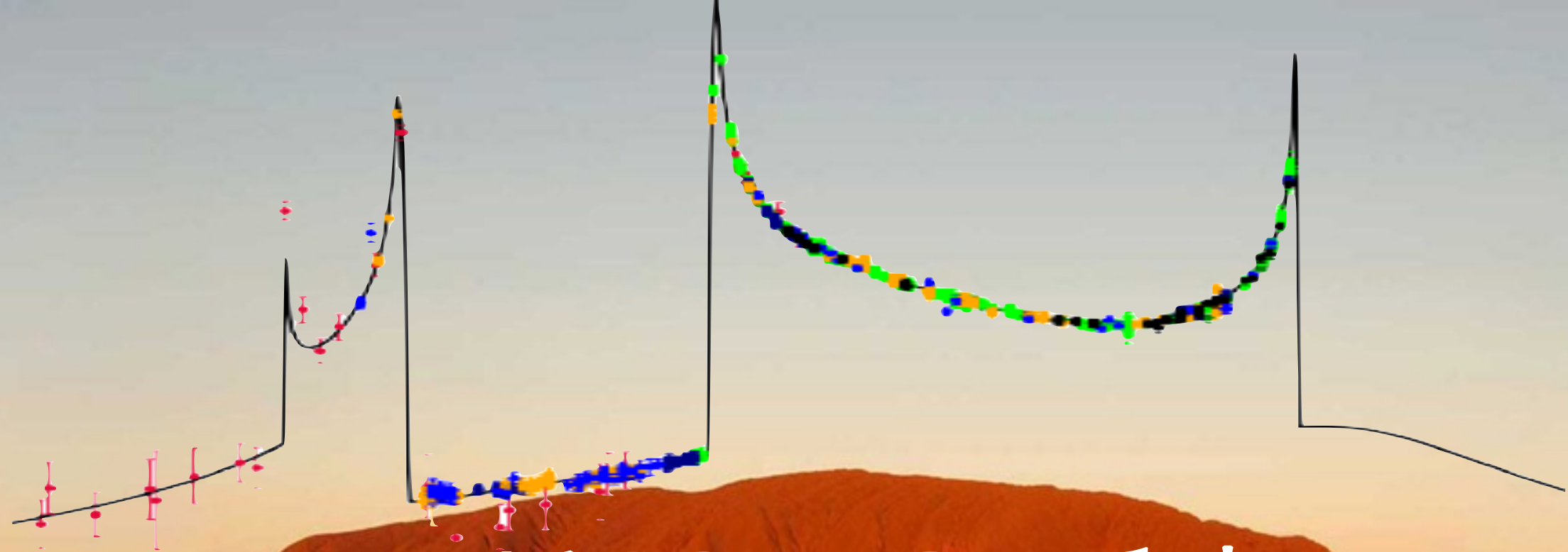




Gaia16 **AYers Rock***

Łukasz Wyrzykowski

(pron: Woocash Vizhikovsky)

Warsaw University Astronomical Observatory, Poland

*Uluru



gaia



UNIVERSITY OF
CAMBRIDGE



7th Gaia Science Alerts Workshop, Utrecht, NL
8 December 2016

collaborators

- Przemek Mroz (Warsaw) - real-time binary modelling
- Krzysztof (Kris) Rybicki (Warsaw) - real-time data reductions
- Nikolay Britavskiy (Odessa / IAC) - spectra analysis
- Zbyszek Kołaczkowski (Wrocław) - photometric data improvement
- Kirill Sokolovsky (Athens) - early coordination, AAVSO, Swift
- + ~100 observers from around the world

OGLE microlensing

- monitors the Galactic Bulge since 1992
- 2000 microlensing events every year, about 15000 found so far

Celebrating **25** years of the **OGLE** project

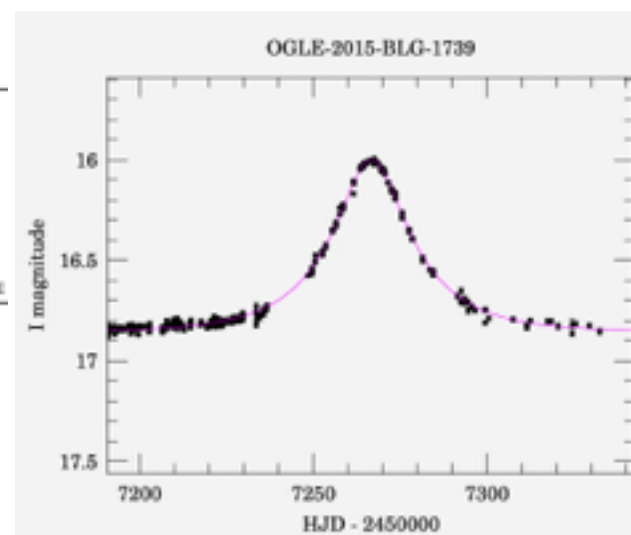
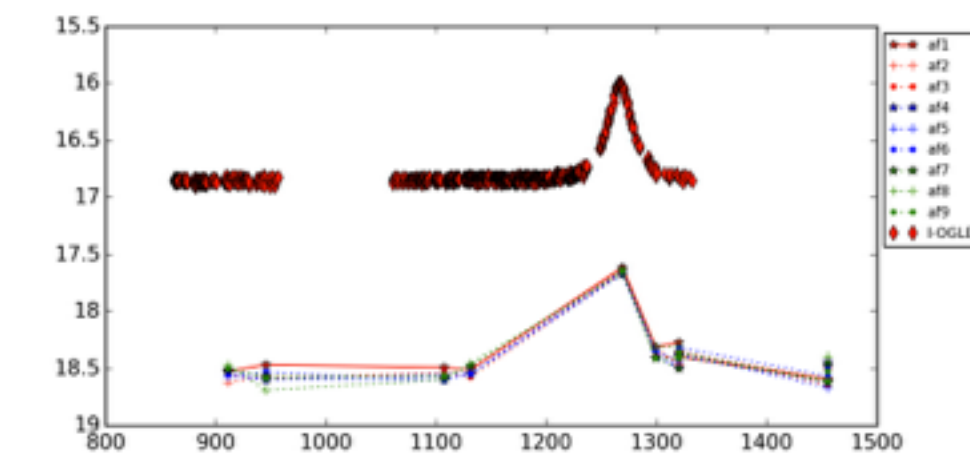
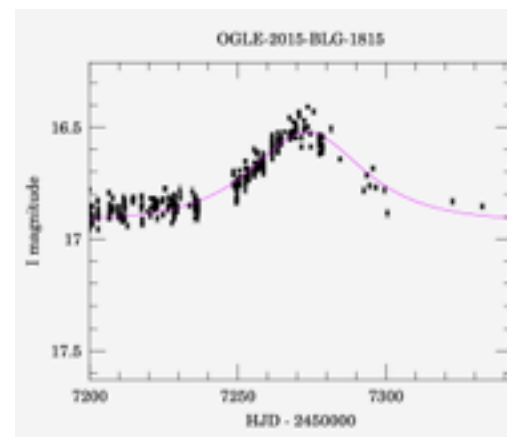
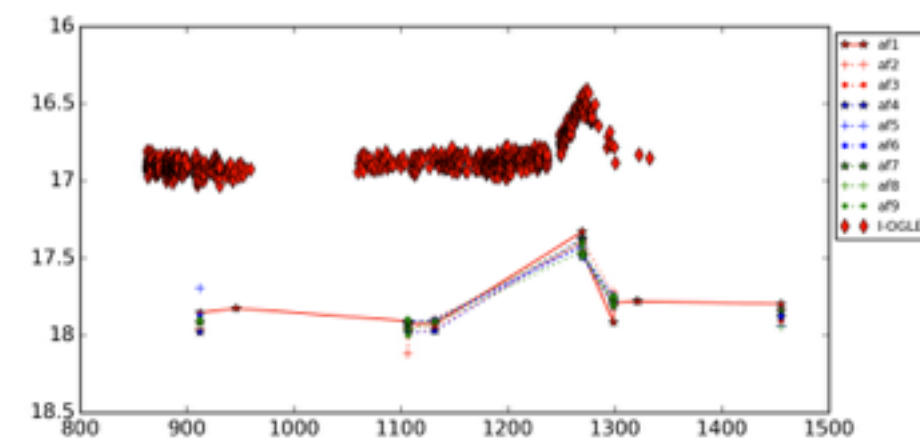
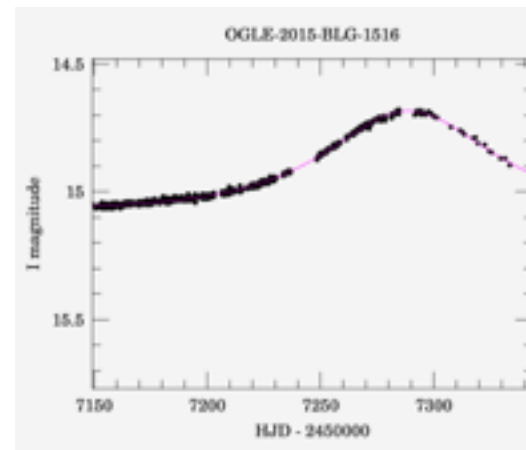
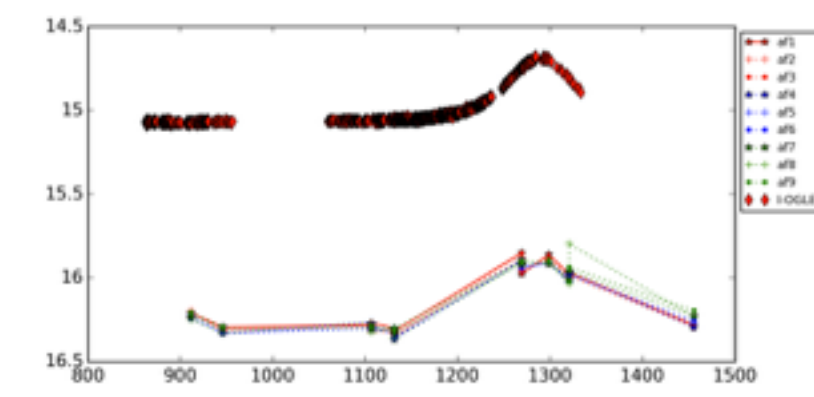
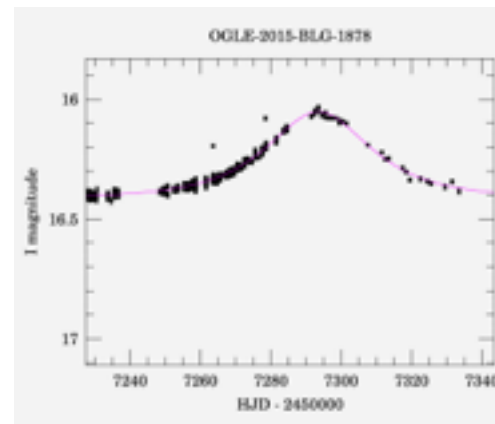
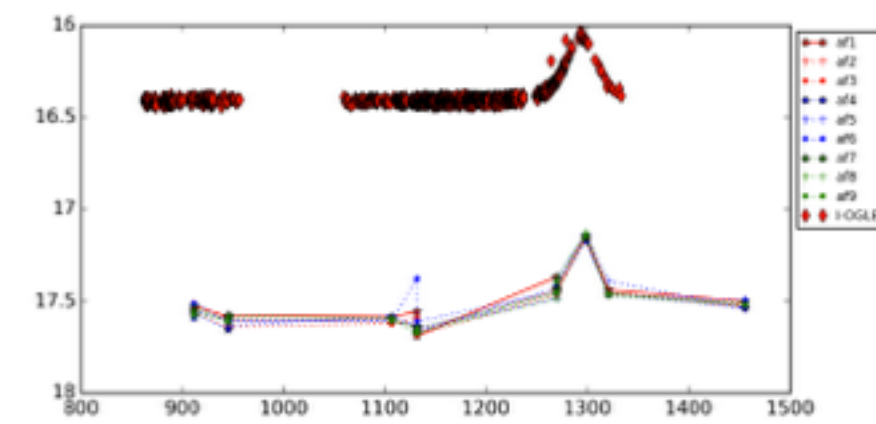


24 – 28 July 2017
Warsaw University, Poland

ogle.astrouw.edu.pl

ogle25.astrouw.edu.pl

photo by Krzysztof Ulaczyk

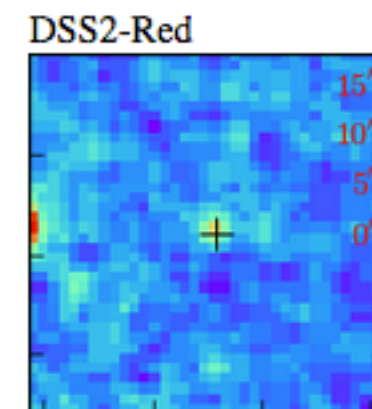
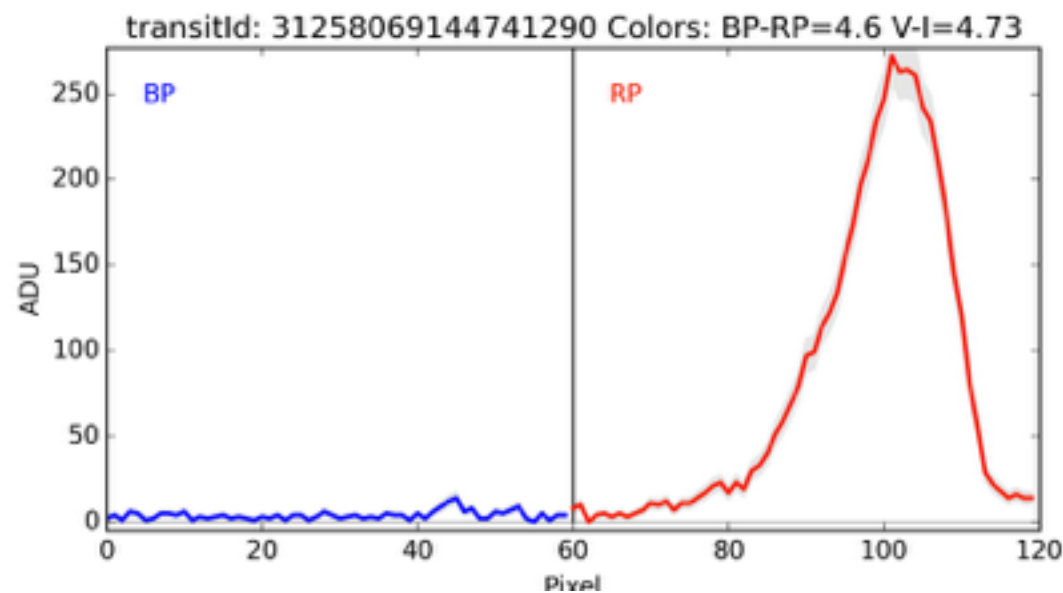
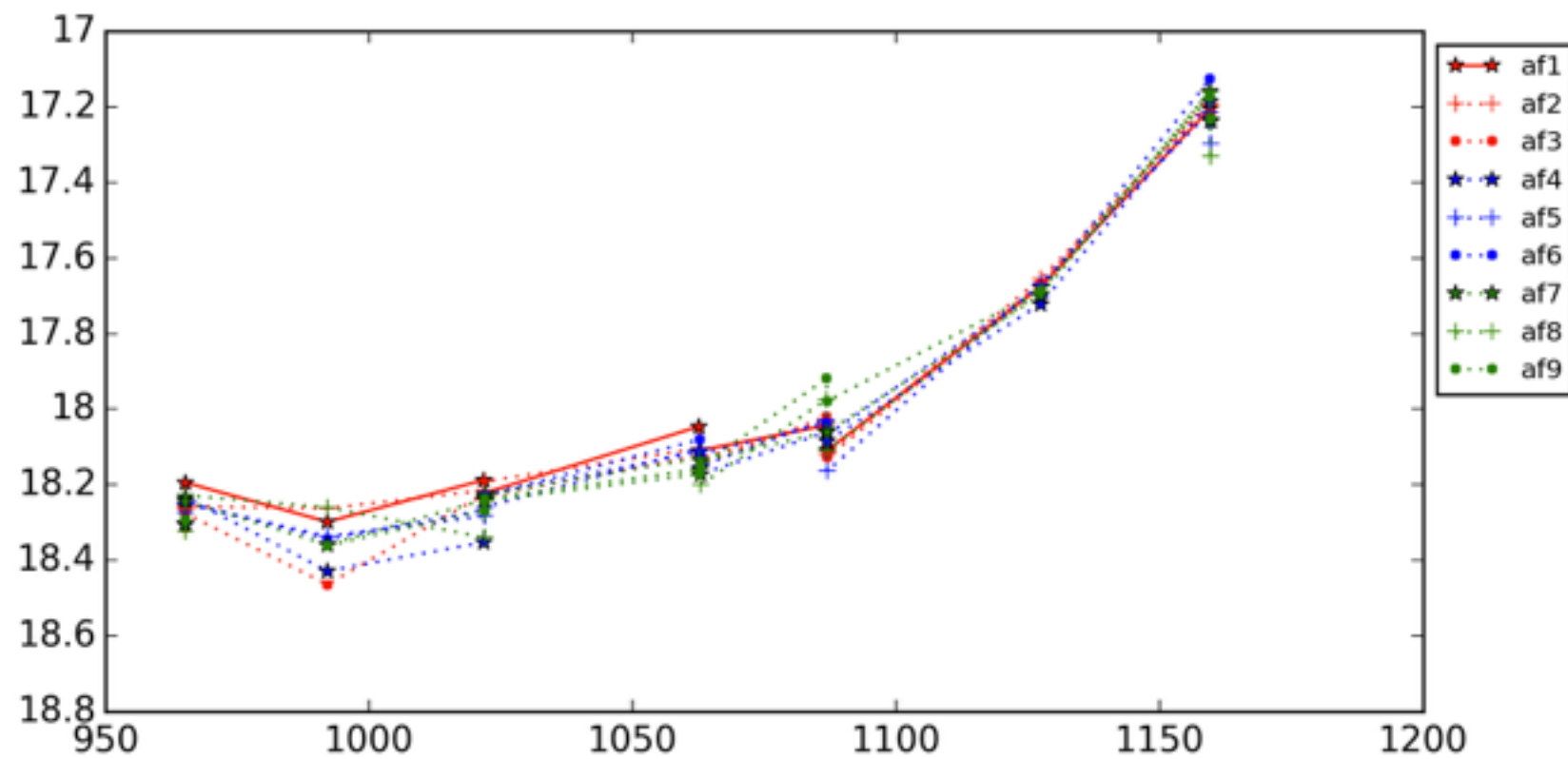


2015-BLG-1466

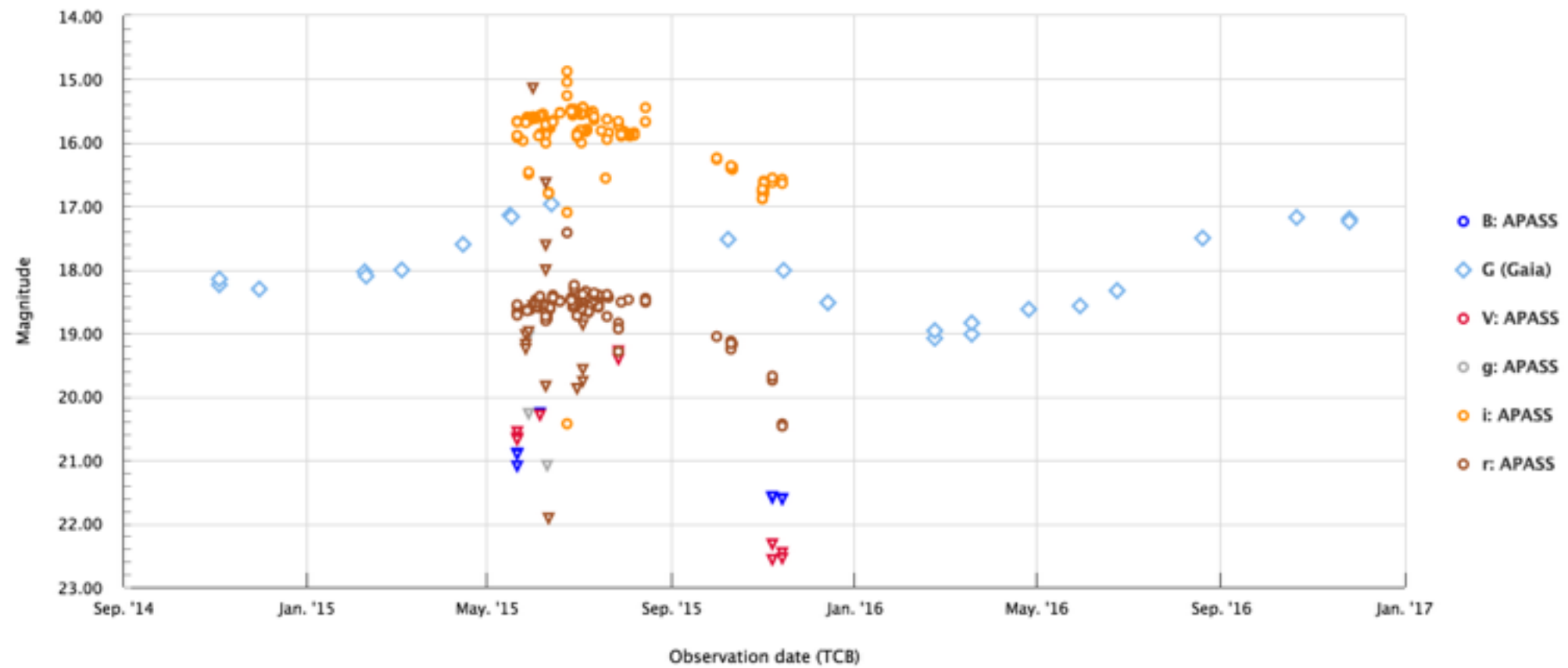
2015-BLG-1463

2015-BLG-1418

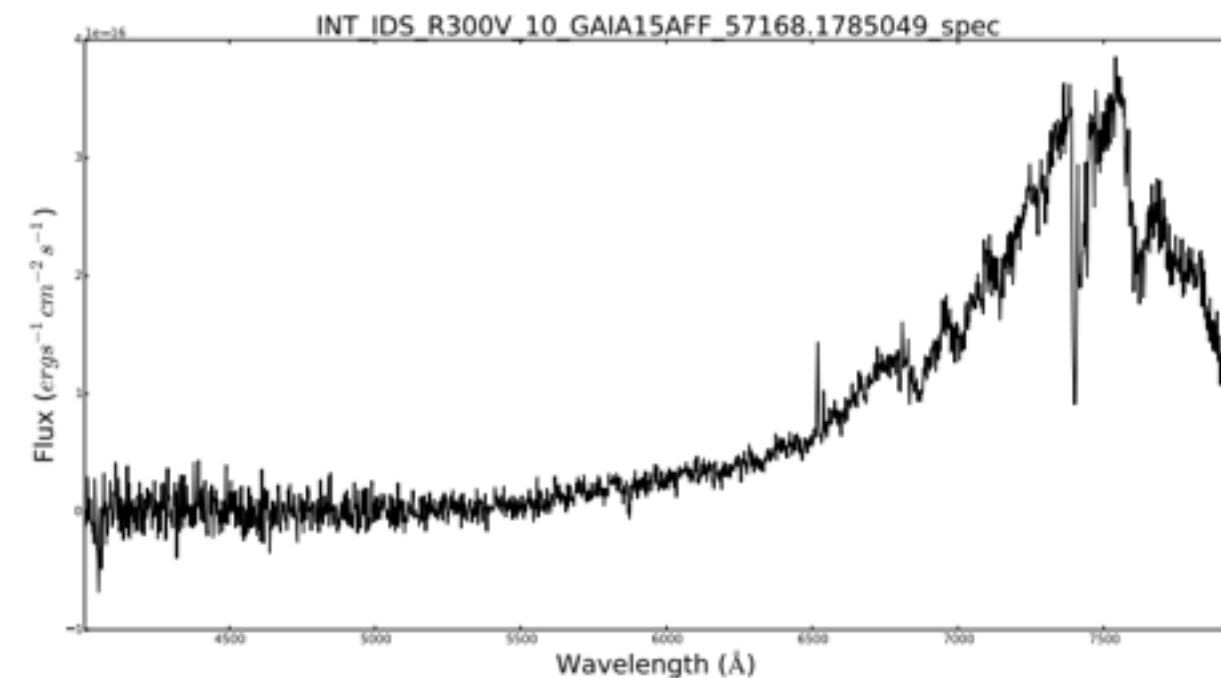
Gaia15aff - first microlensing alert?



Gaia15aff - first microlensing alert?

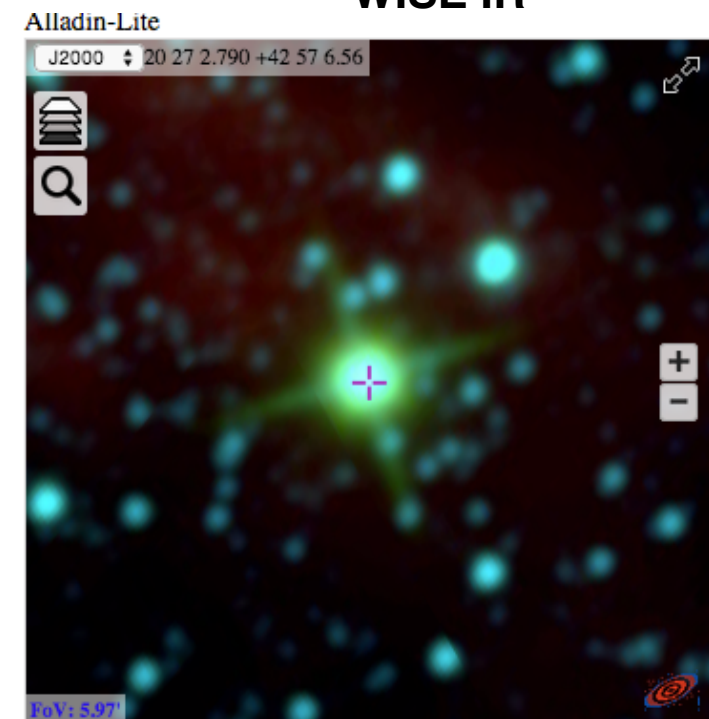


Spectra from INT



**Mira
Variable :(**

WISE IR



GSC 3656-1328 = TAGO EVENT

Near-naked-eye microlensing event in Cassiopeia from 2006

The bright new variable in Cassiopeia - a microlensing event?

ATel #931; *M. Mikolajewski, T. Tomov, A. Niedzielski, K. Czart, C. Galan - Torun Center for Astronomy, Nicolaus Copernicus University, 87-100 Torun, Poland*
on 3 Nov 2006; 20:56 UT

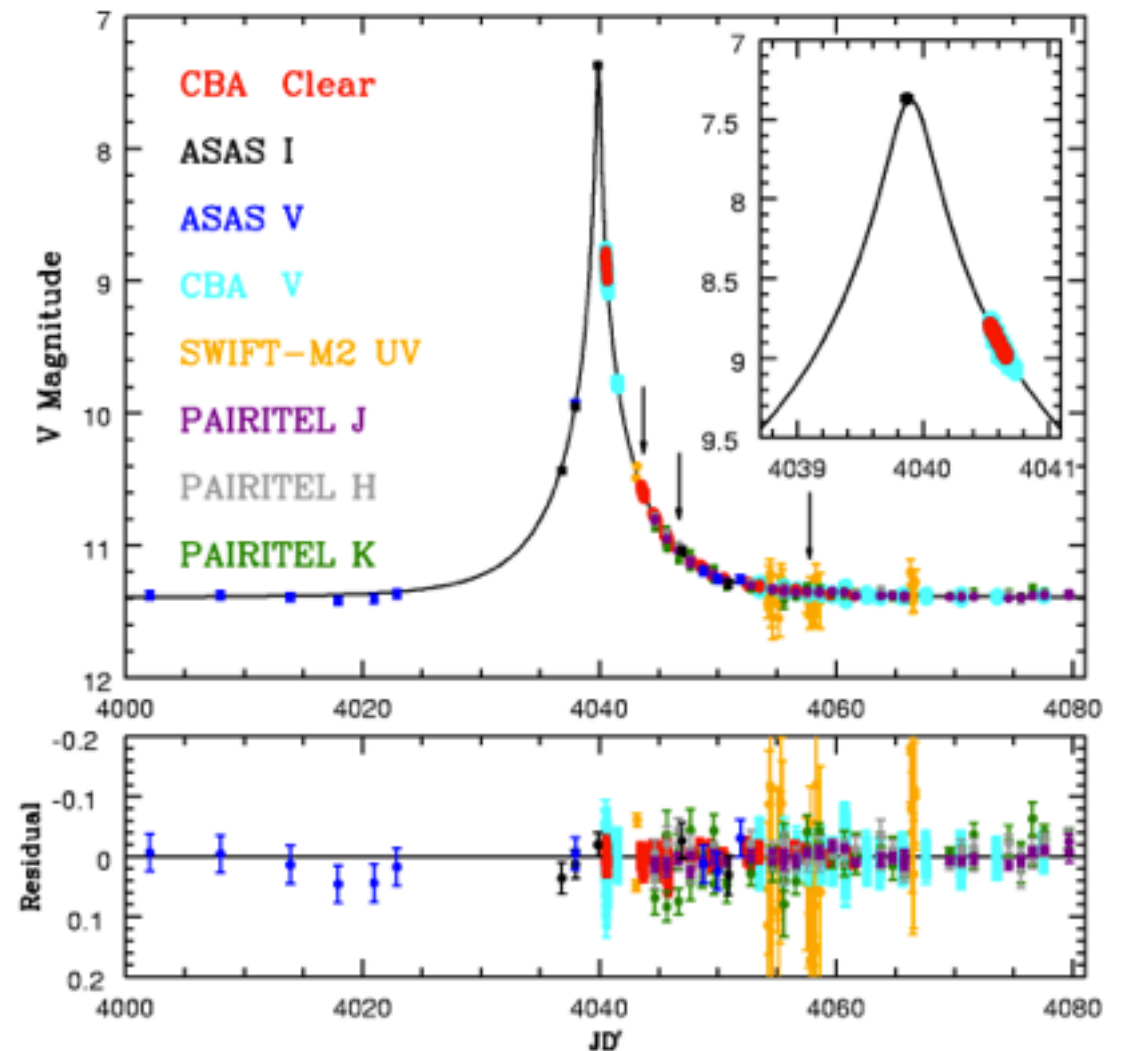
Credential Certification: Andrzej Niedzielski (aniedzi@astri.uni.torun.pl)

Subjects: Optical, Microlensing Event, Star, Variables

Referred to by ATel #: 942, 943

 Tweet  Recommend 0

We report BV photometry and optical spectroscopic observations of a bright new variable in Cassiopeia, identified as GSC 3656-1328 (CBET # 711, # 712). According to SIMBAD database GSC 3656-1328 is a 11.4 star in V with B-V of about 0.2. Our spectra in the region 3700-7300Å and at a resolution of 4Å were obtained with the 60/90cm Schmidt-Cassegrain telescope of Torun Observatory between 2006 November 02.790 UT and November 03.713 UT. They show a typical A0V-A1V star without remarkable spectral variations or line shifts. The Balmer absorptions show an average radial velocity of -45 ± 15 km/s. The brightness estimate: $V=10.15$ and $B=10.35$ was obtained with the 60cm Cassagrain telescope of Torun Observatory on 2006 November 02.765 UT. The SIMBAD data show that before the event GSC 3656-1328 was a slightly reddened A0V-A1V star at a distance of about 1 kps. The only observed change was a sudden rapid increase and then a decrease of the brightness with an amplitude about 4 mag without any spectral changes. It is difficult to associate such an observed phenomenon with any type of variable stars. A possible explanation of the GSC 3656-1328 behavior could be a gravitational microlensing event. If that is the case, this would be the closest microlensing event ever observed.



GSC 3656-1328 = TAGO EVENT

Near-naked-eye microlensing event in Cassiopeia from 2006

TYC 3656-1328-1 00 09 21.995 +54 39 43.83

Gaia DR1 (TGAS):

mag = 11.36

pi = 0.68209

pm_ra = -0.77066

pm_dec = -4.809

D_L = 1.47 kpc

(1 kpc in Gaudi paper)

/0703125v3 11 Mar 2008

DISCOVERY OF A VERY BRIGHT, NEARBY GRAVITATIONAL MICROLENSING EVENT

B. SCOTT GAUDI¹, JOSEPH PATTERSON², DAVID S. SPIEGEL², THOMAS KRAJCI³, R. KOFF⁴, G. POJMAŃSKI⁵, SUBO DONG¹, ANDREW GOULD¹, JOSE L. PRIETO¹, CULLEN H. BLAKE⁶, PETER W. A. ROMING⁷, DAVID P. BENNETT⁸, JOSHUA S. BLOOM^{9,10}, DAVID BOYD¹¹, MICHAEL E. EYLER¹², PIERRE DE PONTIÈRE¹³, N. MIRABAL², CHRISTOPHER W. MORGAN^{1,12}, RONALD R. REMILLARD¹⁴, T. VANMUNSTER¹⁵, R. MARK WAGNER¹⁶, LINDA C. WATSON¹

Draft version January 23, 2014

ABSTRACT

We report the serendipitous detection of a very bright, very nearby microlensing event. In late October 2006, an otherwise unremarkable A0 star at a distance ~ 1 kpc (GSC 3656-1328) brightened achromatically by a factor of nearly 40 over the span of several days and then decayed in an apparently symmetrical way. We present a light curve of the event based on optical photometry from the Center for Backyard Astrophysics and the All Sky Automated Survey, as well as near-infrared photometry from the Peters Automated Infrared Imaging Telescope. This light curve is well-fit by a generic microlensing model. We also report optical spectra and *Swift* X-ray and UV observations that are consistent with the microlensing interpretation. We discuss and reject alternative explanations for this variability. The lens star is probably a low-mass star or brown dwarf, with a relatively high proper motion of $\gtrsim 20$ mas yr⁻¹, and may be visible using precise optical/infrared imaging taken several years from now. A modest, all-sky survey telescope could detect ~ 10 such events per year, which would enable searches for very low-mass planetary companions to relatively nearby stars.

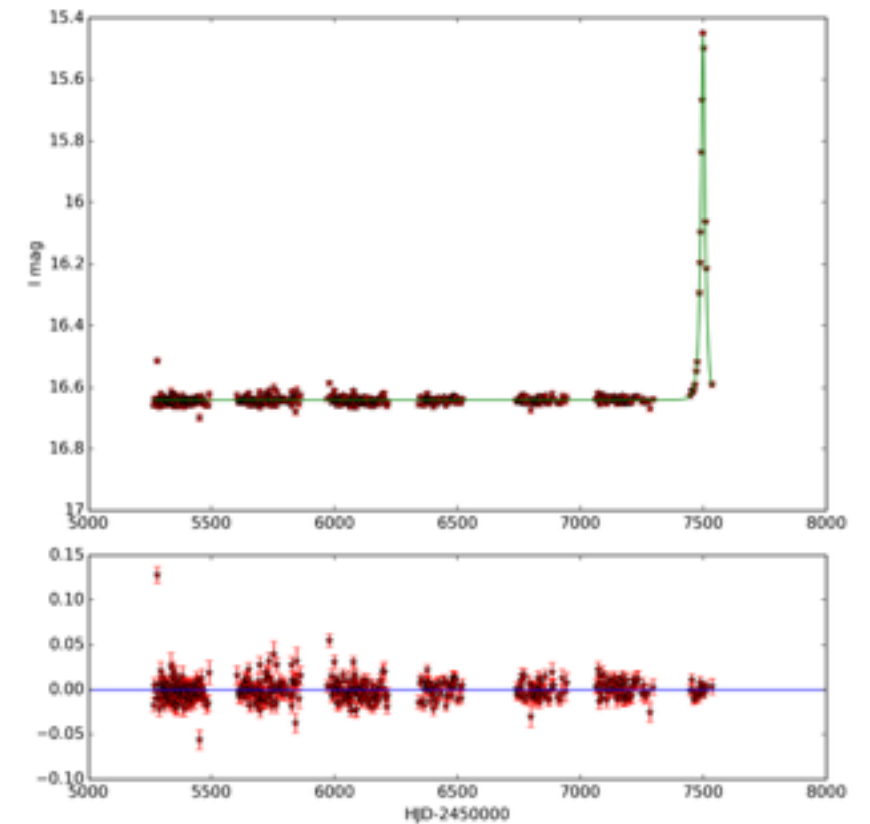
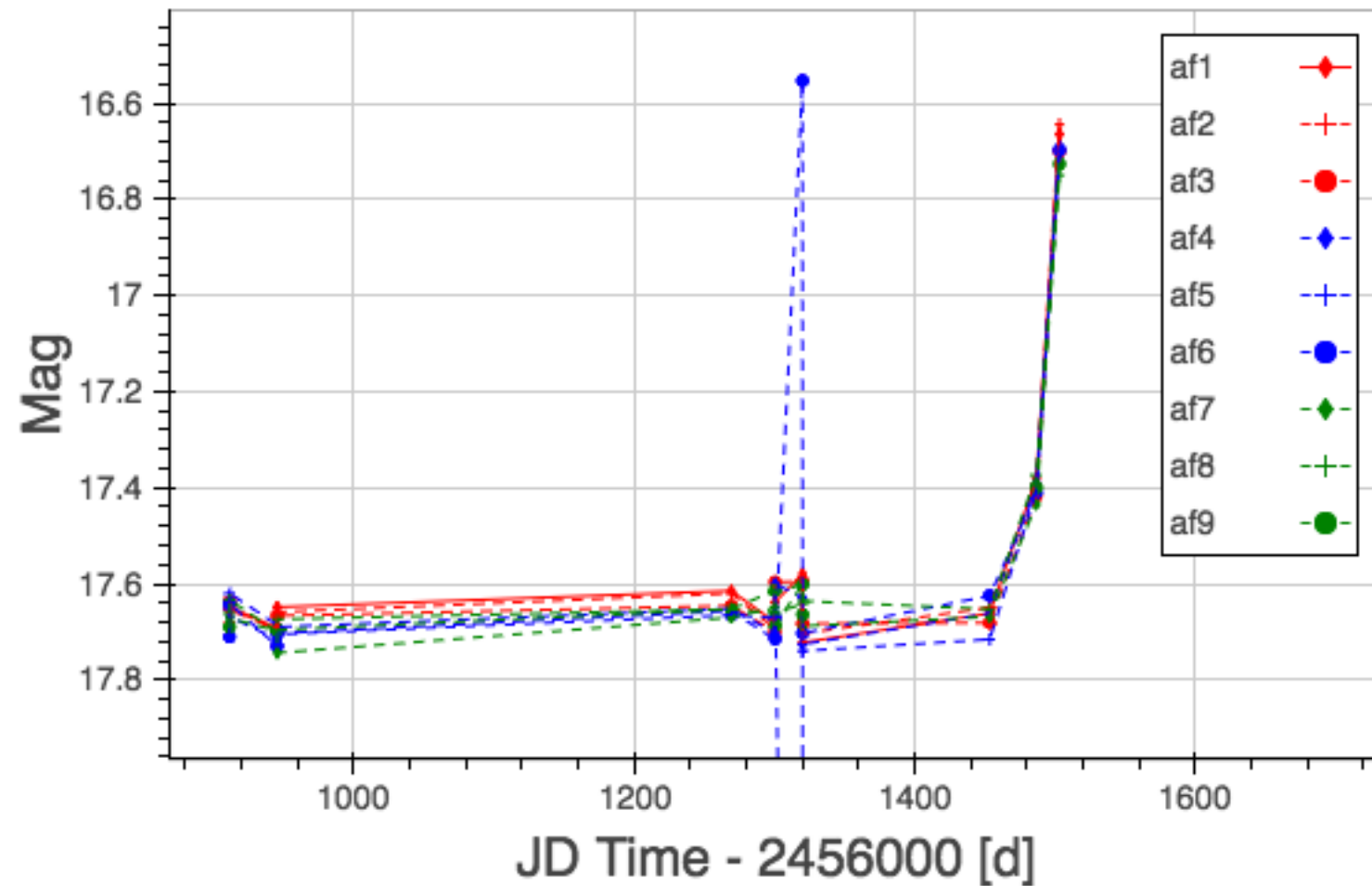
Subject headings: stars: individual (GSC 3656-1328); gravitational lensing

1. INTRODUCTION

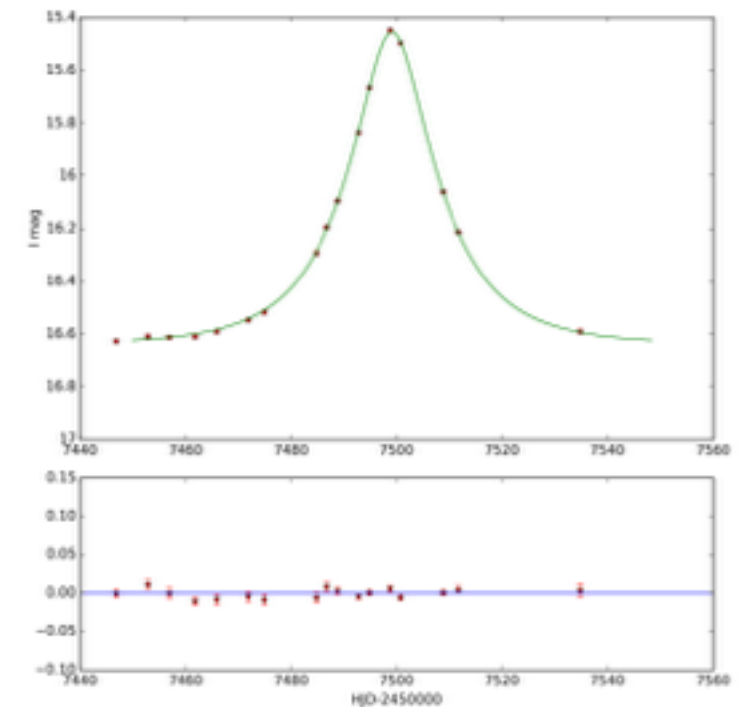
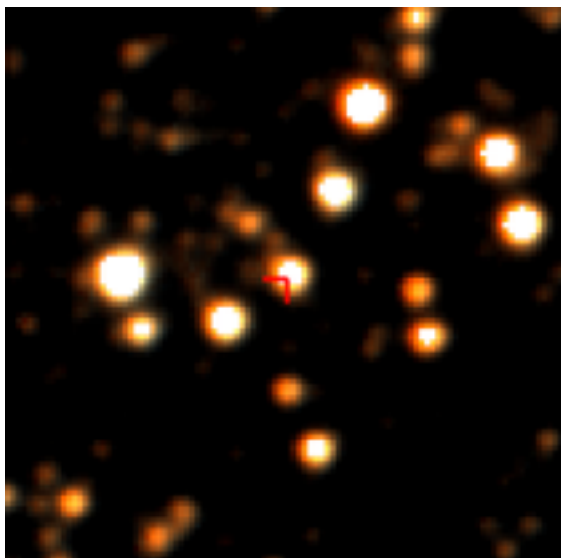
At the very moment in 1936 that he introduced¹⁷ the concept of gravitational microlensing of one star by an-

other closely aligned along its line of sight, Einstein famously dismissed its practical significance. Noting that the characteristic scale (what we now call the “Einstein radius”) was extremely small, he concluded that “there is no great chance of observing this phenomenon, even if dazzling by the light of the much nearer star is dis-

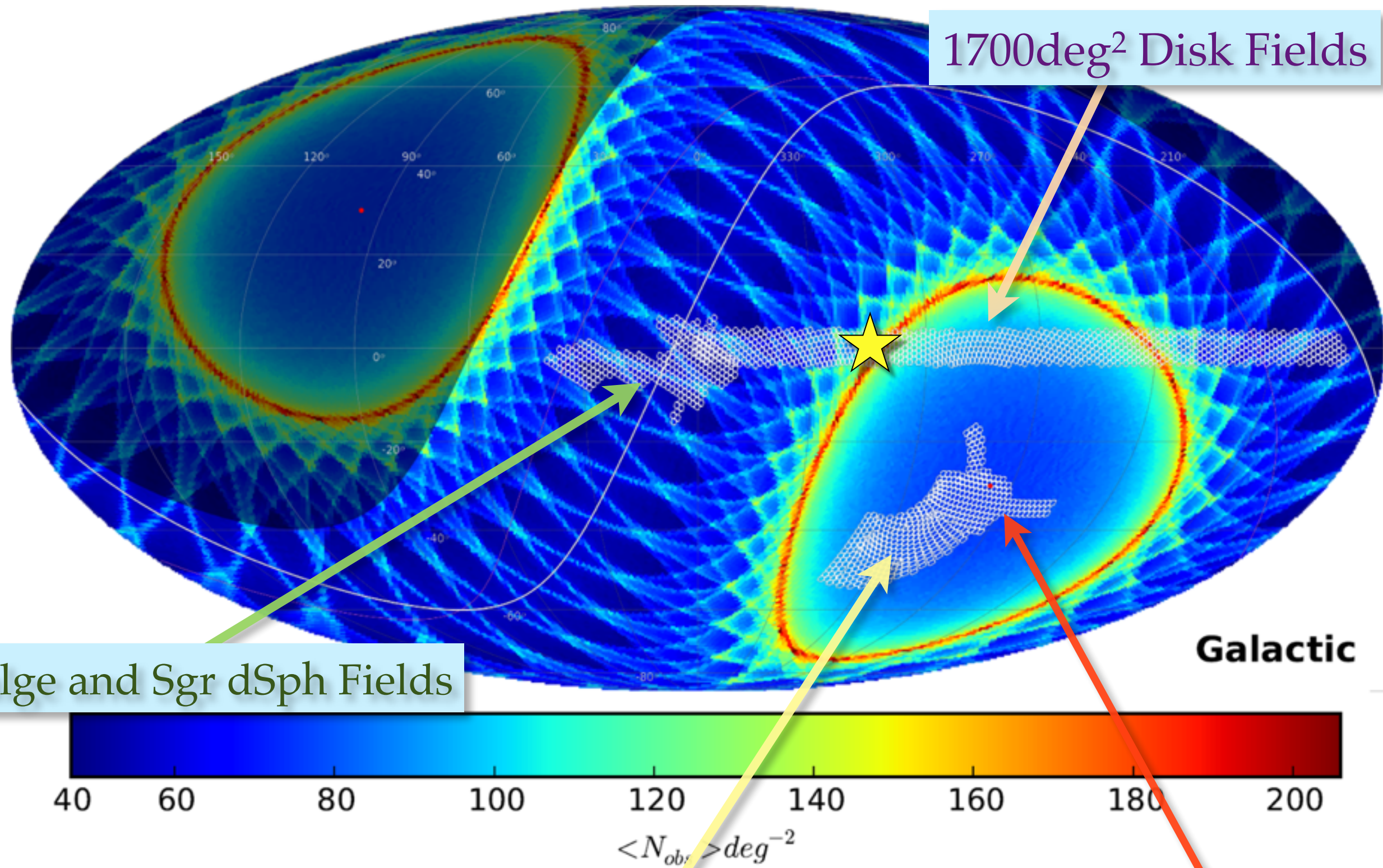
Gaia16aua (Auala)



OGLE-IV data



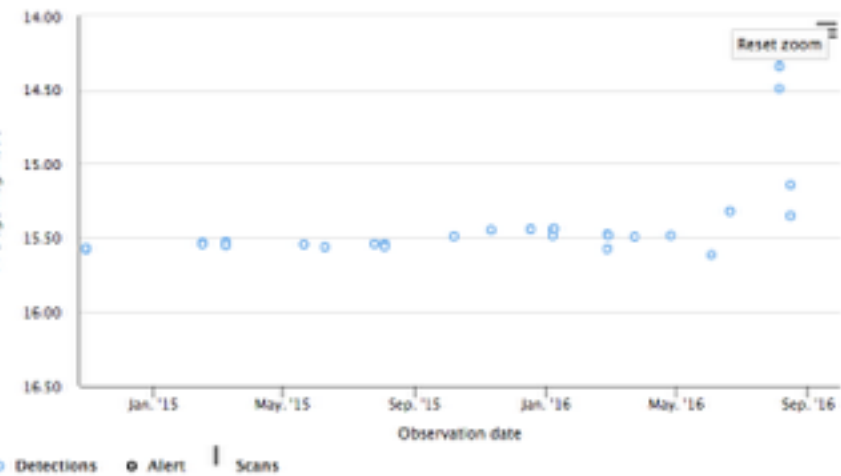
OGLE-Gaia sky



Gaia16aye (Ayers Rock)

Gaia Alerts

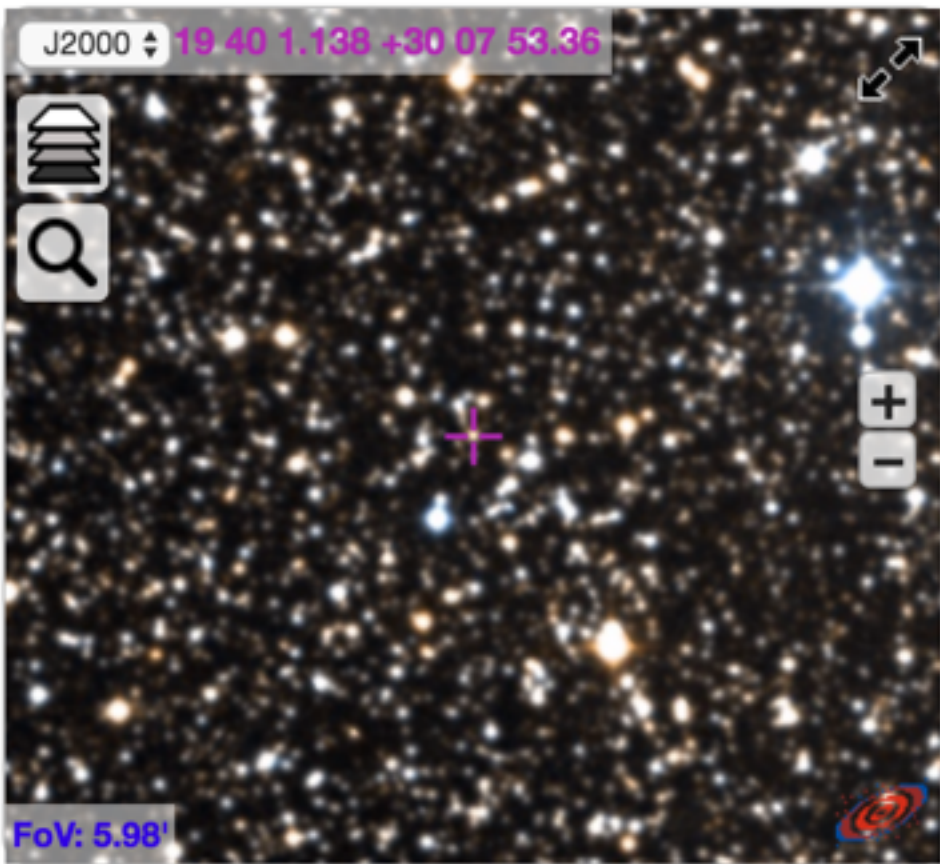
Gaia



Gaia16aye

Details

Follow-up



RA - DEC
295.00474 30.13149
19:40:01.14 30:07:53.36

Alerting date
2016-08-05 00:53:52

Julian date
2457605.54

Alerting magnitude
14.27

Historic magnitude
15.51

Historic StdDev
0.06

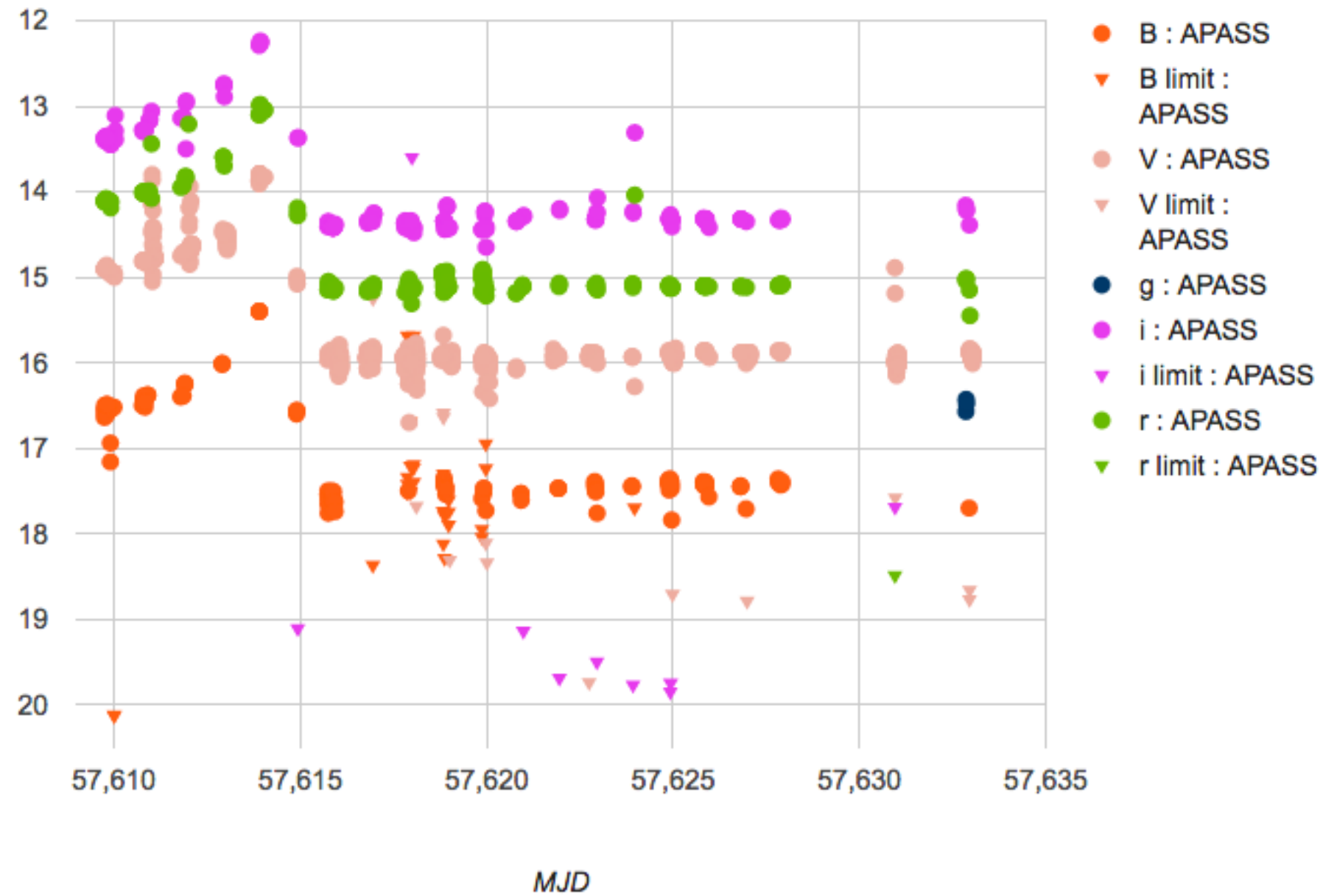
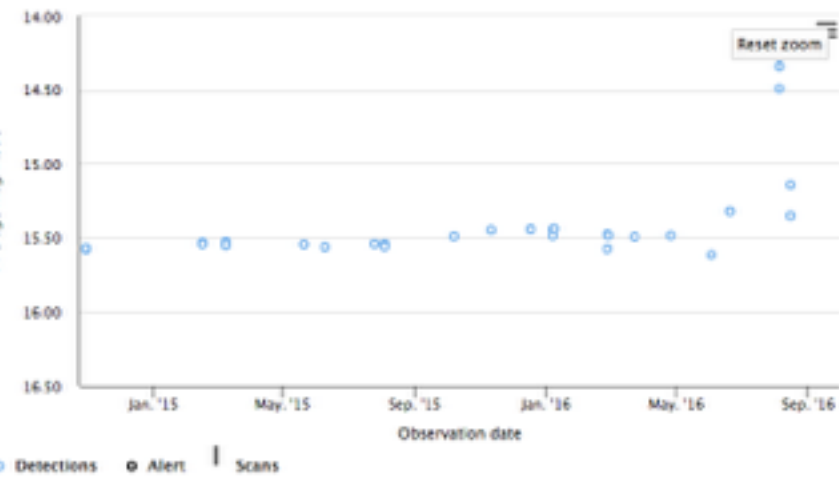
Class
ULENS

Publication date
Aug. 9, 2016, 10:45 a.m.

5th Aug.2016

Gaia16aye (Ayers Rock)

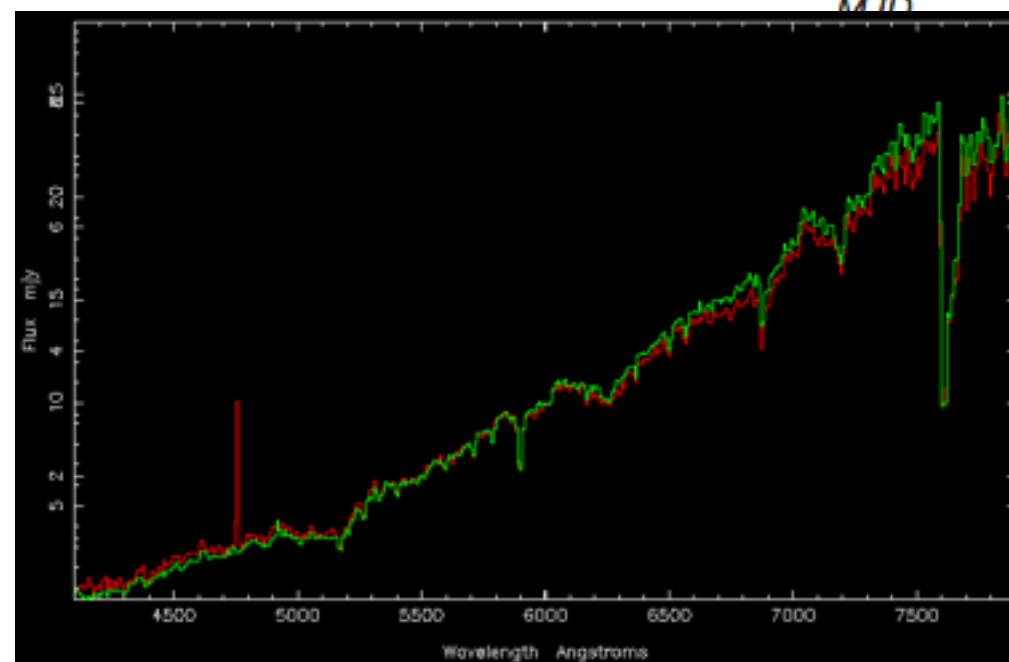
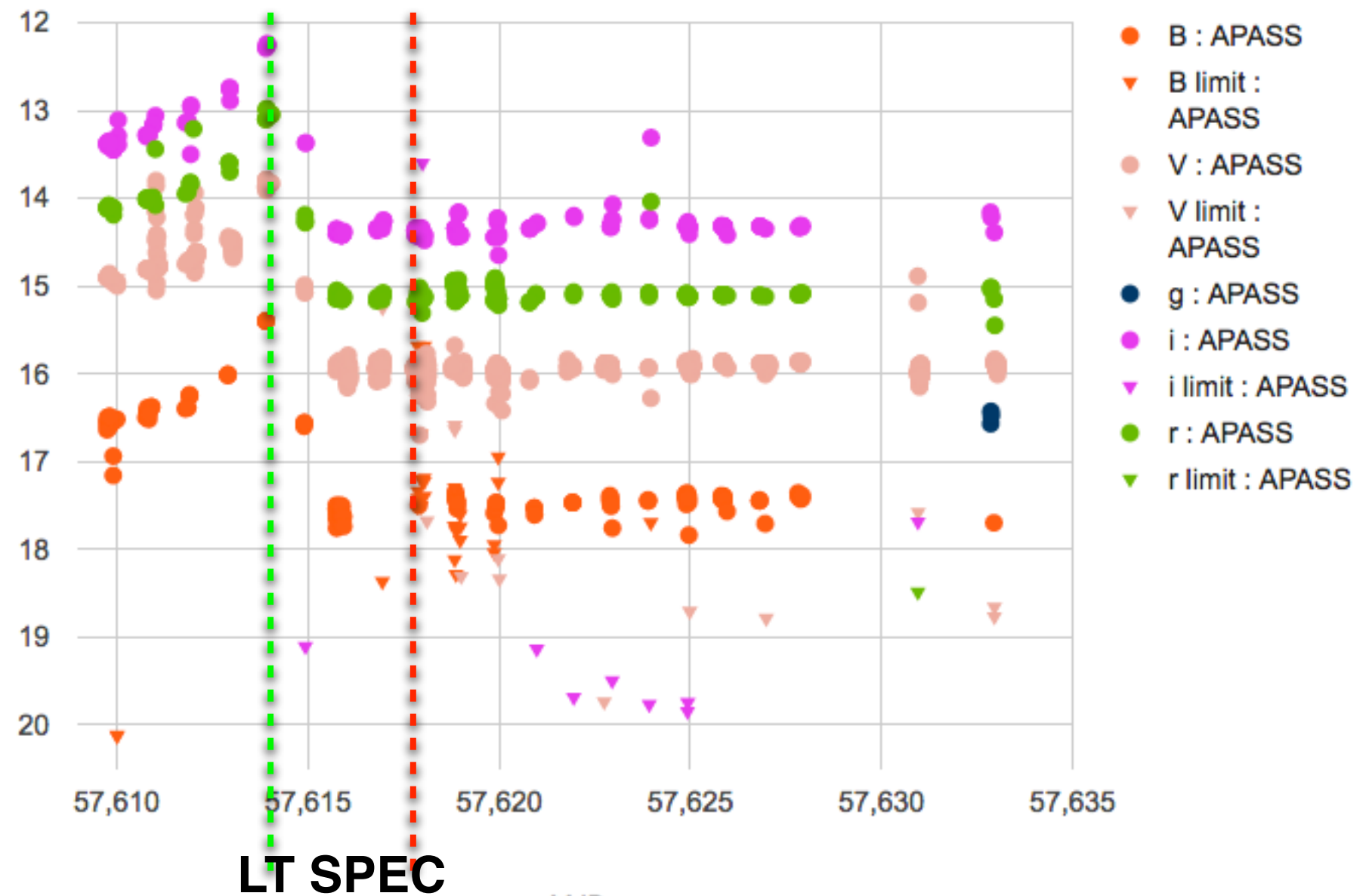
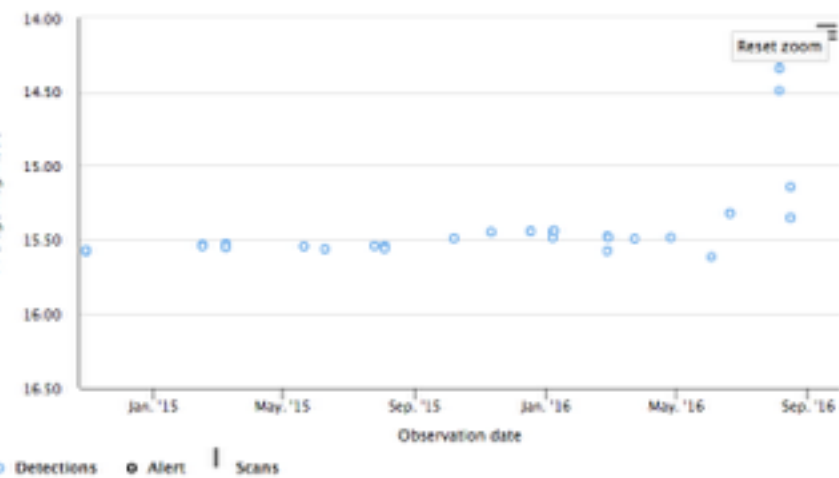
Gaia



Aug.2016

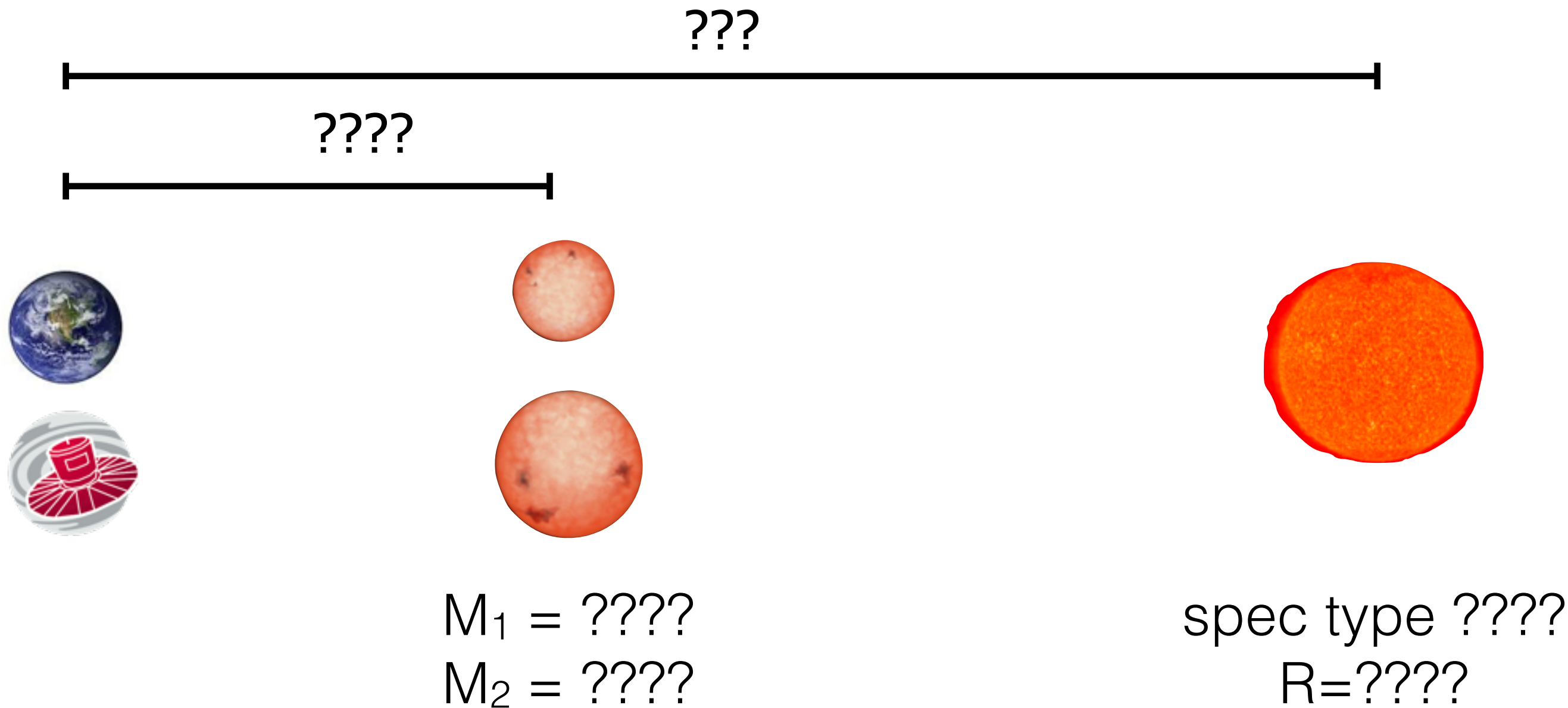
Gaia16aye (Ayers Rock)

Gaia



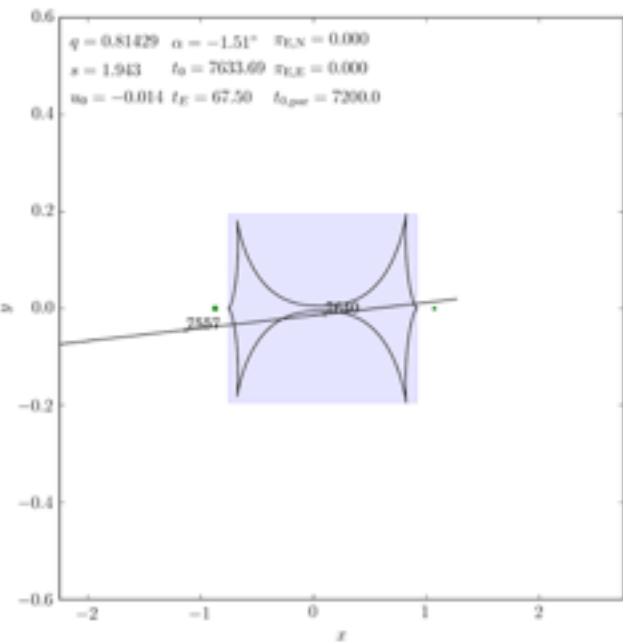
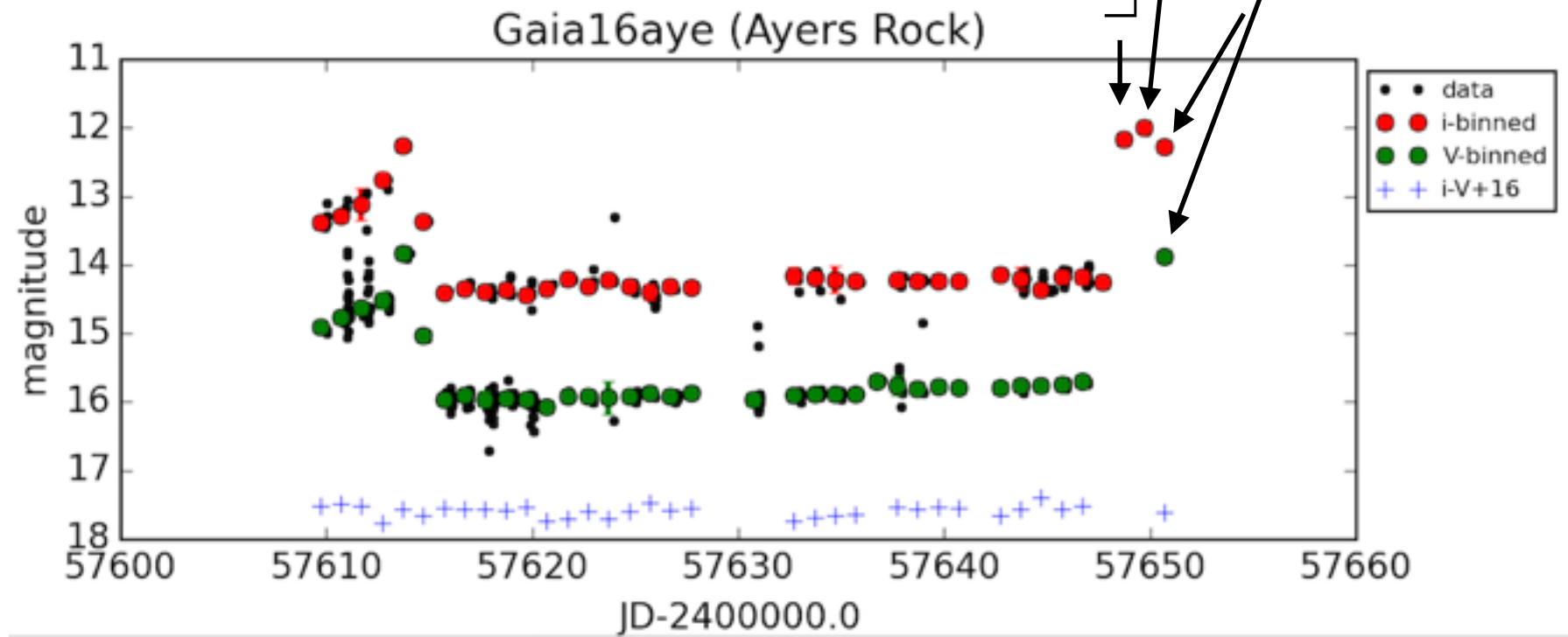
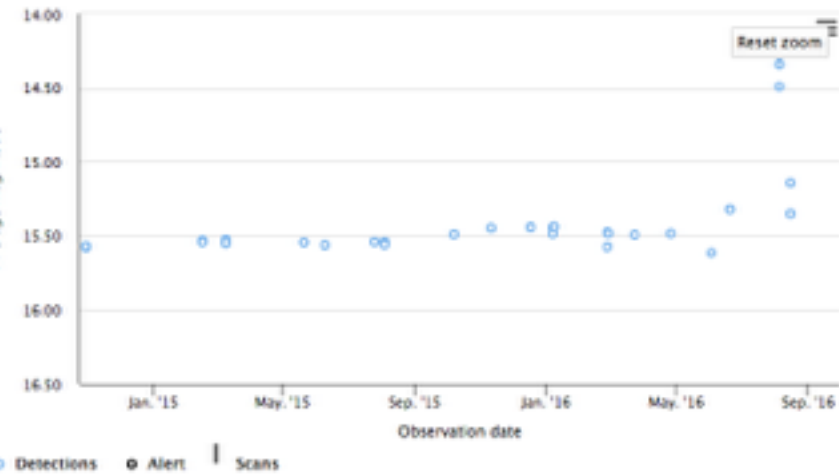
Aug.2016

Binary microlensing event

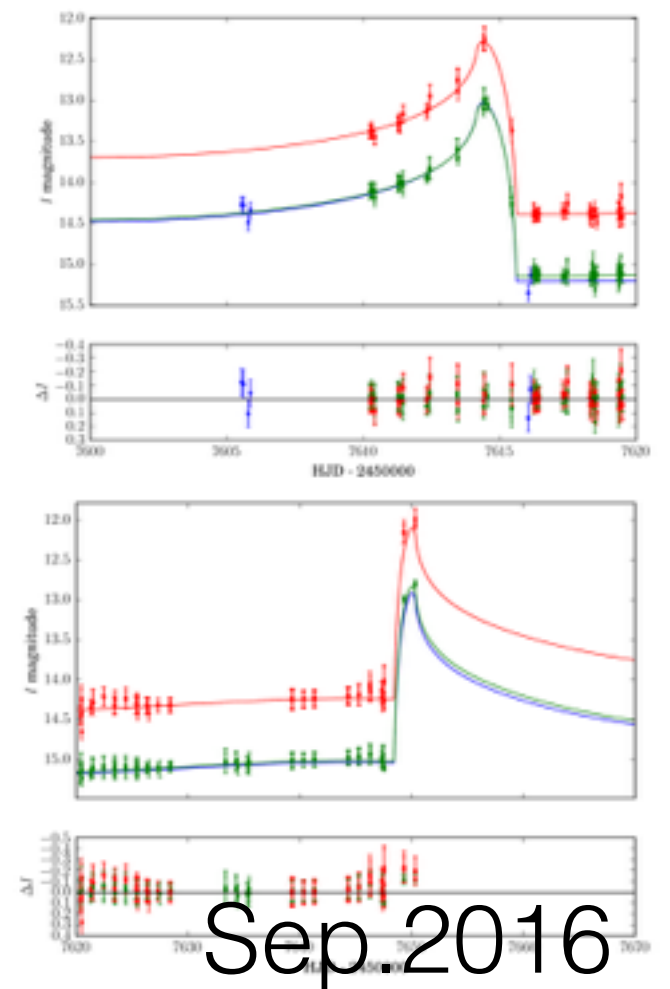
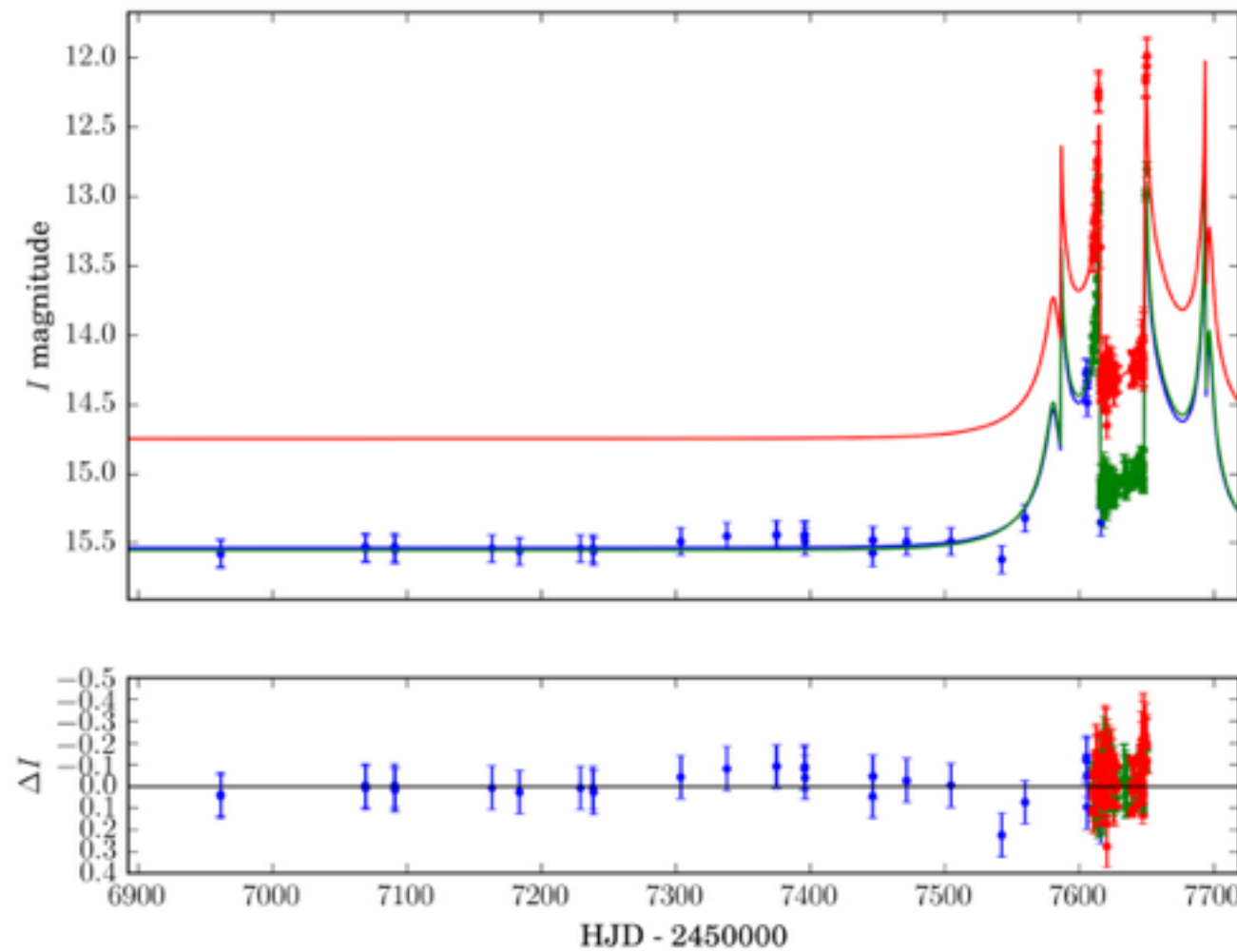


Gaia16aye (Ayers Rock)

Gaia

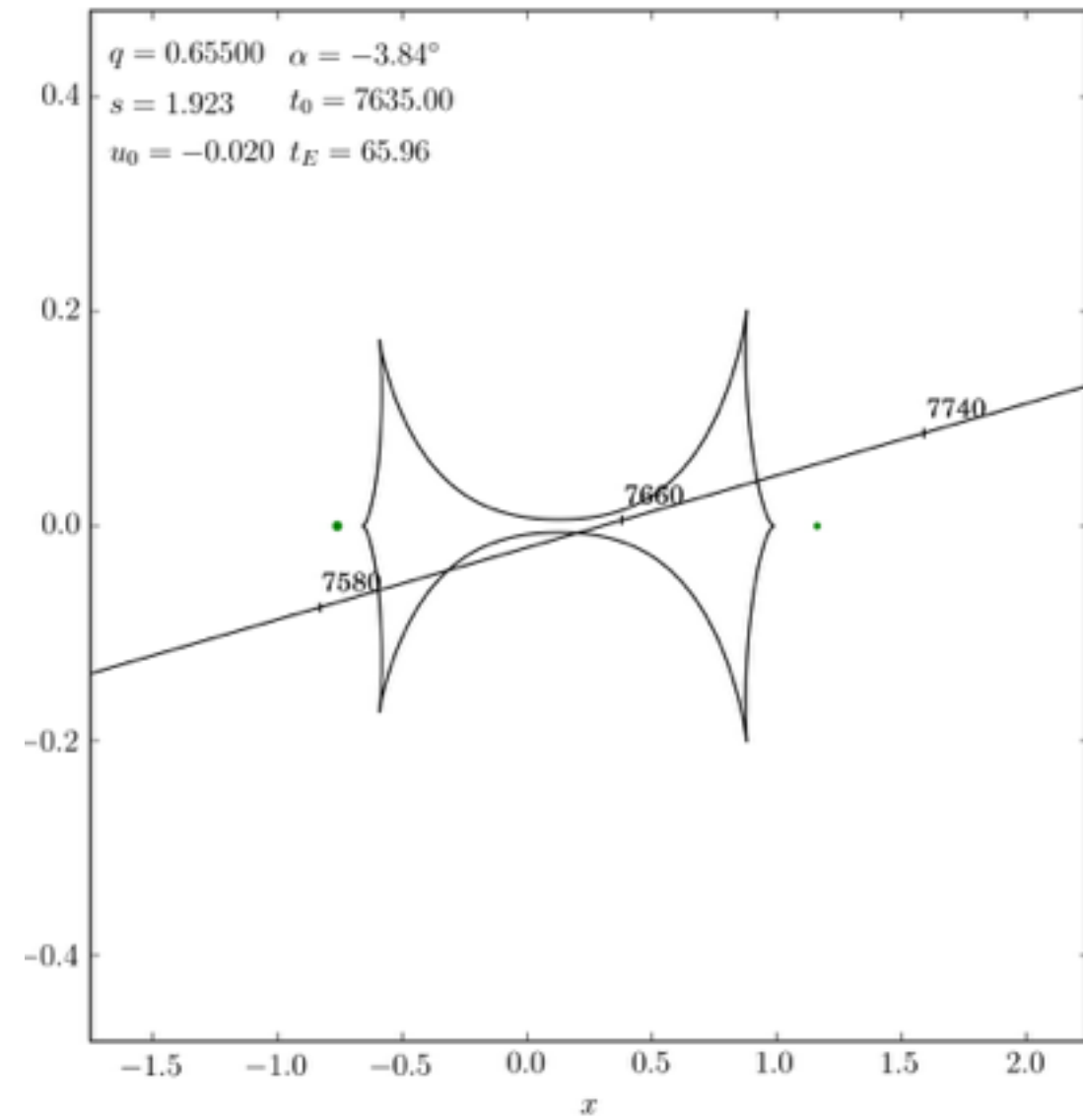
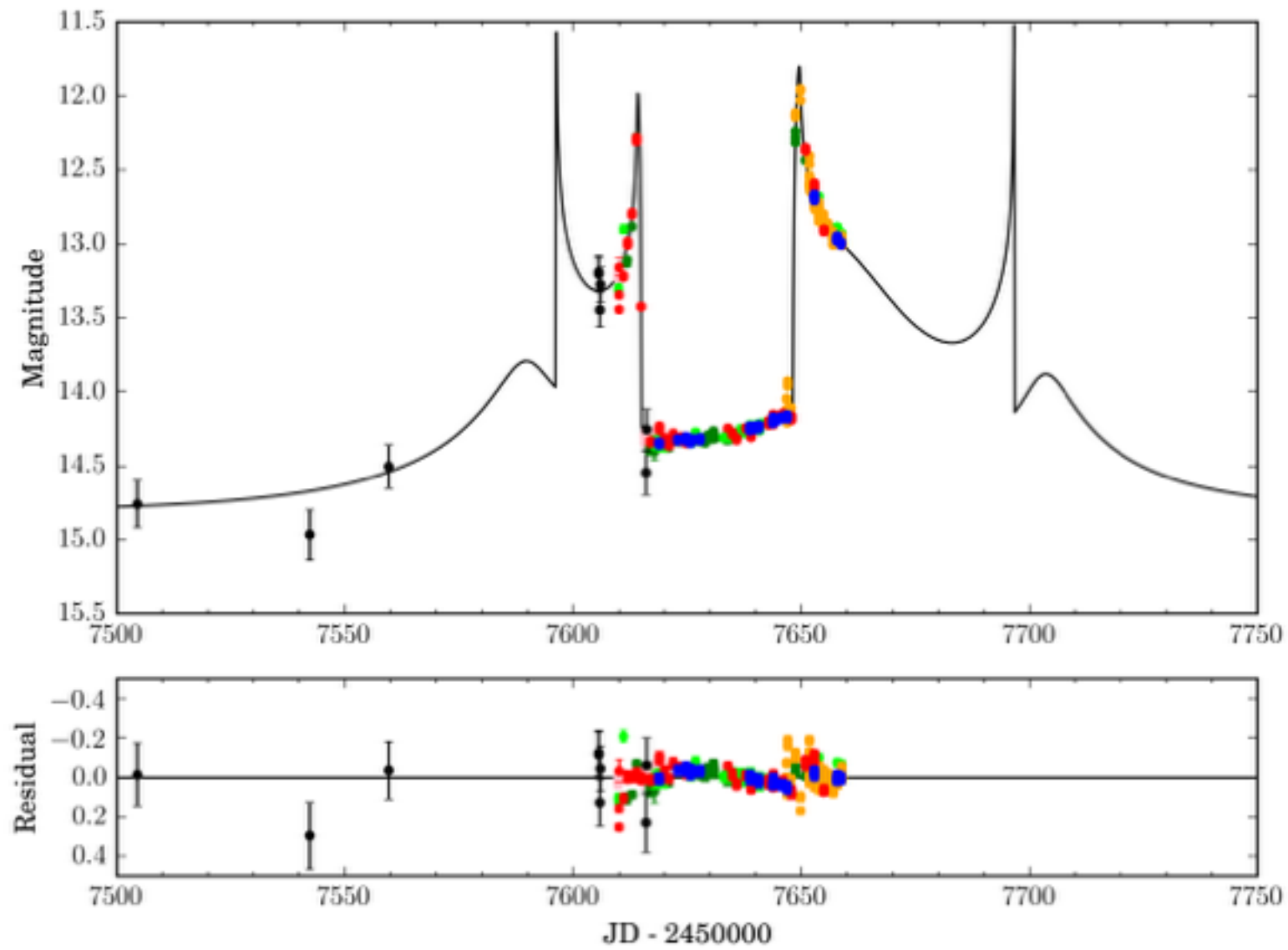


model by P.M.



Sep. 2016

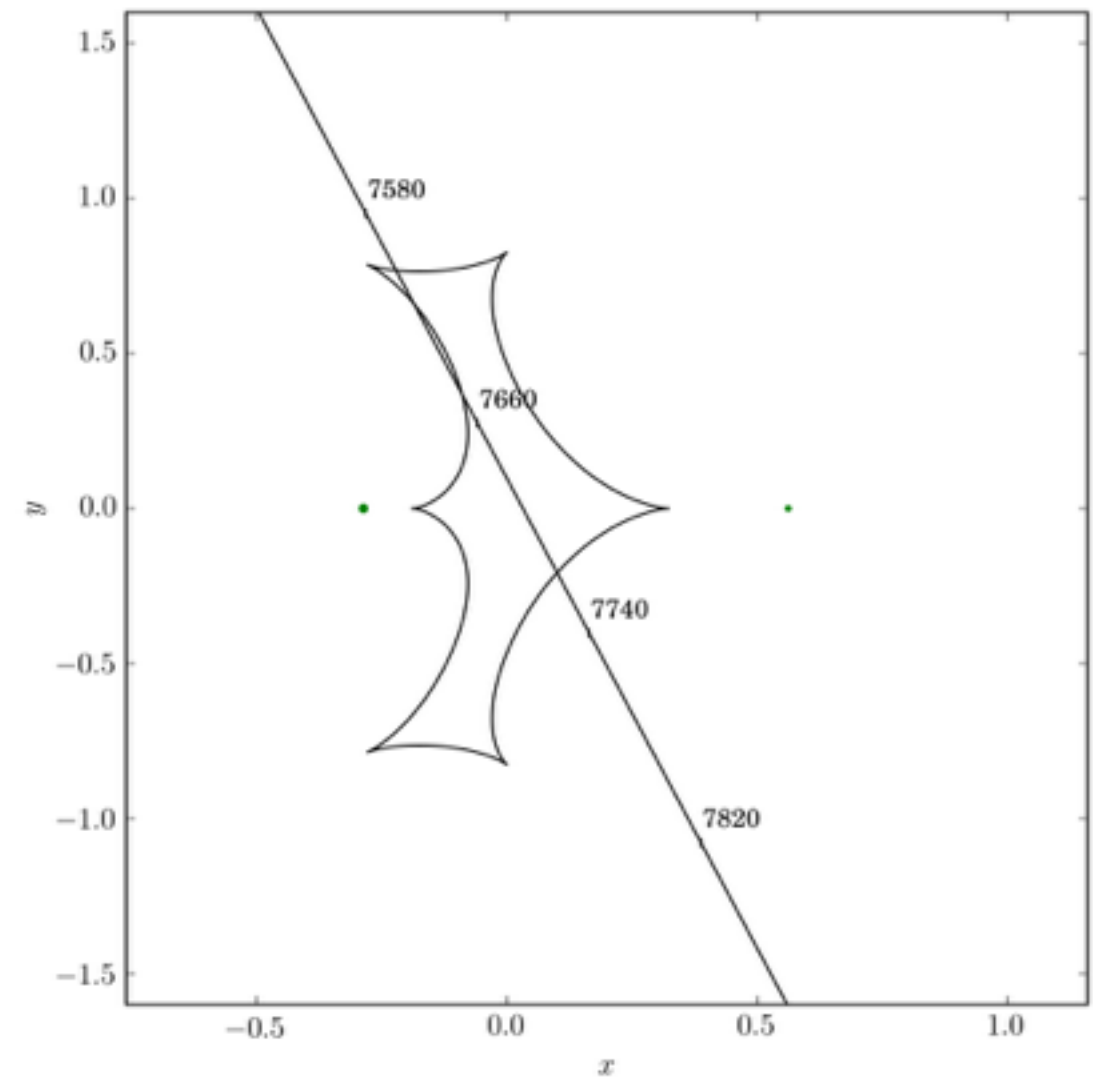
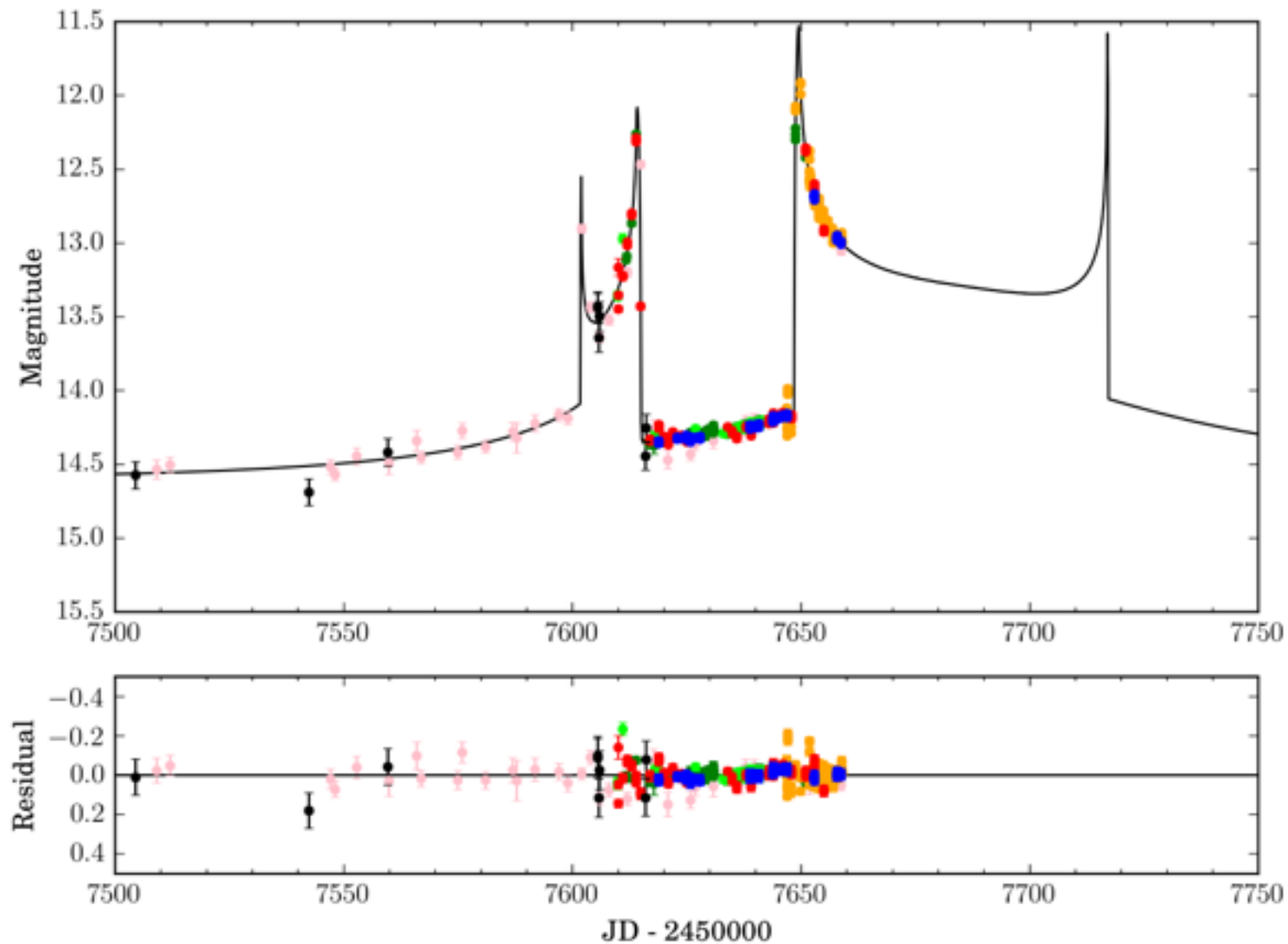
Gaia16aye (Ayers Rock)



models by Przemek Mroz (Warsaw)

29.Sep

Gaia16aye (Ayers Rock)

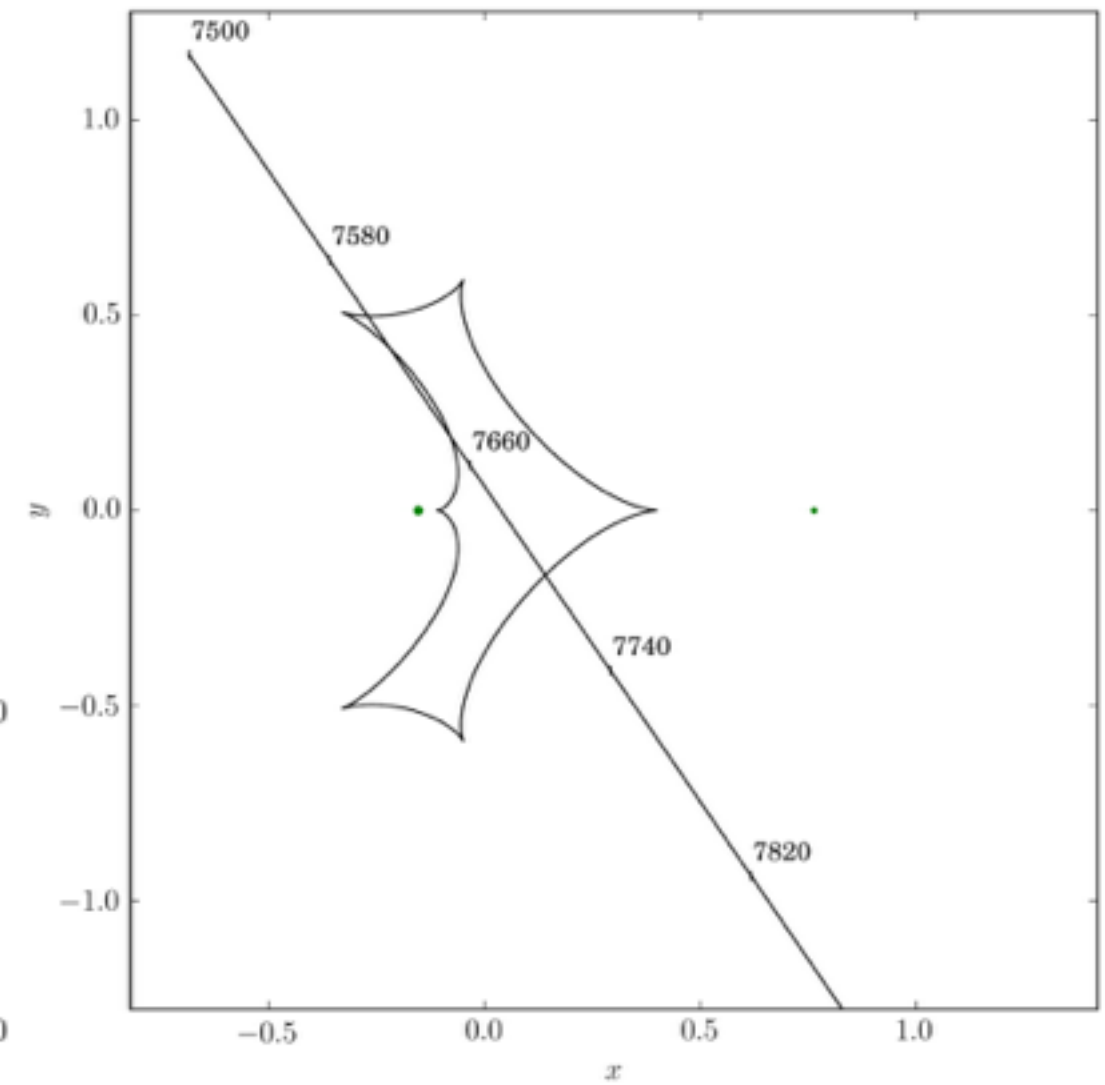
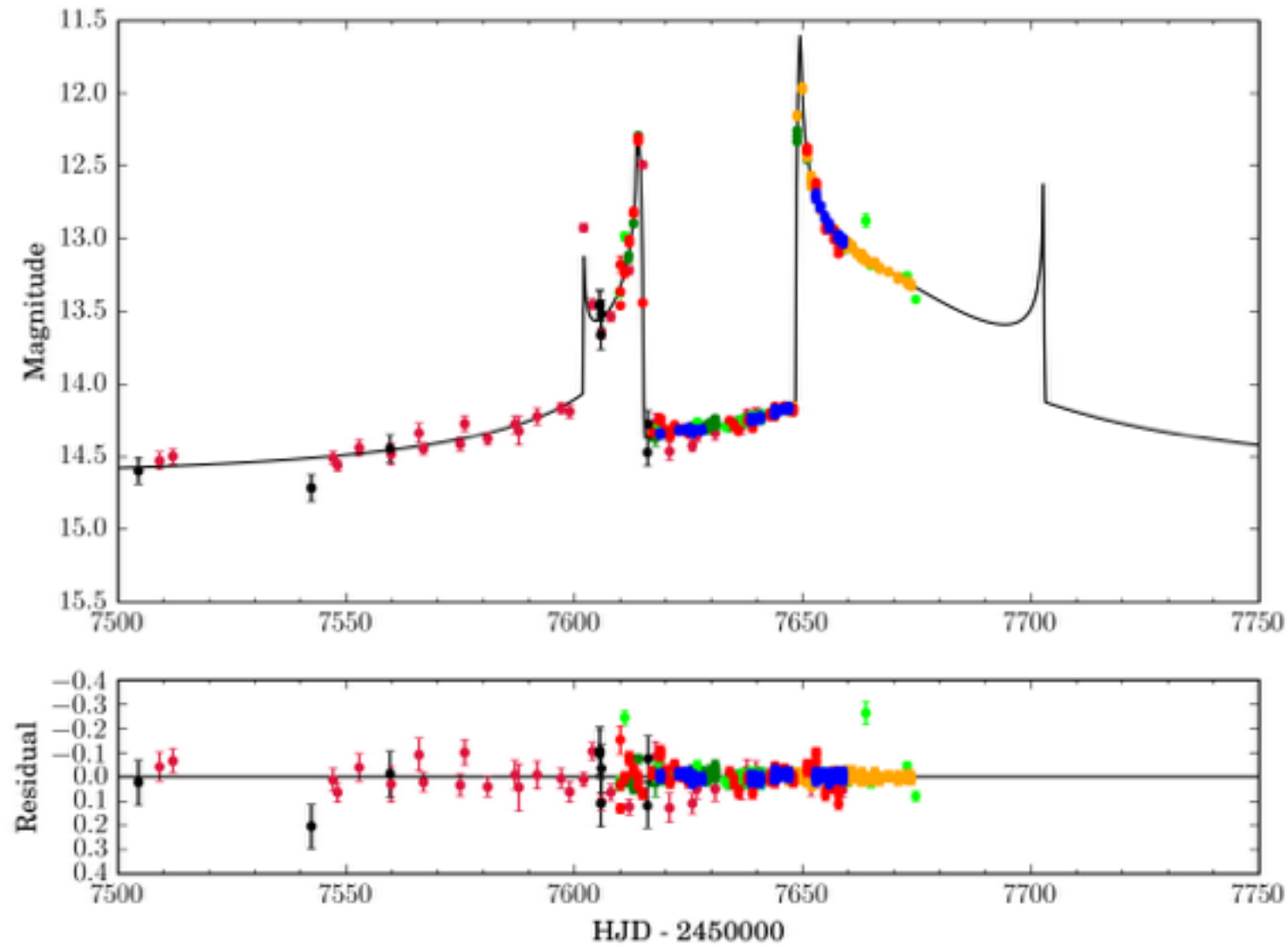


**ASAS-SN in pink, Gaia in black
other follow-up in colours**

model by P.M.

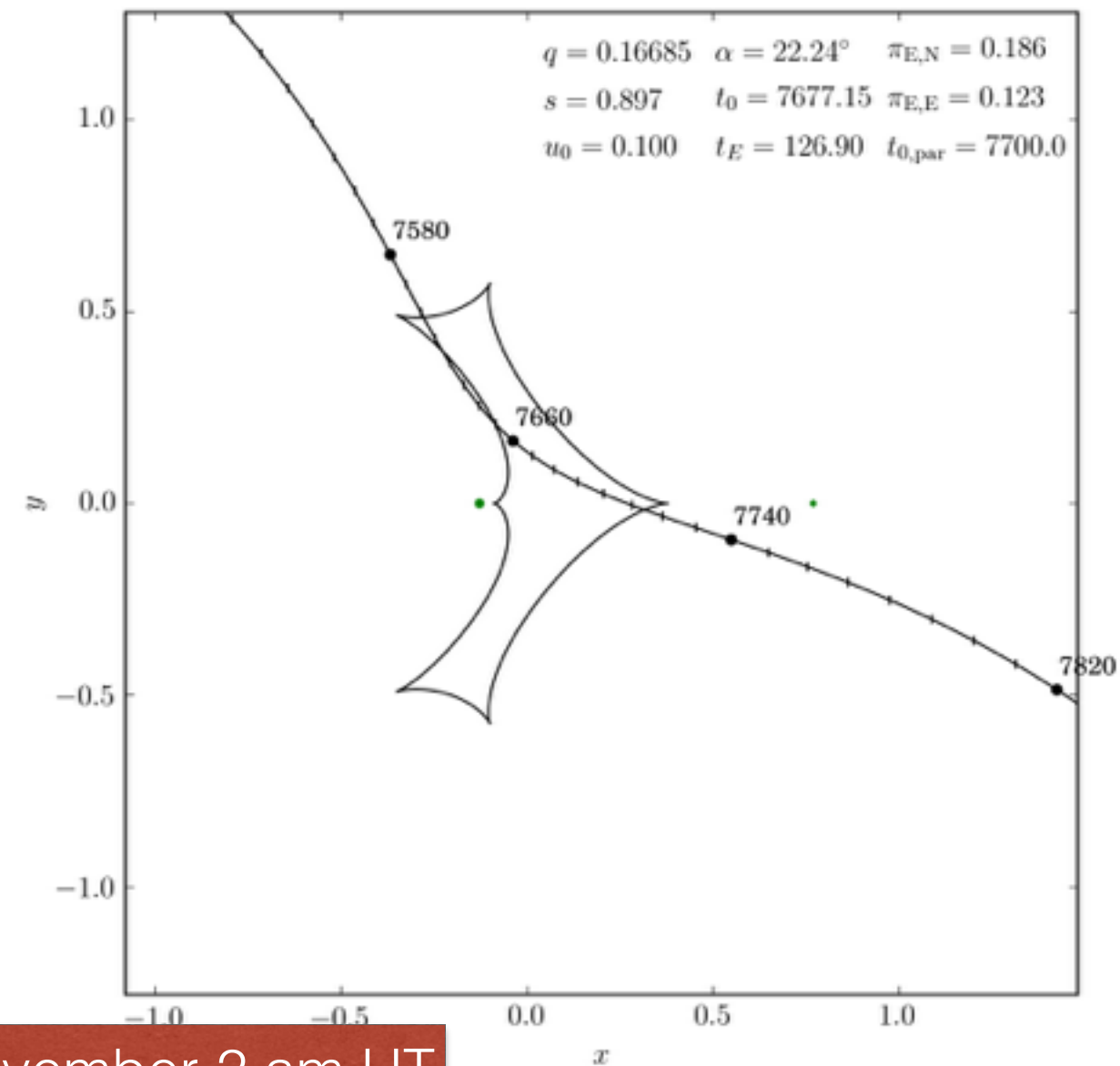
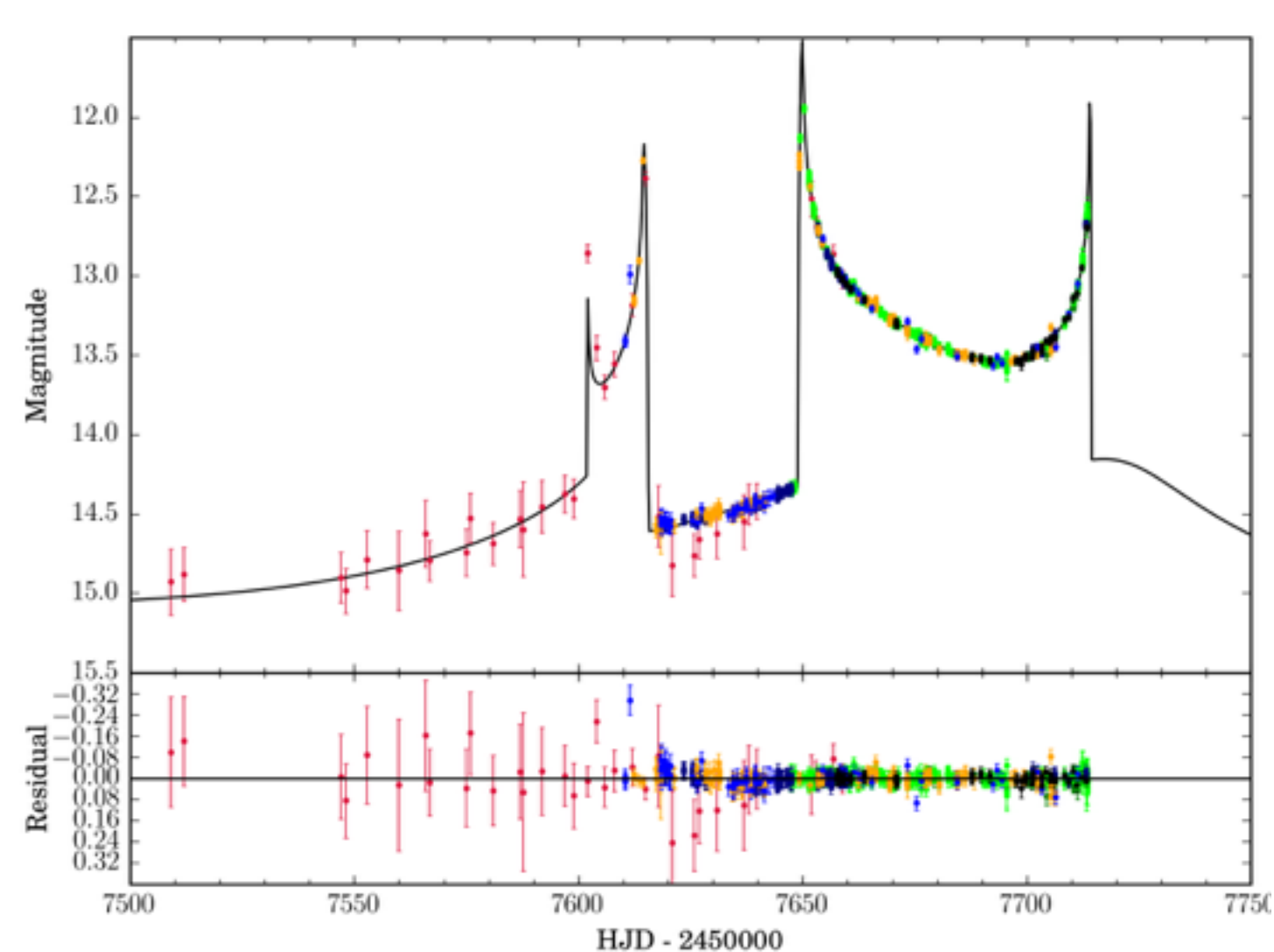
30.Sep

Gaia16aye (Ayers Rock)



Caustic exit ~7.November!

Gaia16aye (Ayers Rock)



Caustic exit 21 November 2 am UT

spectroscopy:

DDT allocations:
WHT/ACAM
INT/IDS
TNG/DOLORES

other:
Liverpool
Asiago
INT/IDS

photometry:

OPTICON-net
AAVSO
LCOGT
friends in US, India, Japan

21.Nov



#Gaia16aye

Kouji Ohnishi 大西浩次 @koujiohnishi · Nov 22 [View translation](#)

#Gaia16aye

はくちょう座のくちばし方向の「連星重力マイクロレンズ現象」
Gaia16aye ただいま、コースティック通過中。

gsaweb.ast.cam.ac.uk/alerts/alert/G...

Lukasz Wyrzykowski @lukasz206265

#Gaia16aye peak data rapidly sent to CPCS
(gsaweb.ast.cam.ac.uk/followup/) by: CrAO, RTT150, Bialkow, Ostrowik, Foligno, UCLO, LT, pt5m. Thanks!

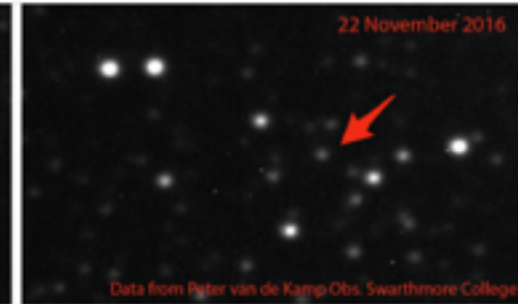
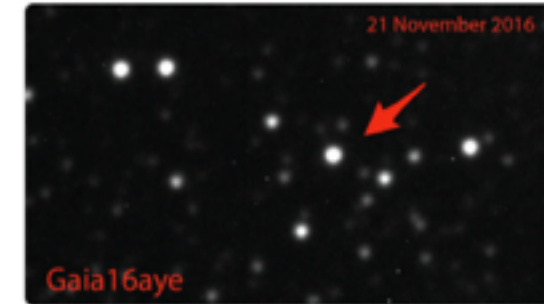
1 4

Simon Hodgkin and 3 others Retweeted

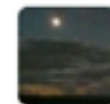


Eric Jensen @elnjensen · Nov 23

What a difference a day makes! **#Gaia16aye** fades dramatically as caustic crossing part of microlensing event ends. **#GaiaMission**



18 15



Daniel Fischer @cosmos4u · Nov 22

Light curve from Turkey could nail down peak time of the final **#Gaia16aye** caustic crossing: astronomerstelegam.org/?read=9780 - 17:54 UTC yesterday.

2 2



Lukasz Wyrzykowski @lukasz206265 · Nov 22

#Gaia16aye magnitude drop by 2.5 from last night - clearly the caustic crossing is over!

1 2 2

Lorraine Hanlon and 1 other liked



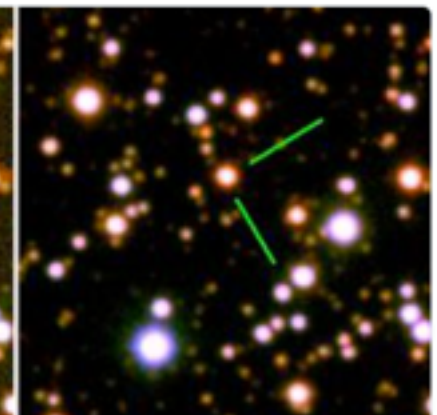
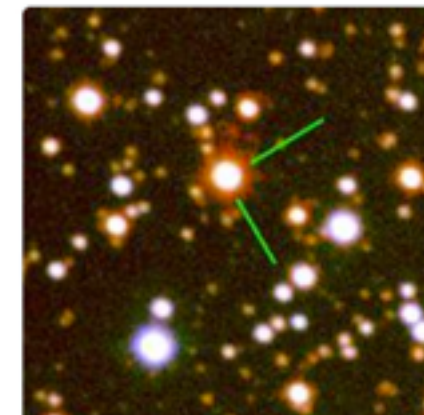
JJ Hermes @jotajotahermes · Nov 22

When global news gets you down, remember we're living in an era where we can



Daniel Fischer @cosmos4u · Nov 27

In Turkey they are celebrating their measurements (astronomerstelegam.org/?read=9780) of **#Gaia16aye**'s final caustic crossing:



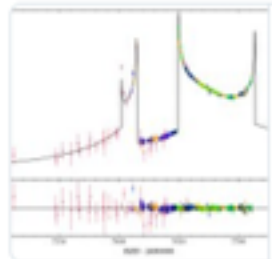
Parlayan yıldızın ışığını TÜBİTAK yakaladı

TÜBİTAK Başkanı Ergin, "TÜBİTAK Ulusal Gözlemevinin, coğrafi konum ve atmosferik koşullarının avantajını kullanarak, Gaia16aye isimli yıldızdan ...
aa.com.tr



ZaubDerSterne.de @ZaubDerSterne · Nov 19

Die (Mikro-)Gravitationslinse **#Gaia16aye** für Amateurlteleskope: abenteuer-astronomie.de/microlensing-i..., himmelslichter.net/update-mikro-g... und



Gaia16aye: Seltenes Microlensing-Ereignis mit Ans...

Zurzeit ereignet sich im Schwan nahe des hellen Sterns phi Cyg ein spektakuläres Himmelsphänomen. Das Microlensing-Ereignis Gaia16aye (Spitzname Ayers Ro...
zauberdersterne.wordpress.com

2 2

Gaia-GOSA and 2 others follow



Jan Hattenbach @JanHattenbach · Nov 19

Morgen abend gibt's Gravitationslinse: himmelslichter.net/update-mikro-g...
#Gaia16aye



Update: Mikro-Gravitationslinse Gaia16aye soll Son...

Ein neues Modell sagt das vierte und letzte Aufleuchten der Mikro-Gravitationslinse Gaia16aye für Sonntag, den 20. November kurz vor 22 Uhr MEZ (20,8 UT) voraus. ...
himmelslichter.net

1 6 3

Jos de Bruijne Retweeted

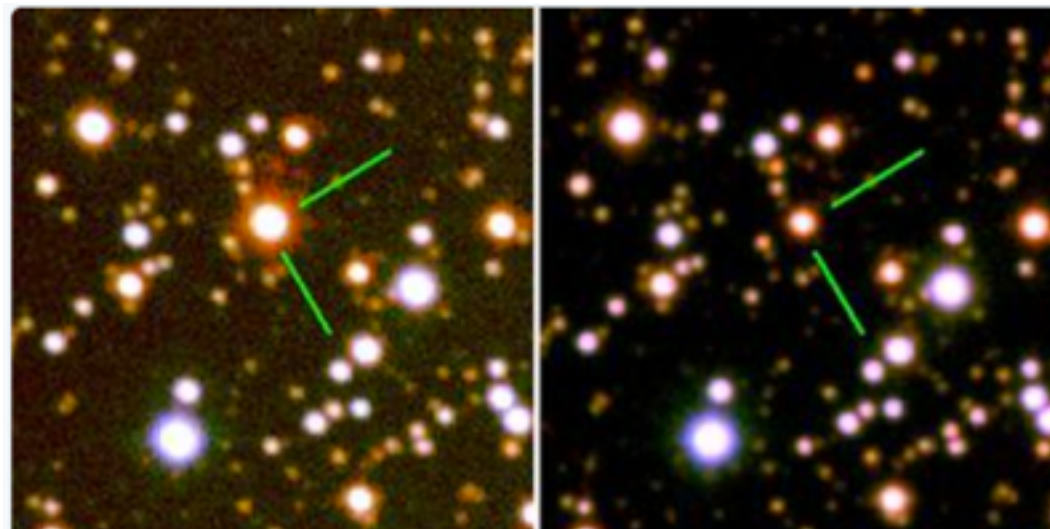
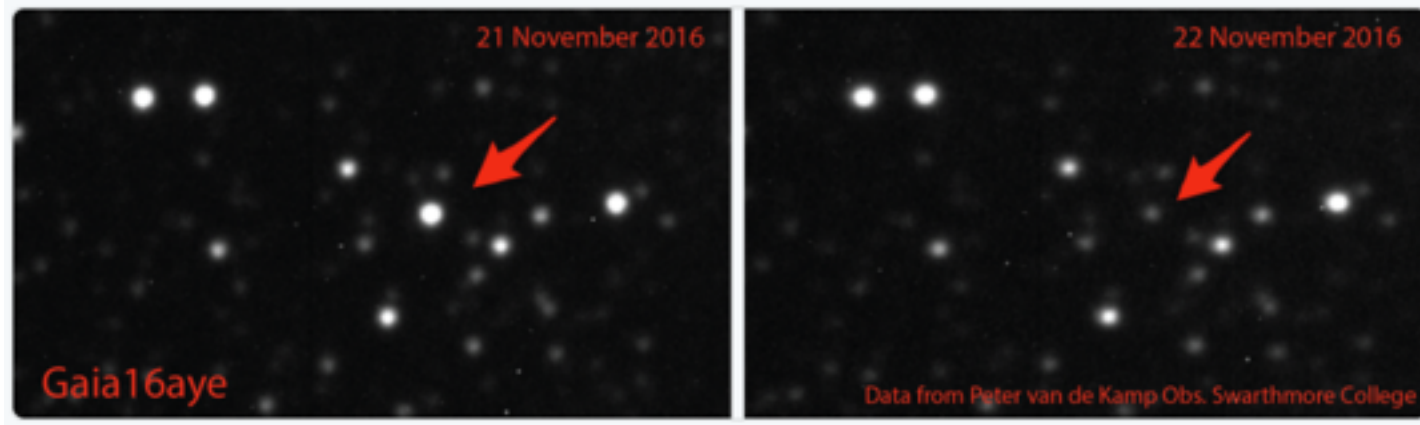


Jan Hattenbach @JanHattenbach · Nov 18

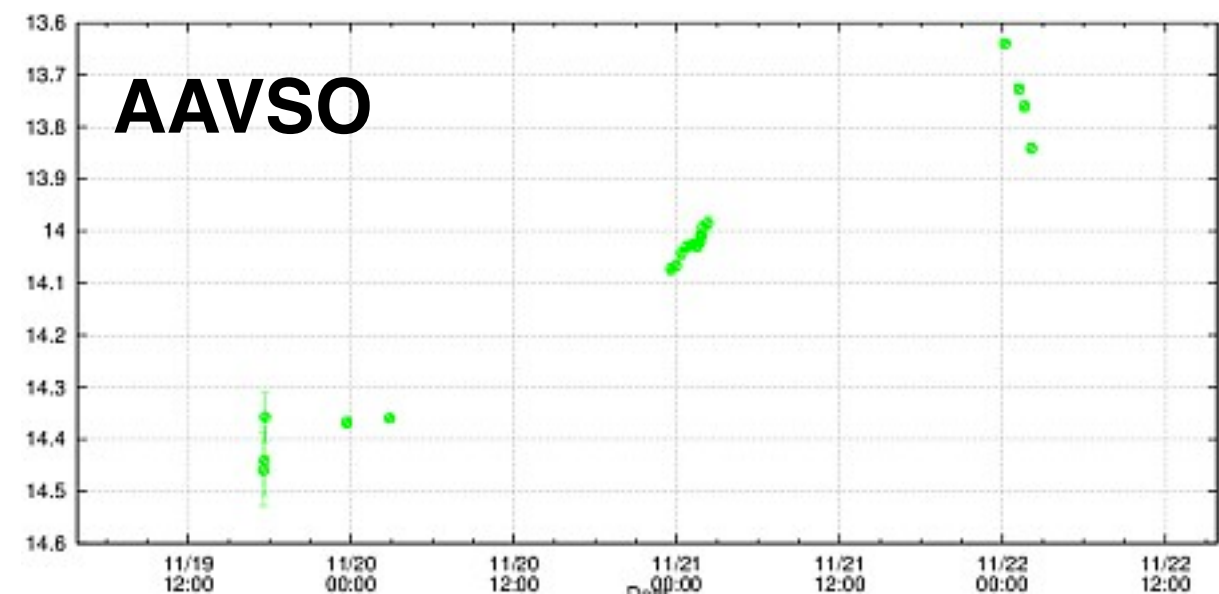
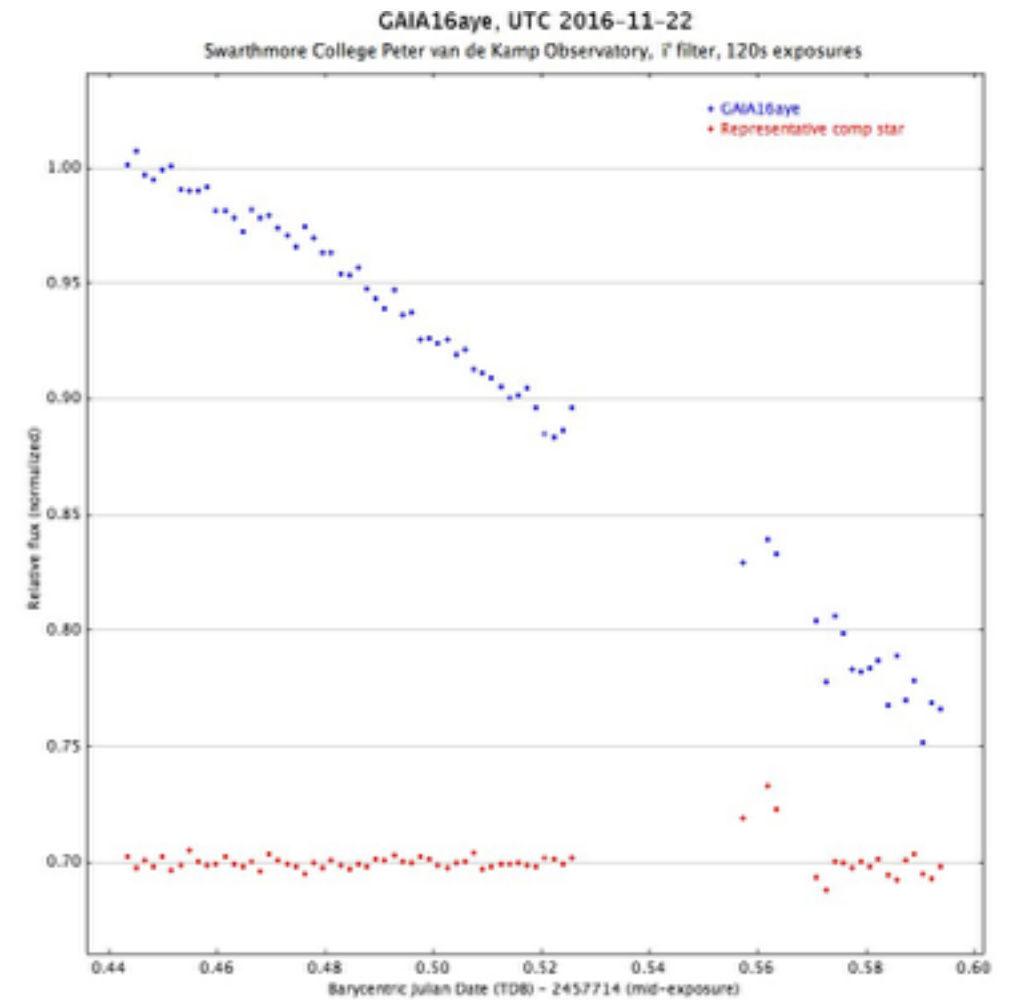
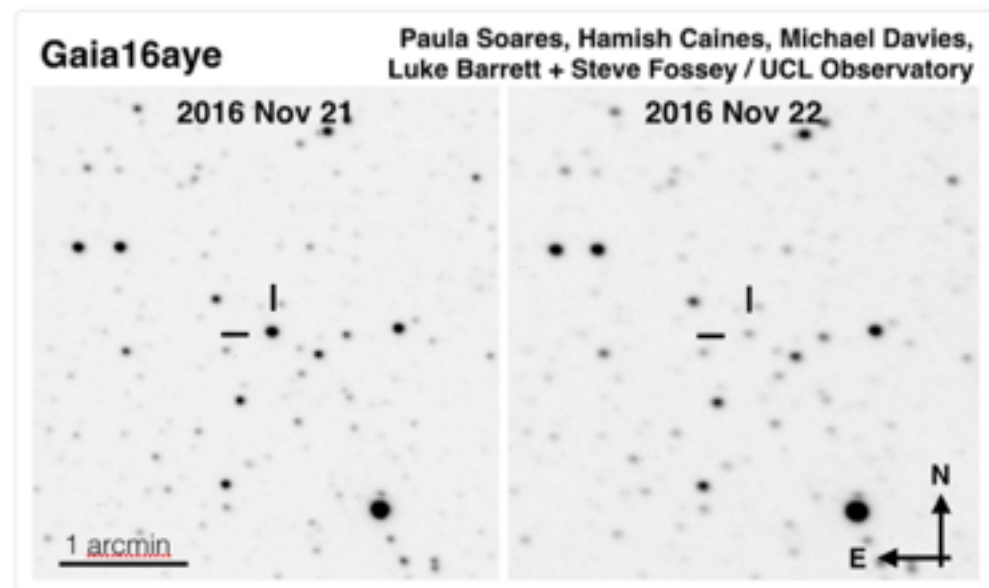
Binärv microlensina model predicts 4th & final caustic crossing of **#Gaia16aye**

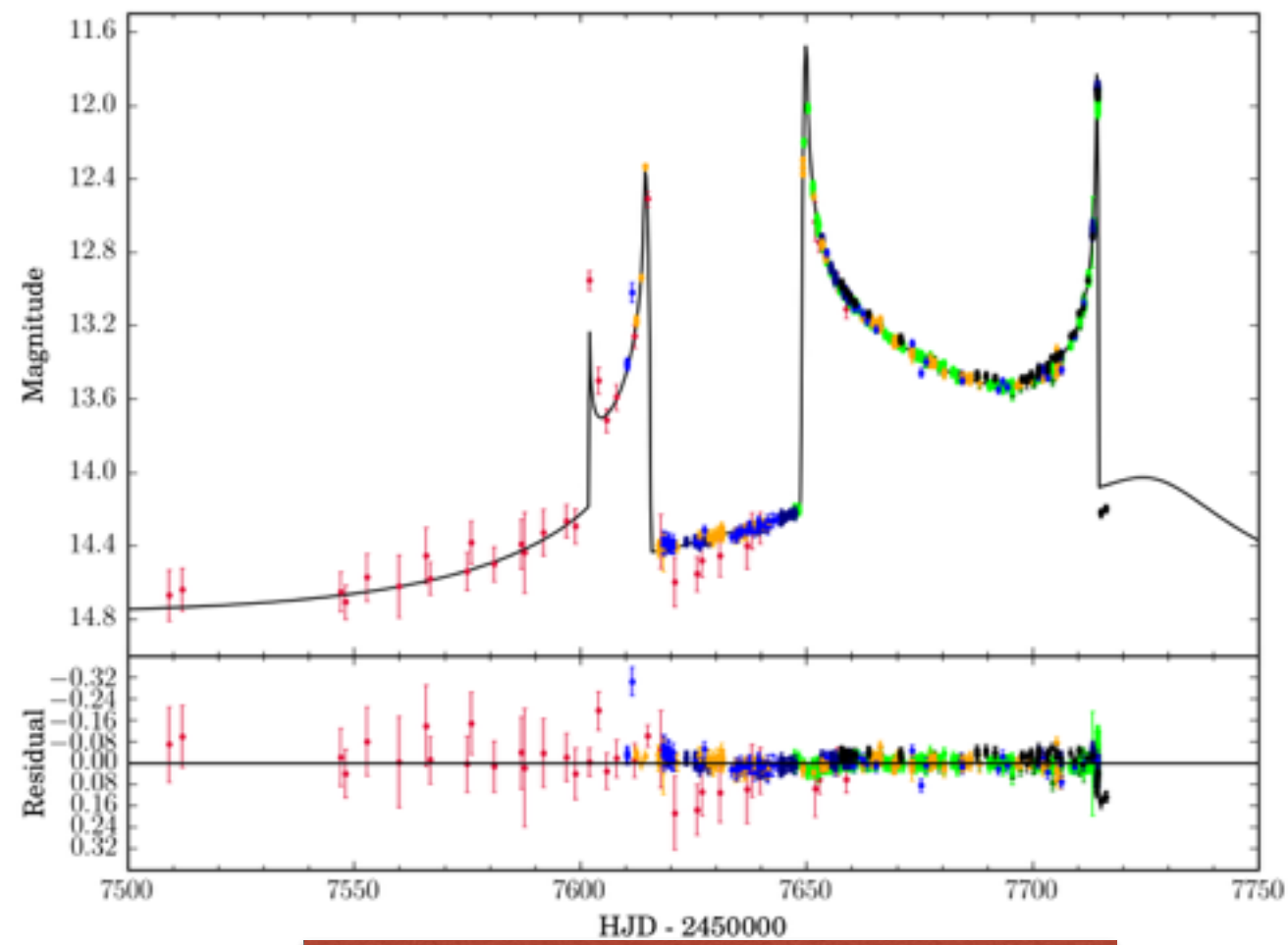


#Gaia16aye

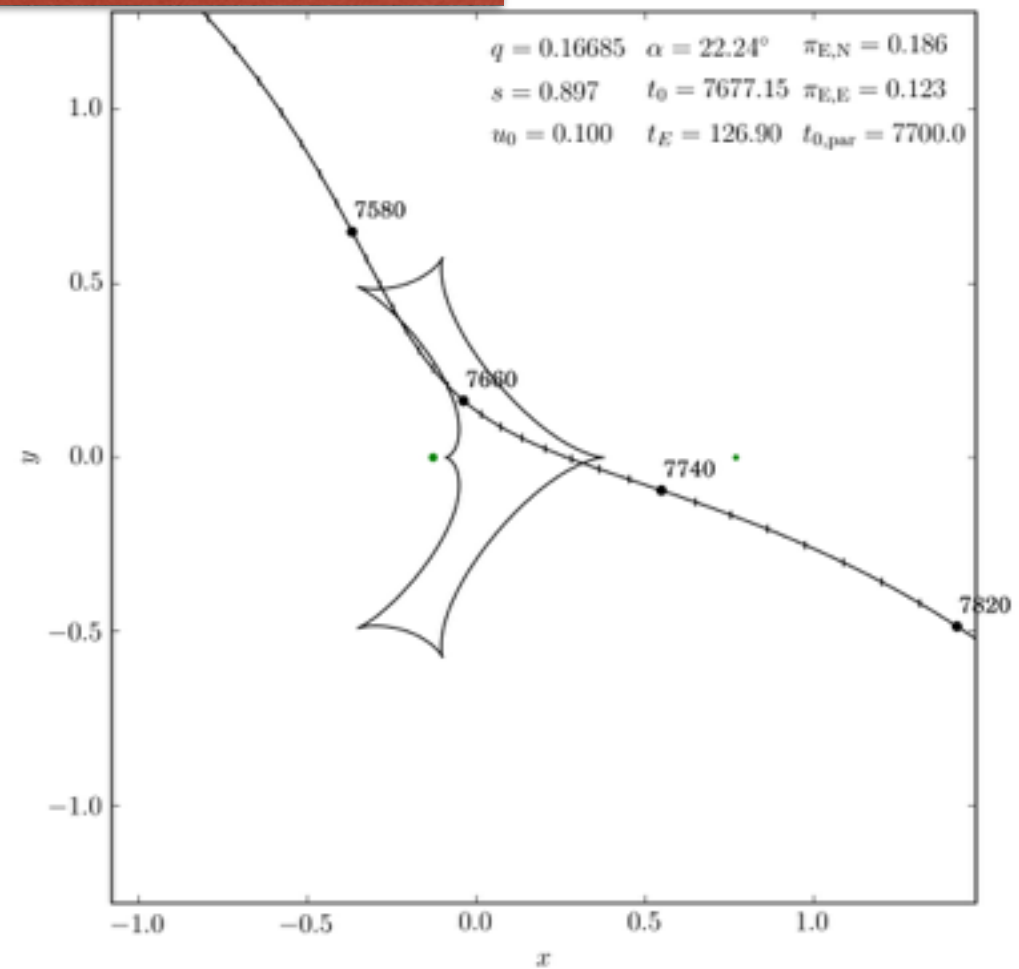
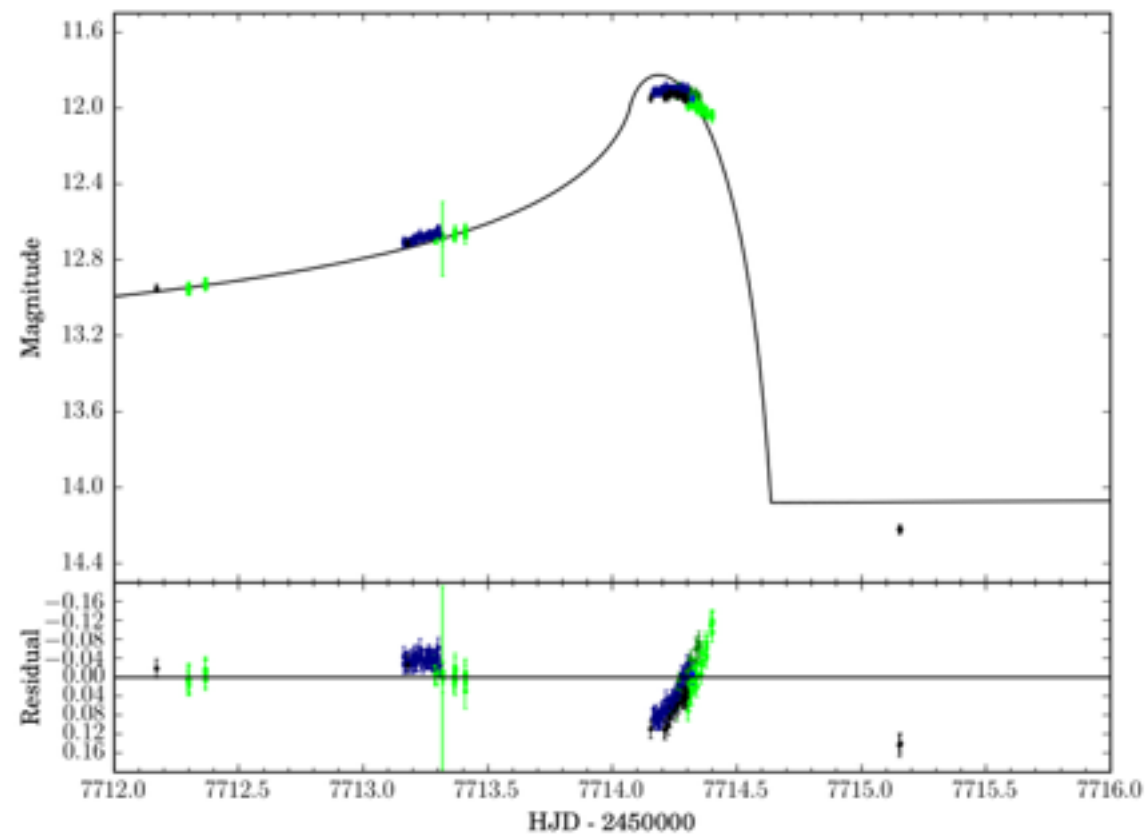


Parlayan yıldızın ışığını TÜBİTAK yakaladı

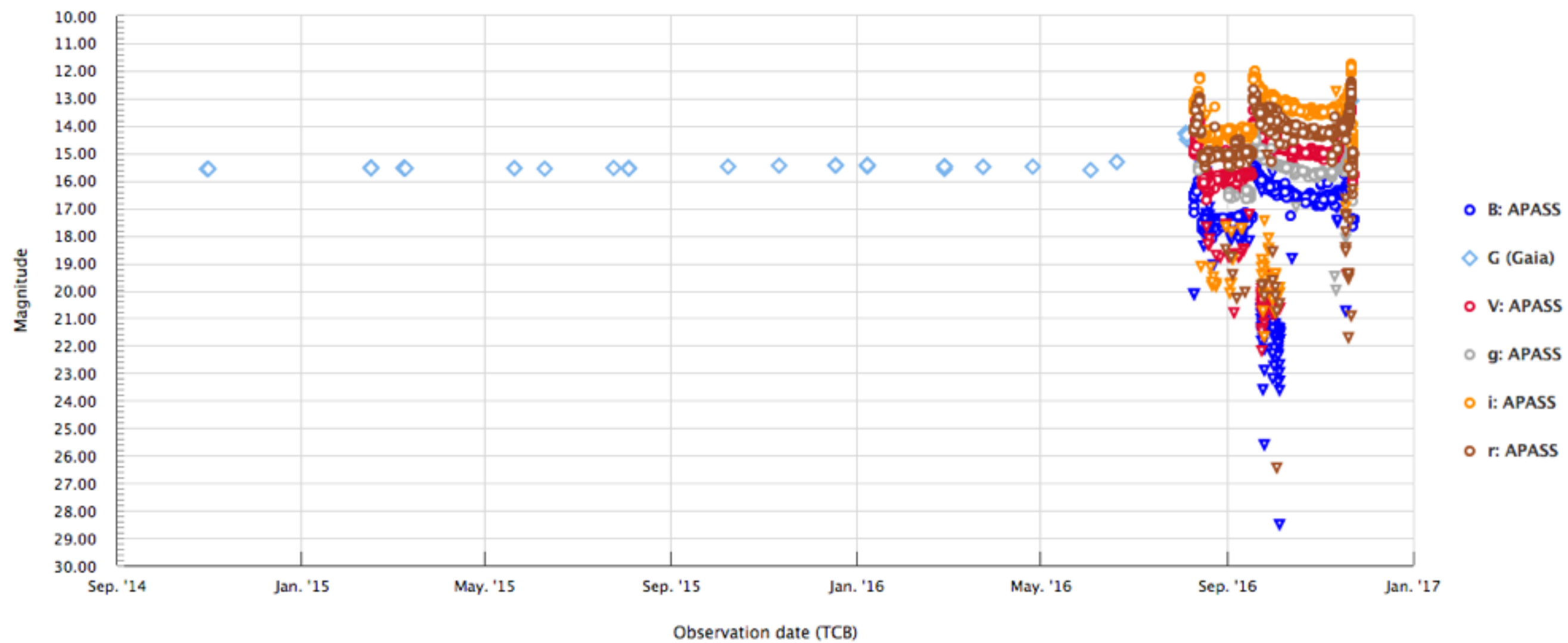


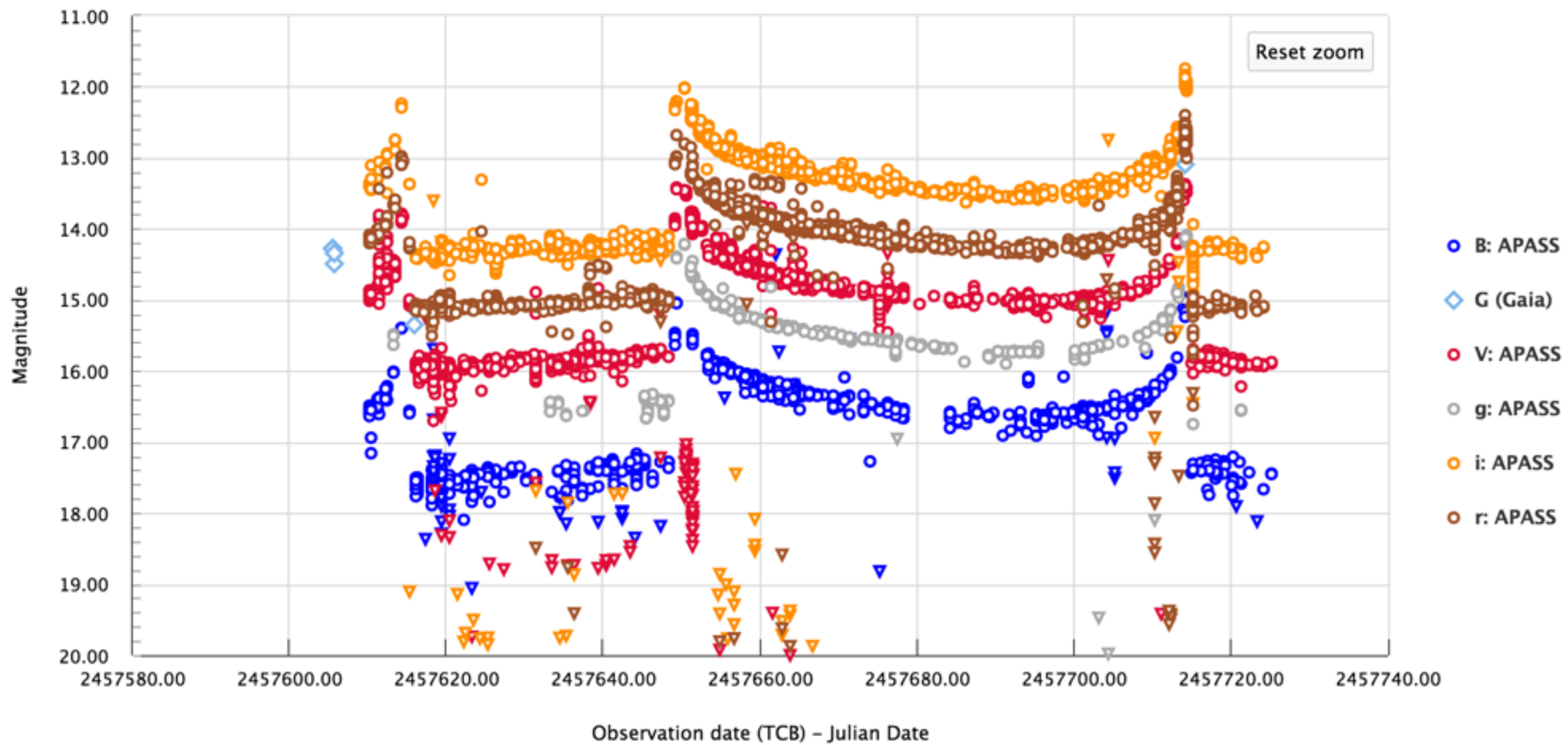


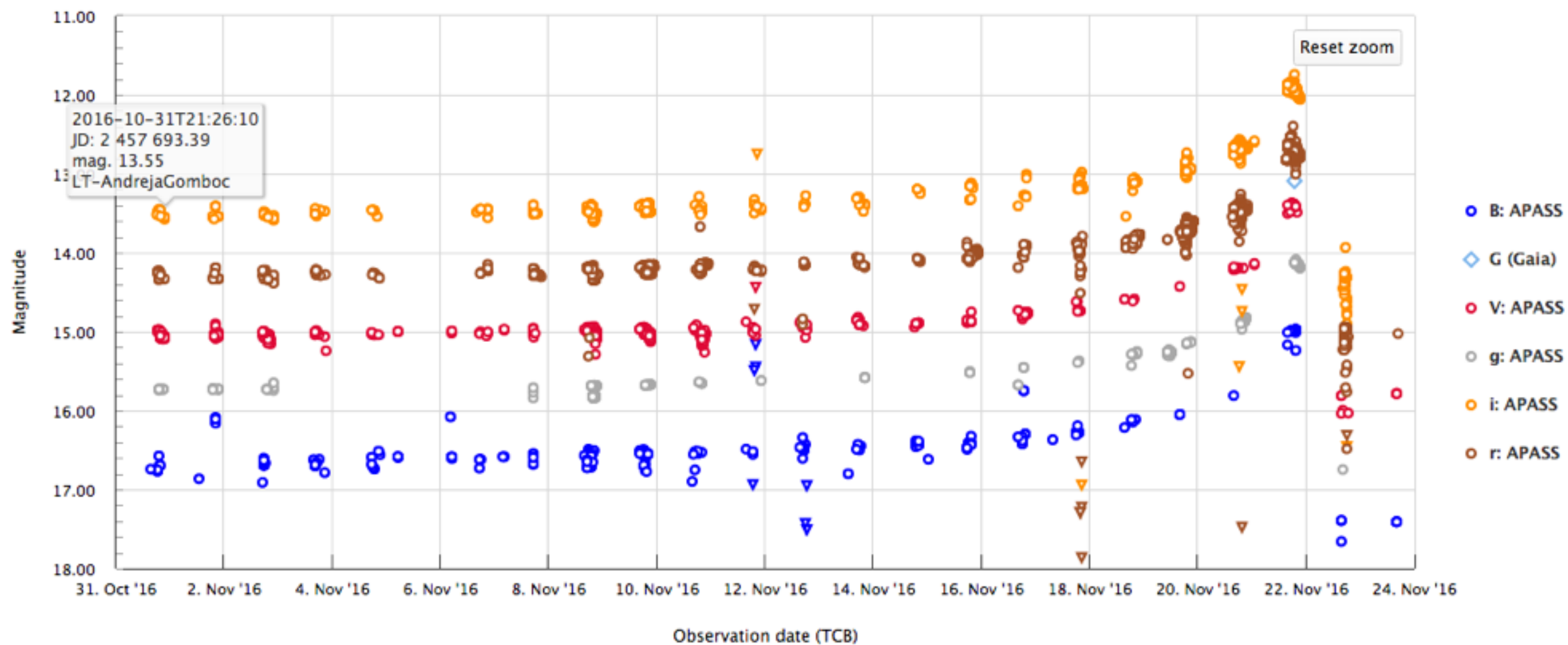
actual peak: 21 Nov ~16 UT

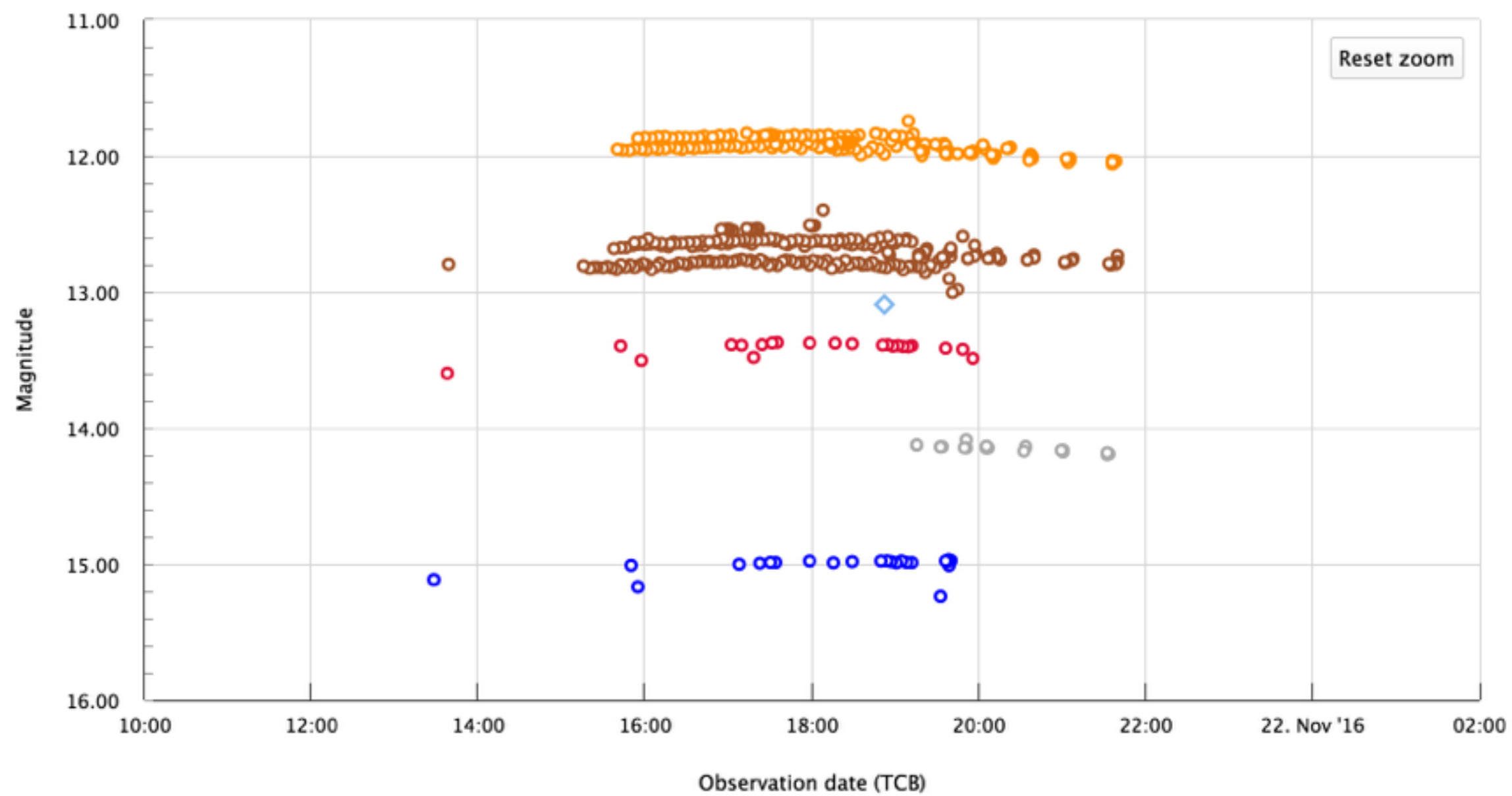


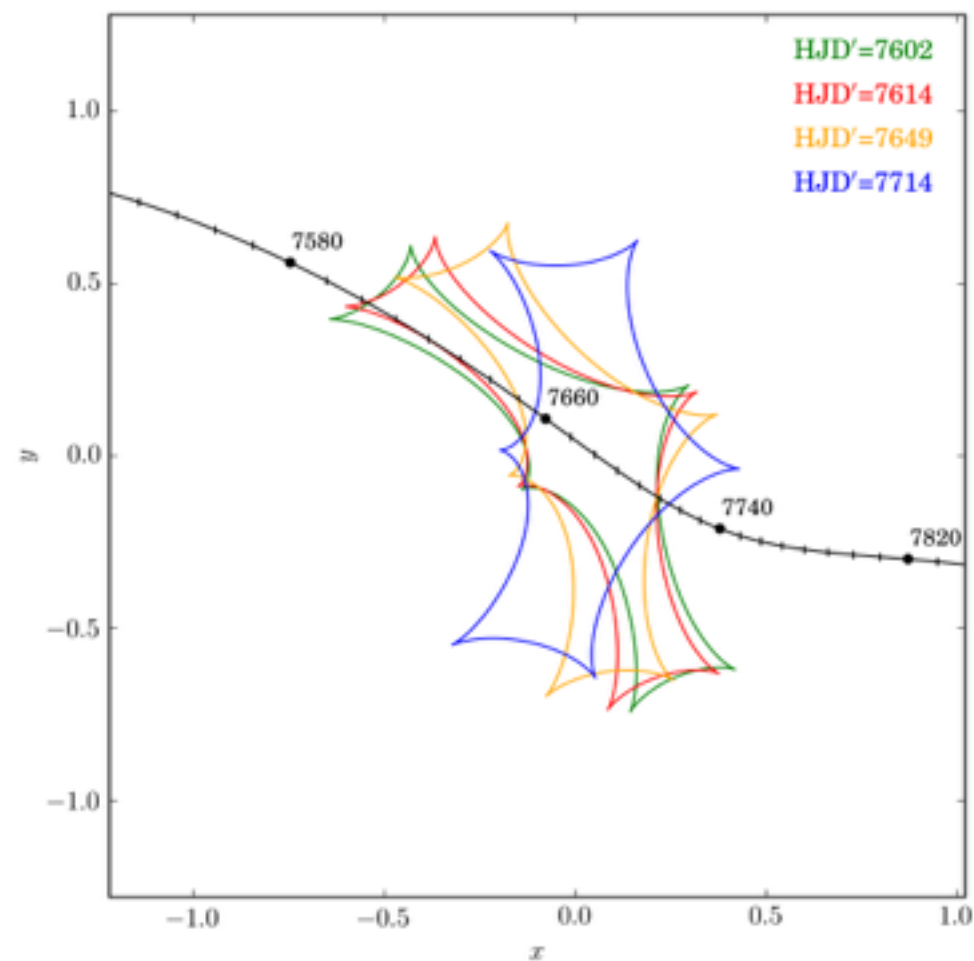
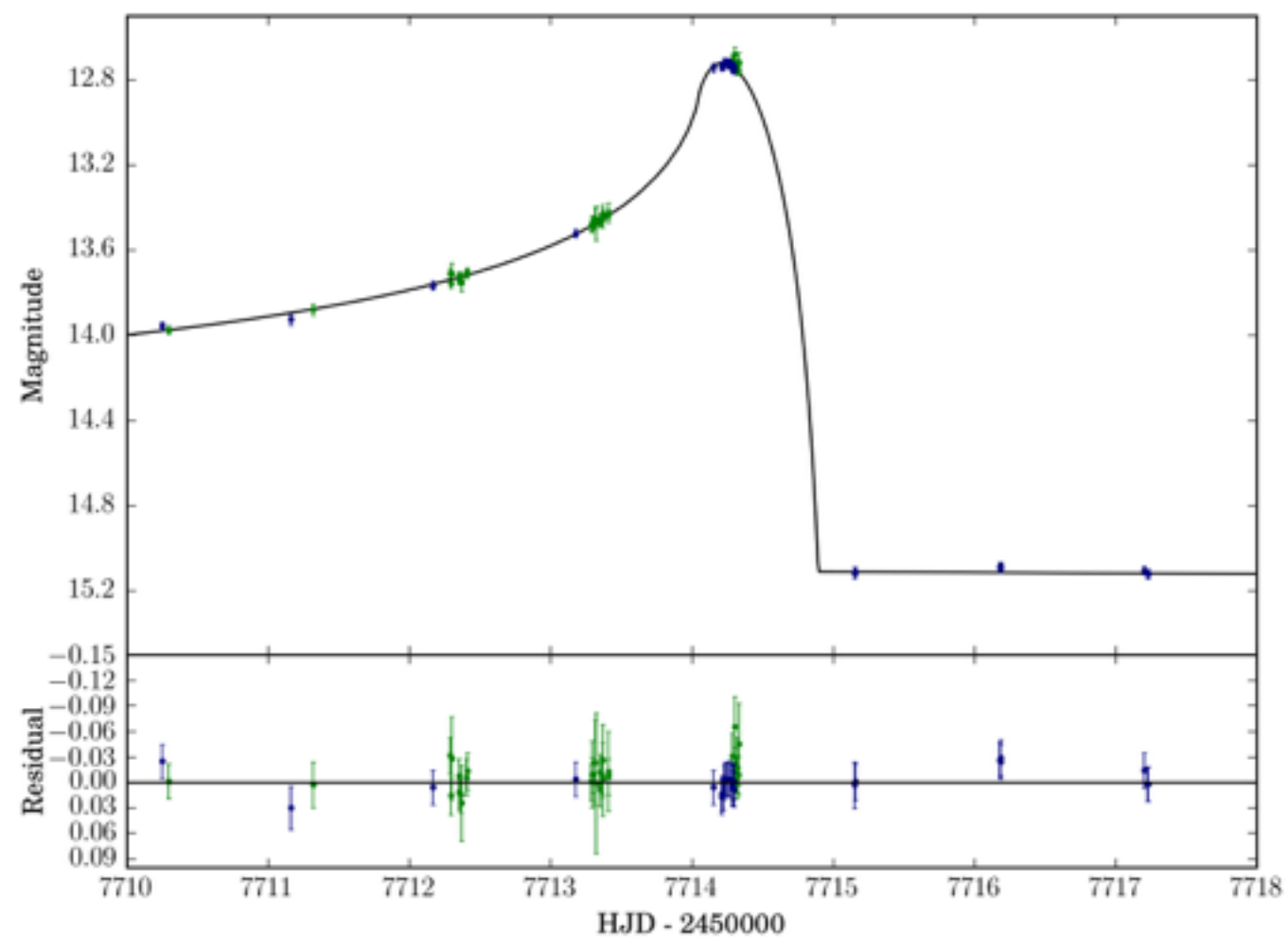
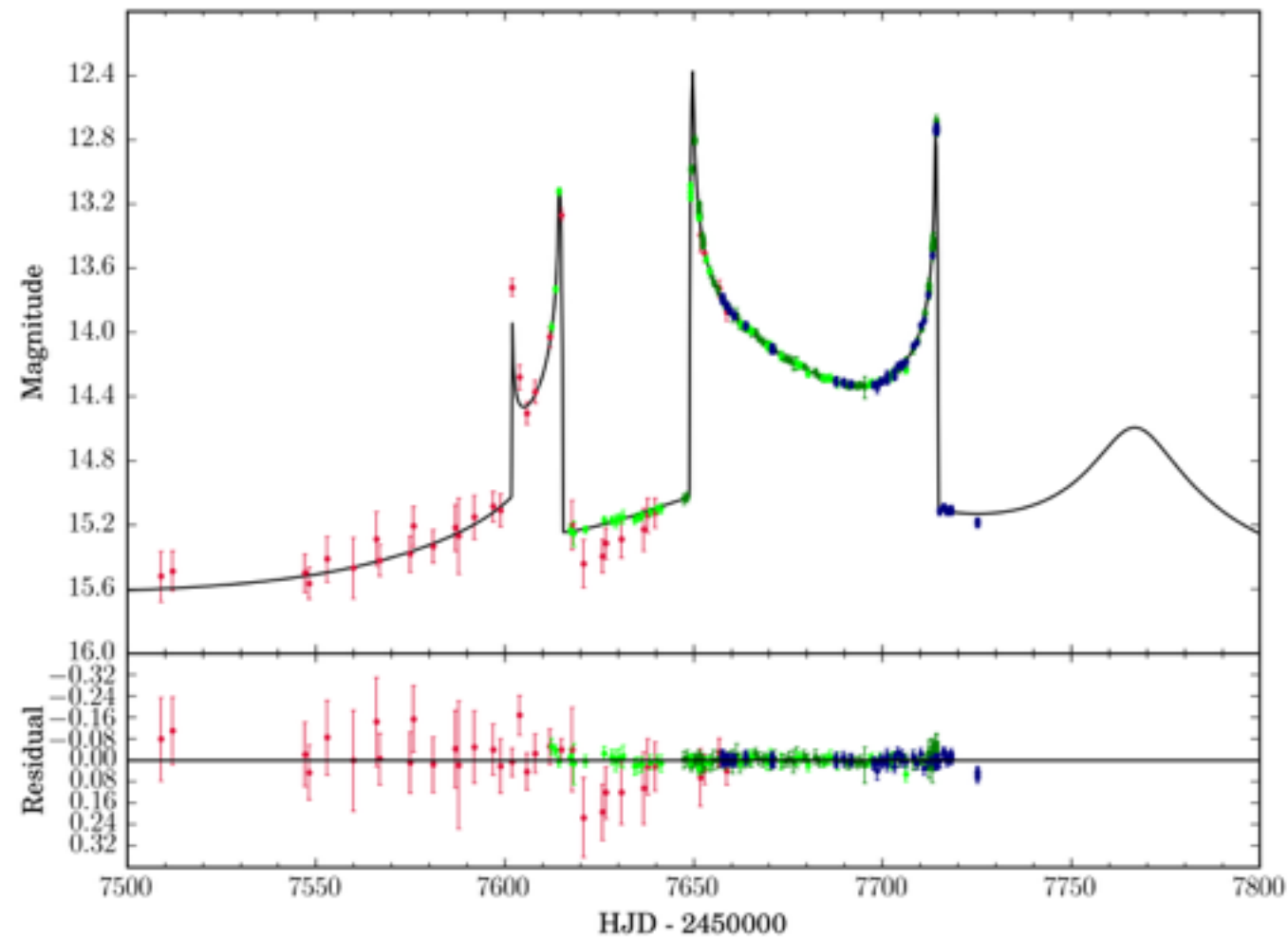
21.Nov









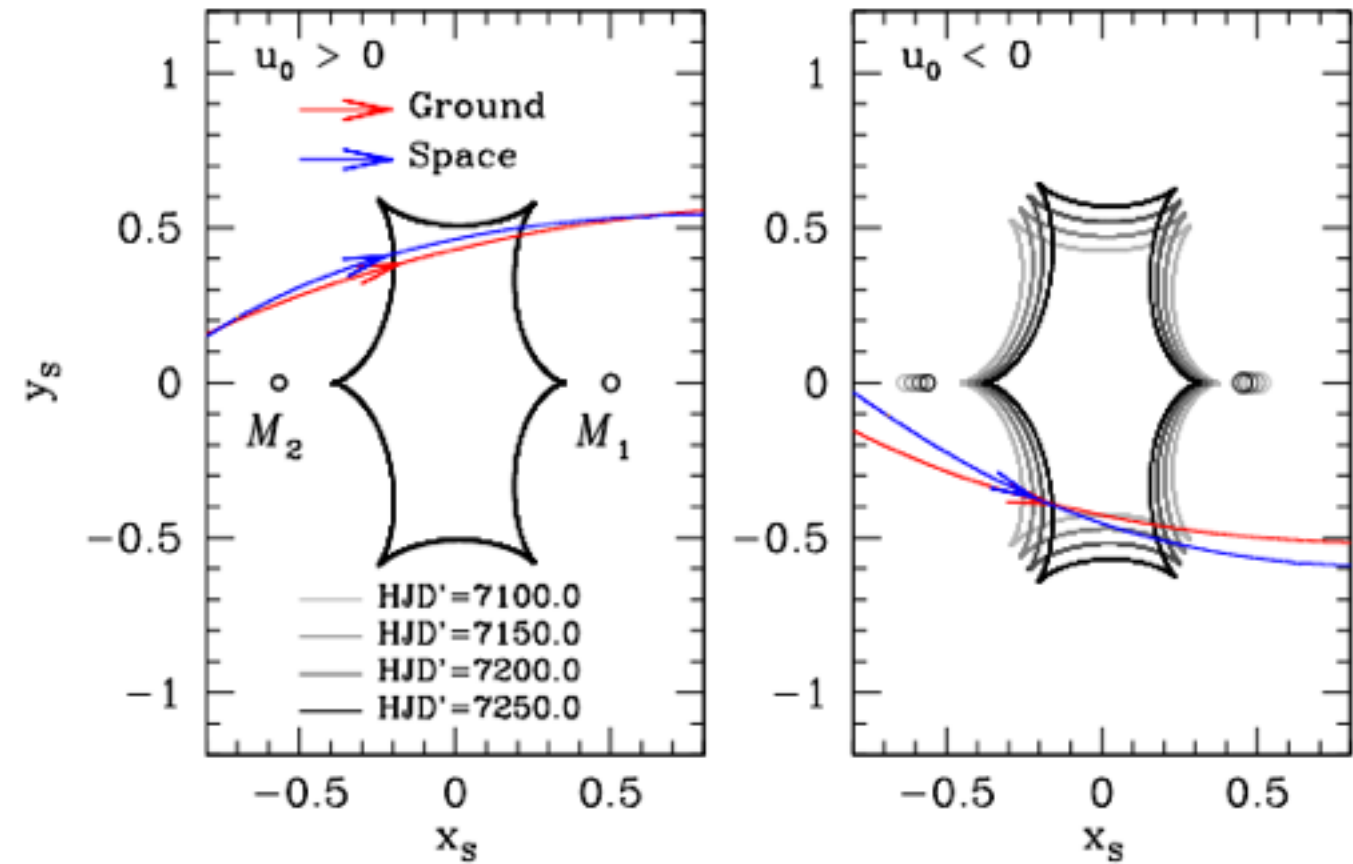
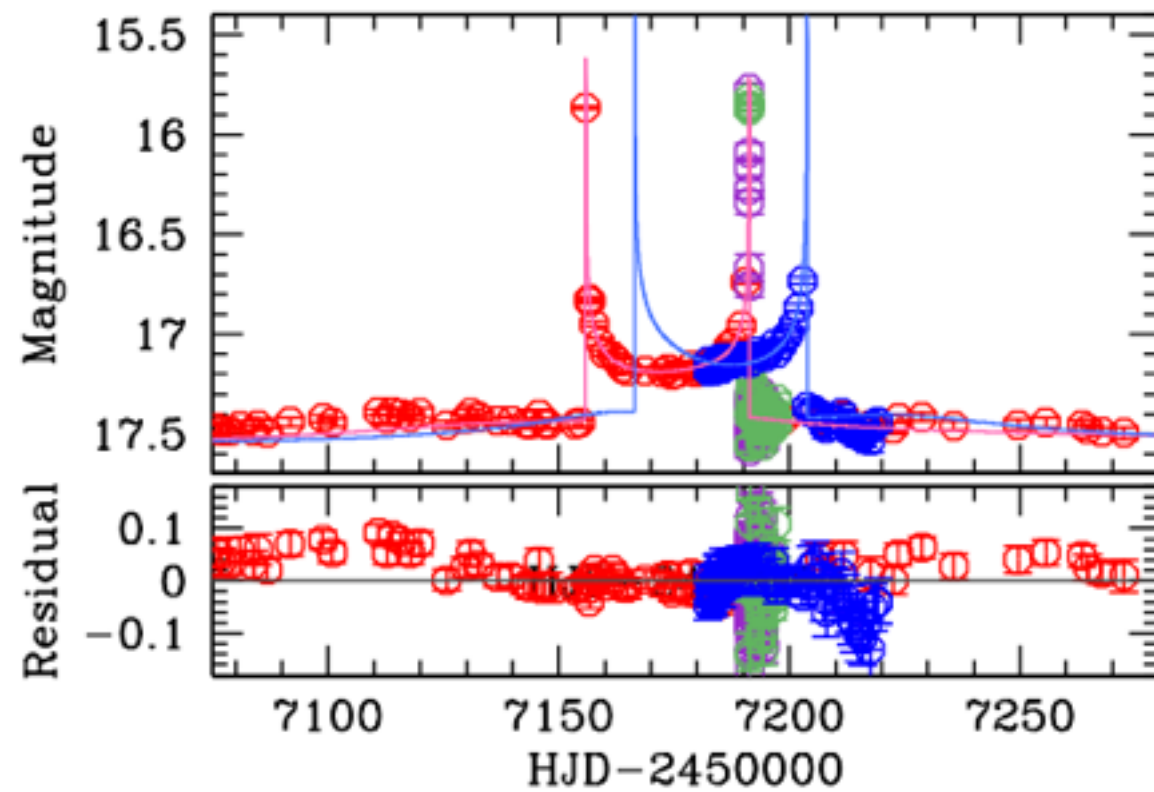


latest model,
includes orbital motion
of the binary lens

5.Dec

Space parallax

OGLE-2015-BLG-0479A,B



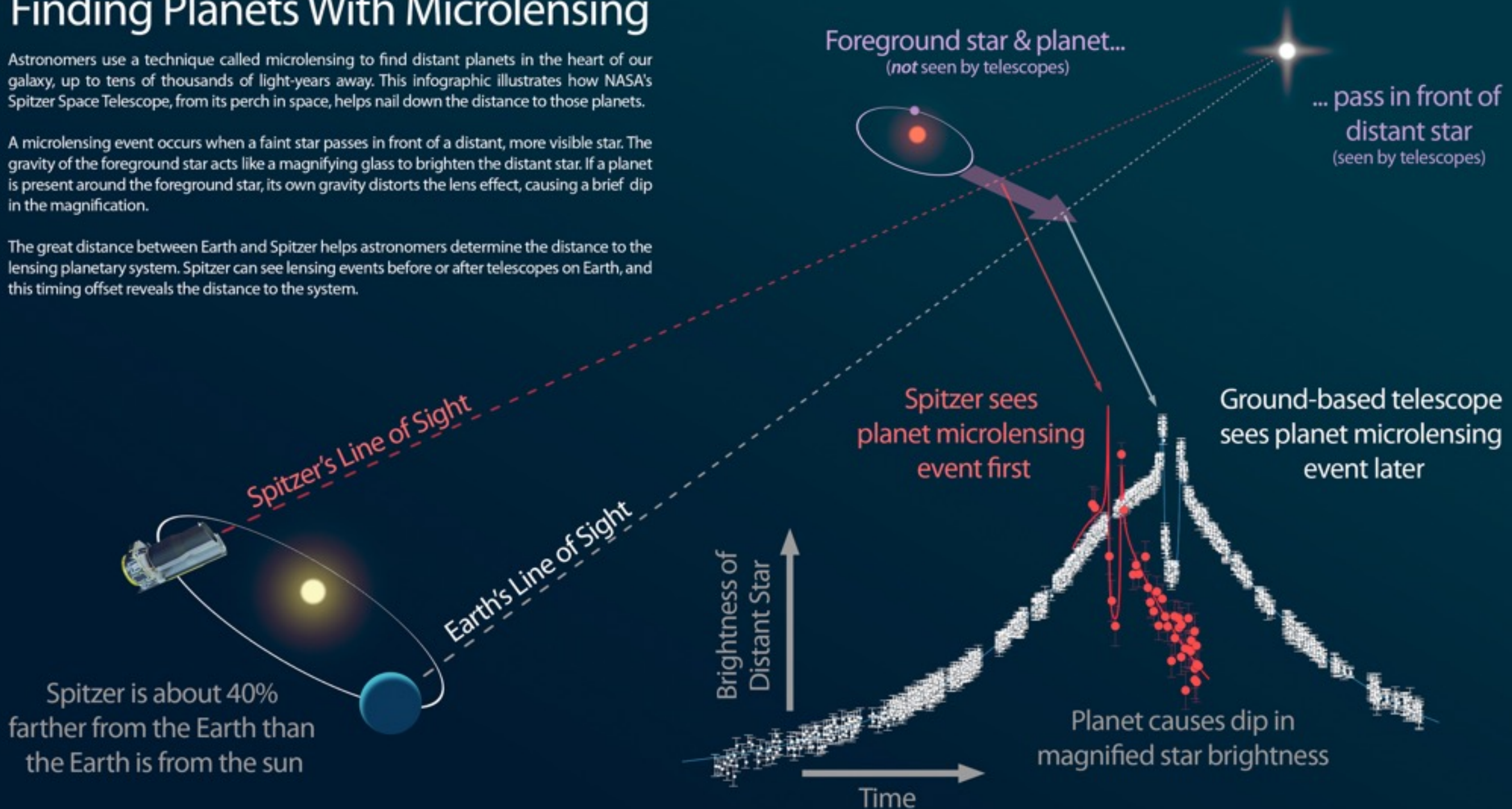
Space parallax

Finding Planets With Microlensing

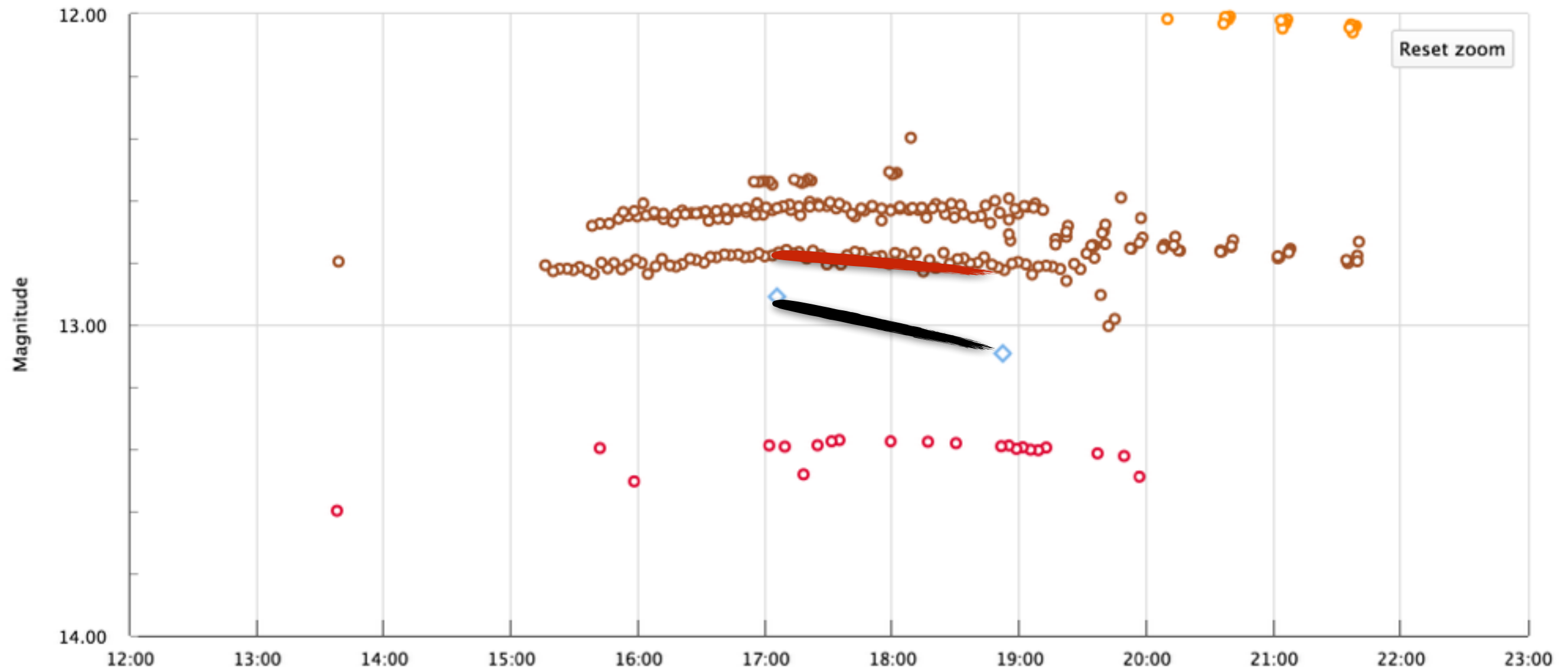
Astronomers use a technique called microlensing to find distant planets in the heart of our galaxy, up to tens of thousands of light-years away. This infographic illustrates how NASA's Spitzer Space Telescope, from its perch in space, helps nail down the distance to those planets.

A microlensing event occurs when a faint star passes in front of a distant, more visible star. The gravity of the foreground star acts like a magnifying glass to brighten the distant star. If a planet is present around the foreground star, its own gravity distorts the lens effect, causing a brief dip in the magnification.

The great distance between Earth and Spitzer helps astronomers determine the distance to the lensing planetary system. Spitzer can see lensing events before or after telescopes on Earth, and this timing offset reveals the distance to the system.



Space parallax



$$\pi_E = \frac{\text{AU}}{D_\perp} \left(\frac{\Delta t_0}{t_E}, \Delta u_0 \right),$$

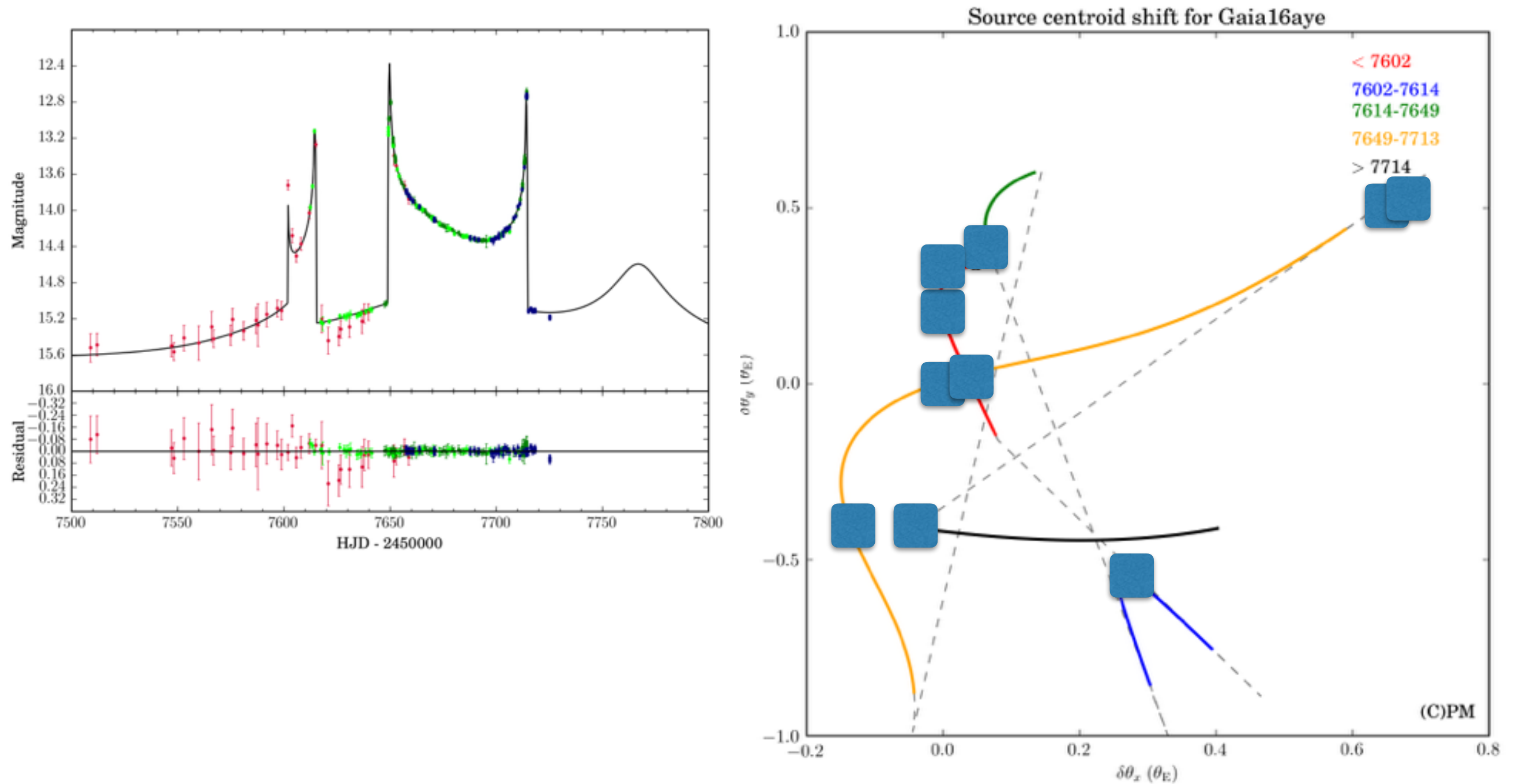
Offset in both time and mag between
Earth-based and Gaia-based observations



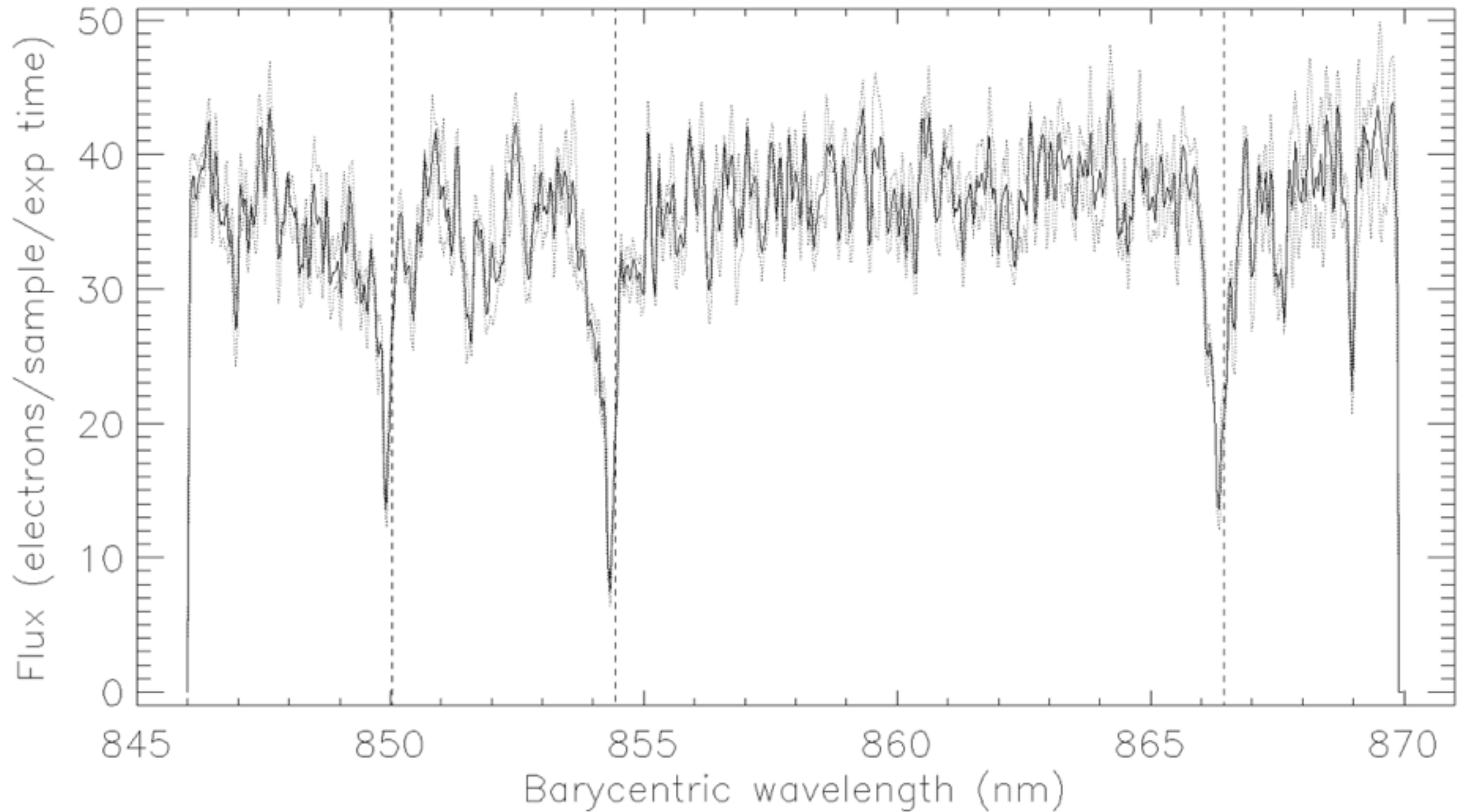
microlensing
parallax

Astrometry

First time ever a chance to detect astrometric microlensing!



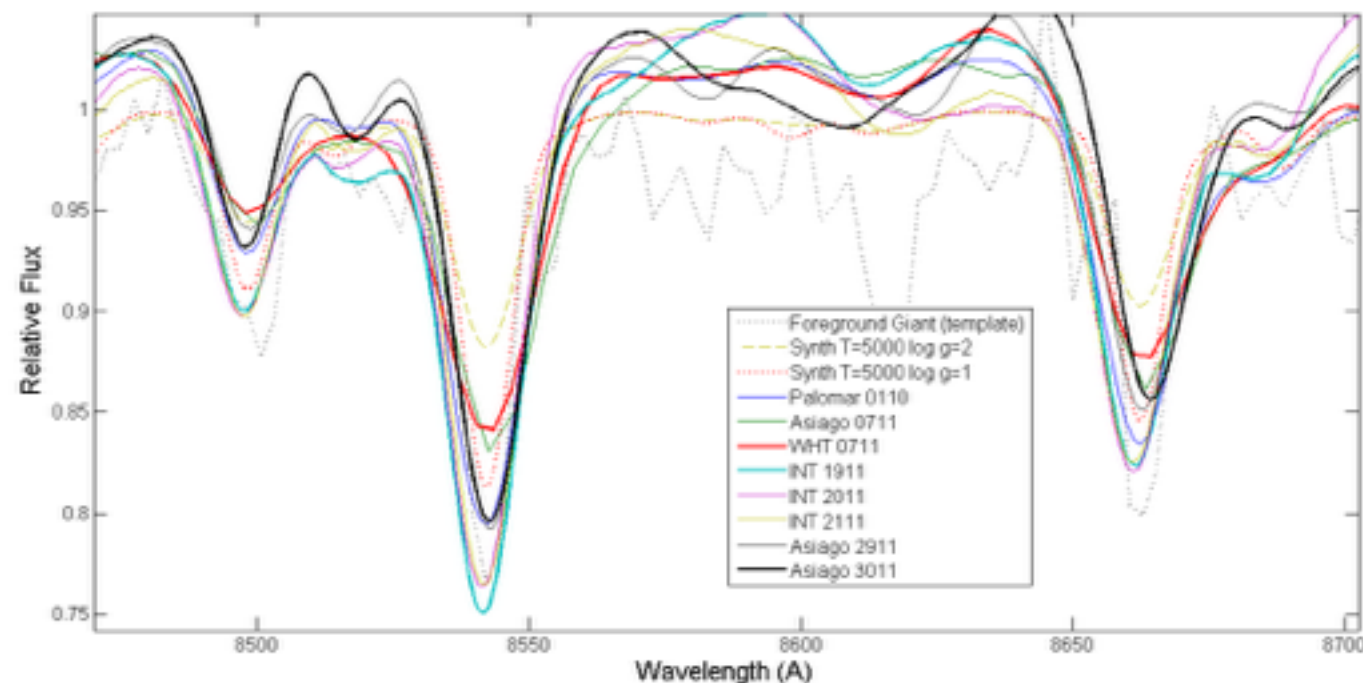
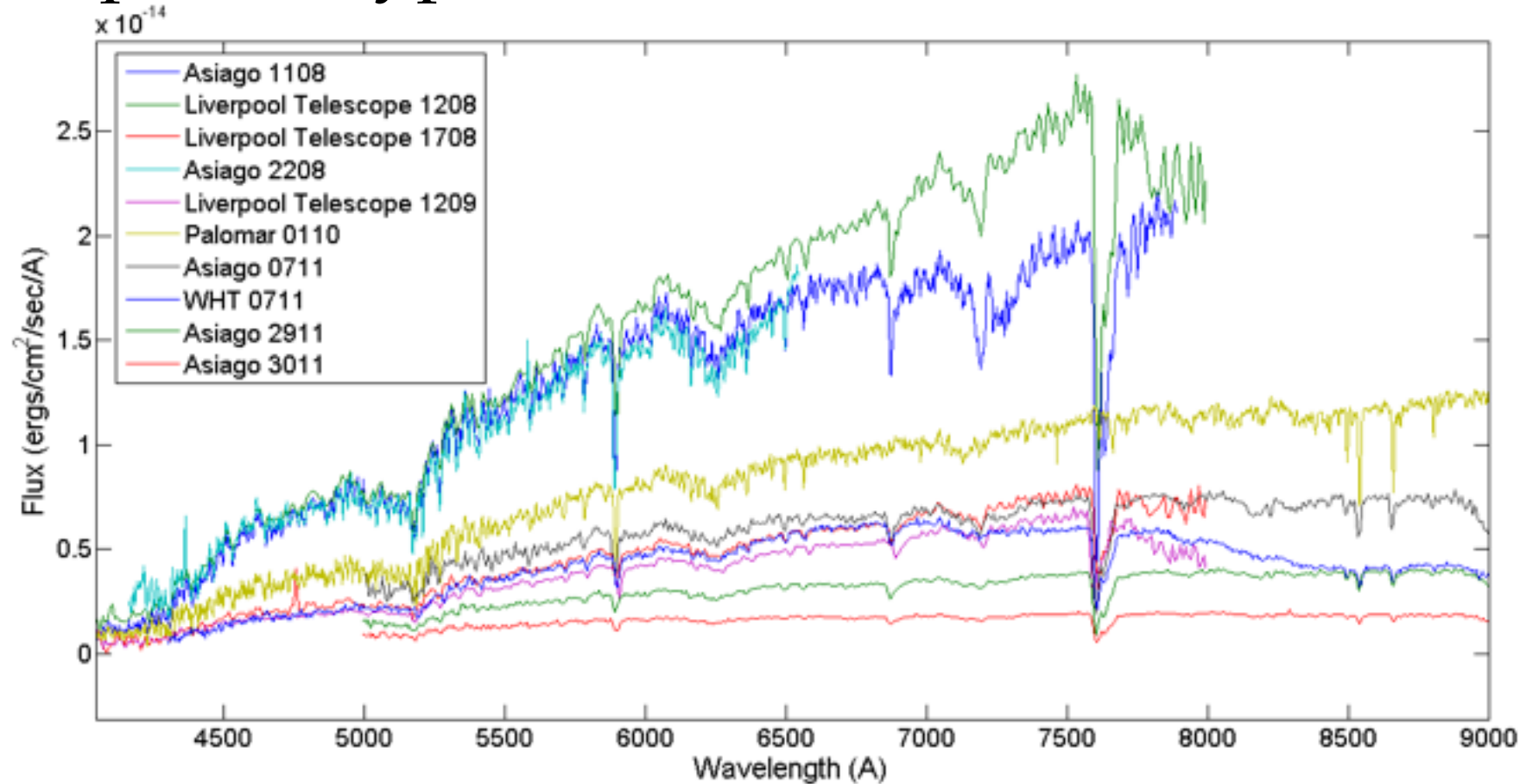
Radial velocity from Gaia



credit: George Seabroke
& DPAC/CU6

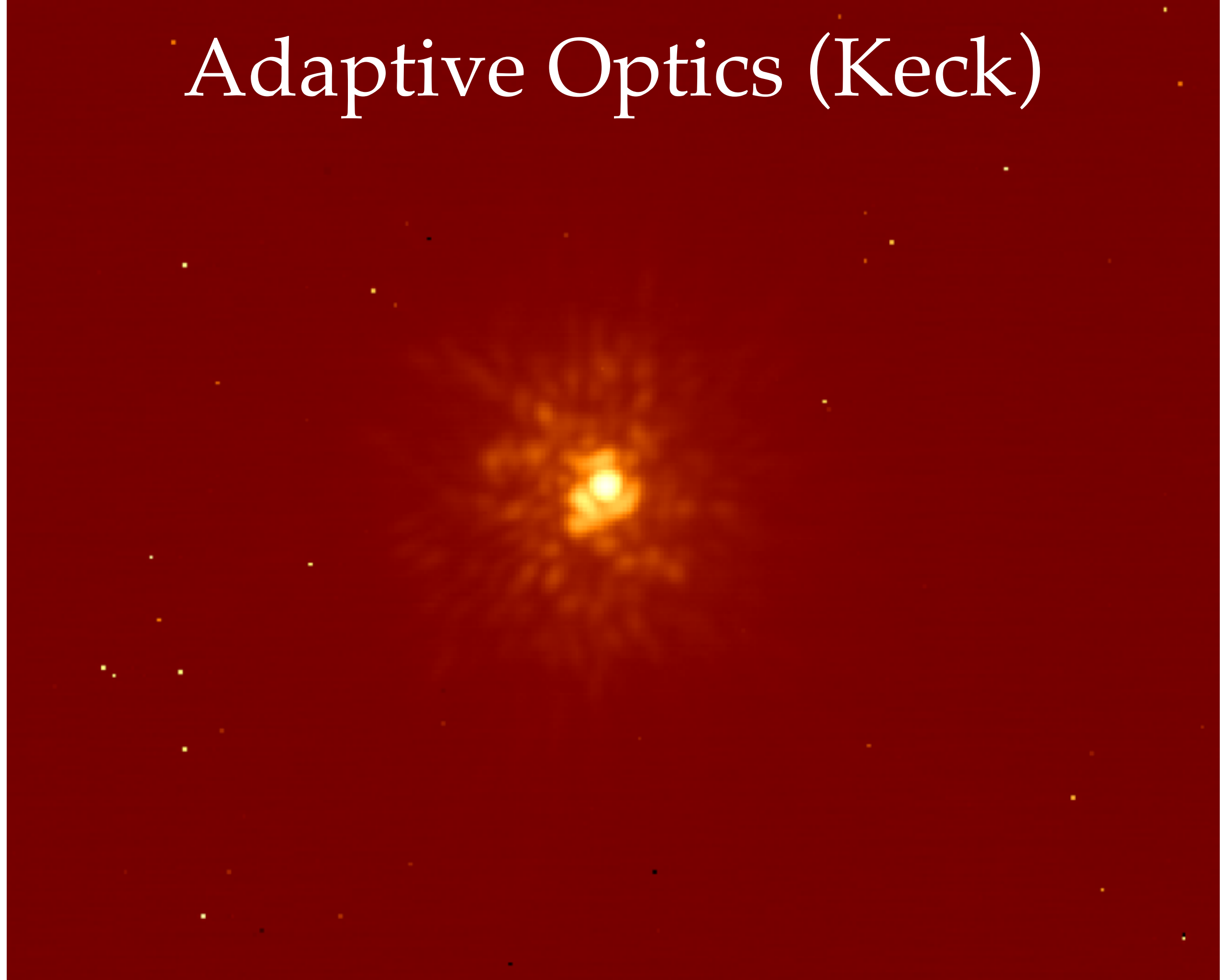
Spectroscopy

Spectral type and distance of the source star



**best match:
K4III at ~8kpc**

Adaptive Optics (Keck)



Most likely solution (prelim!)

