Science from the first year of Gaia Science Alerts

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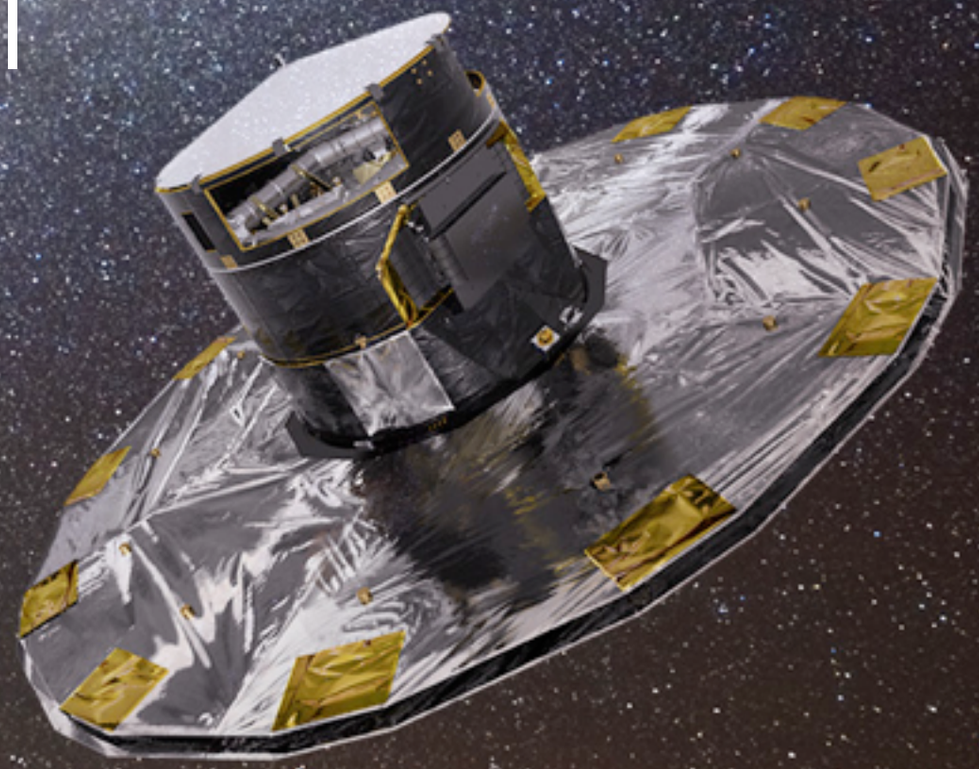
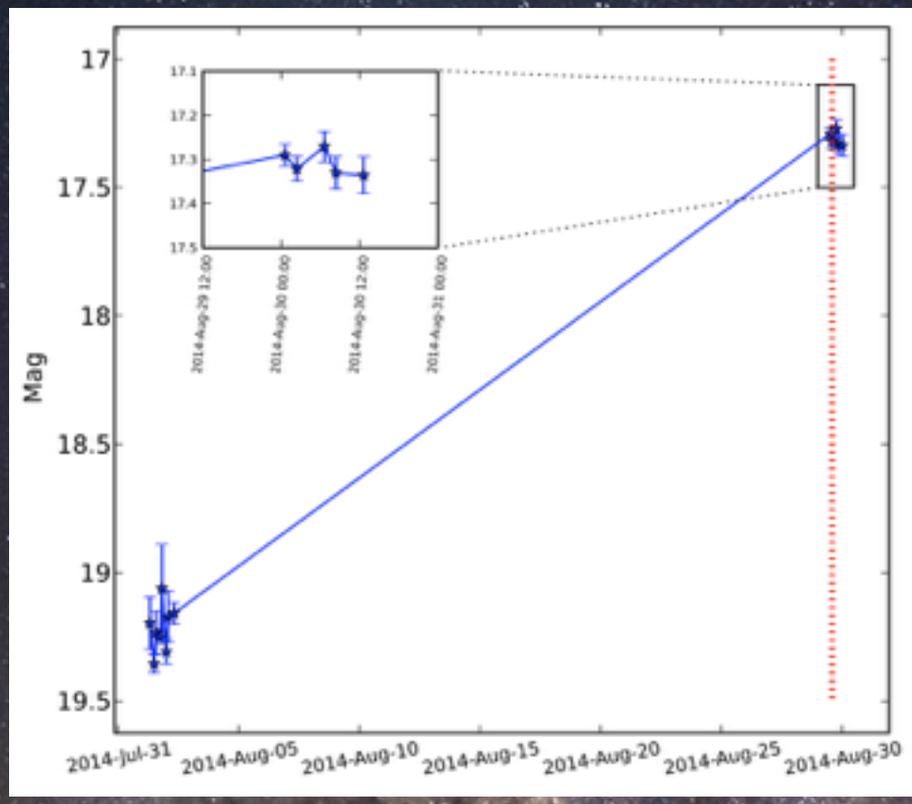
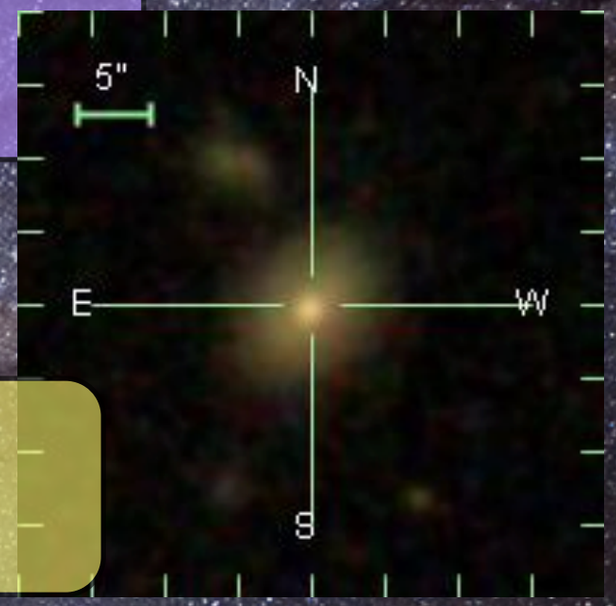


Gaia14aaa- Gaia's first Supernova

Gaia light curve

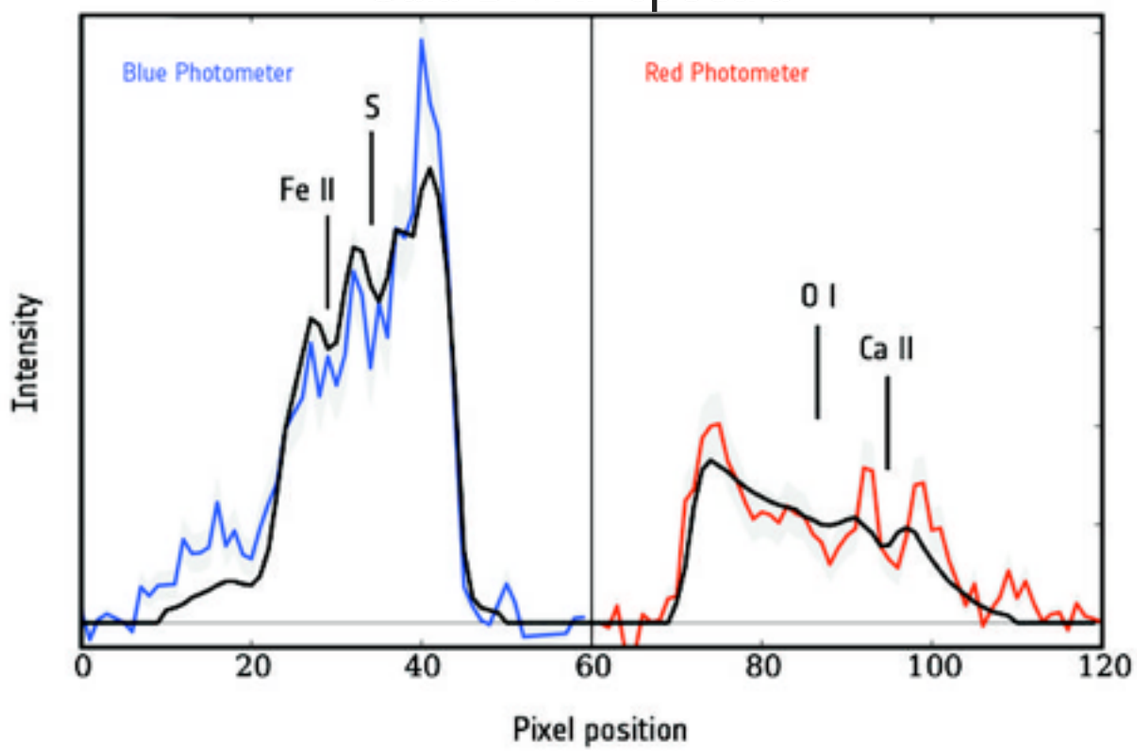


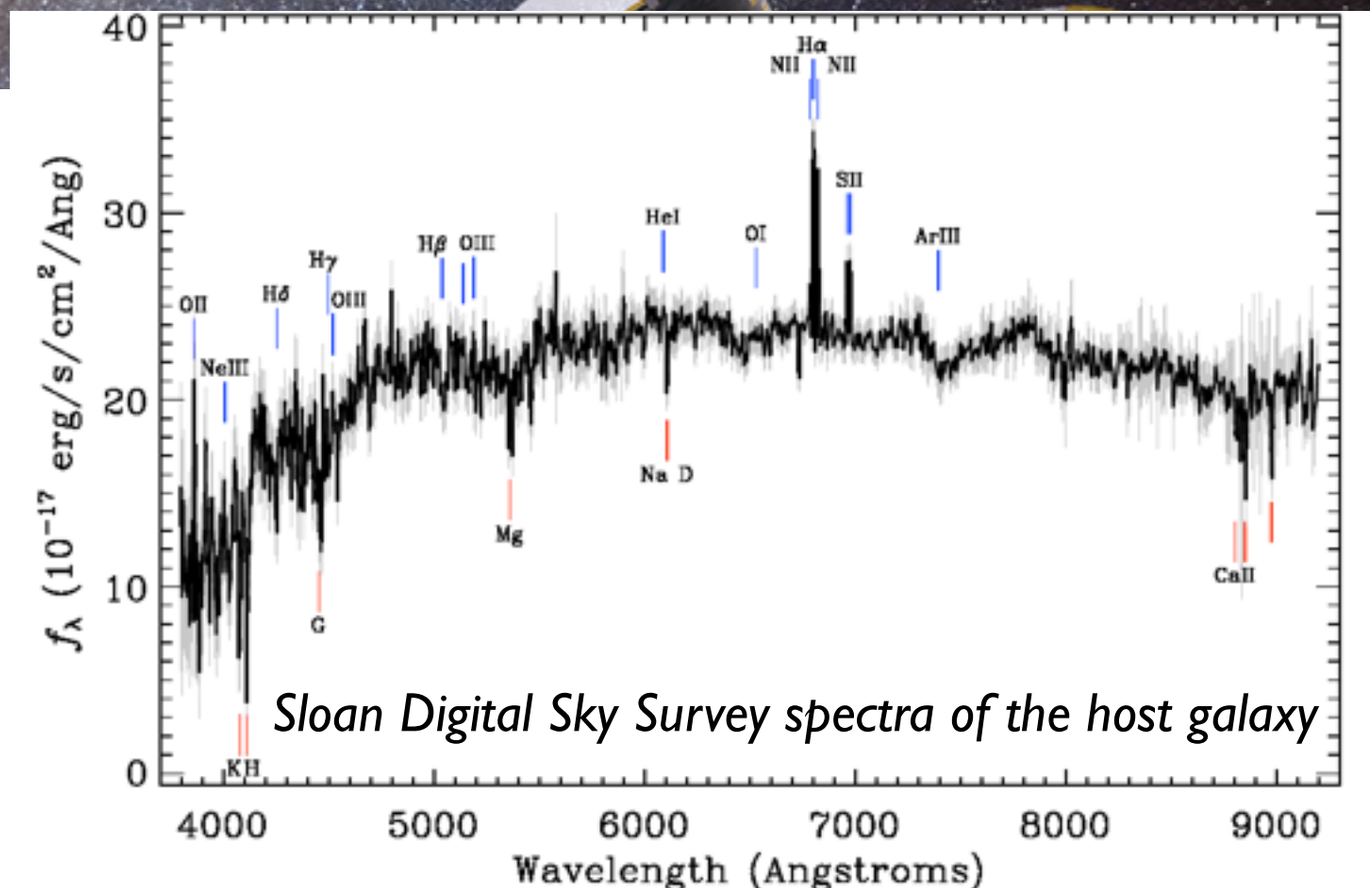
Discovery Date: 2014-08-30 02:22:31
Position: 200.25961 45.53943
Magnitude: 17.32



Sloan Digital Sky Survey image of the host galaxy

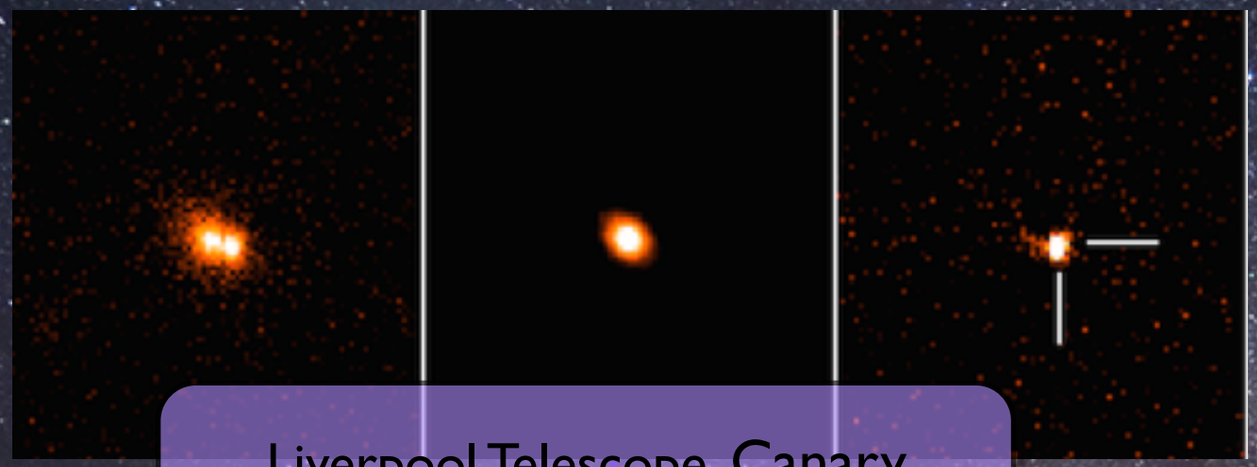
Gaia BP/RP spectra





Sloan Digital Sky Survey spectra of the host galaxy

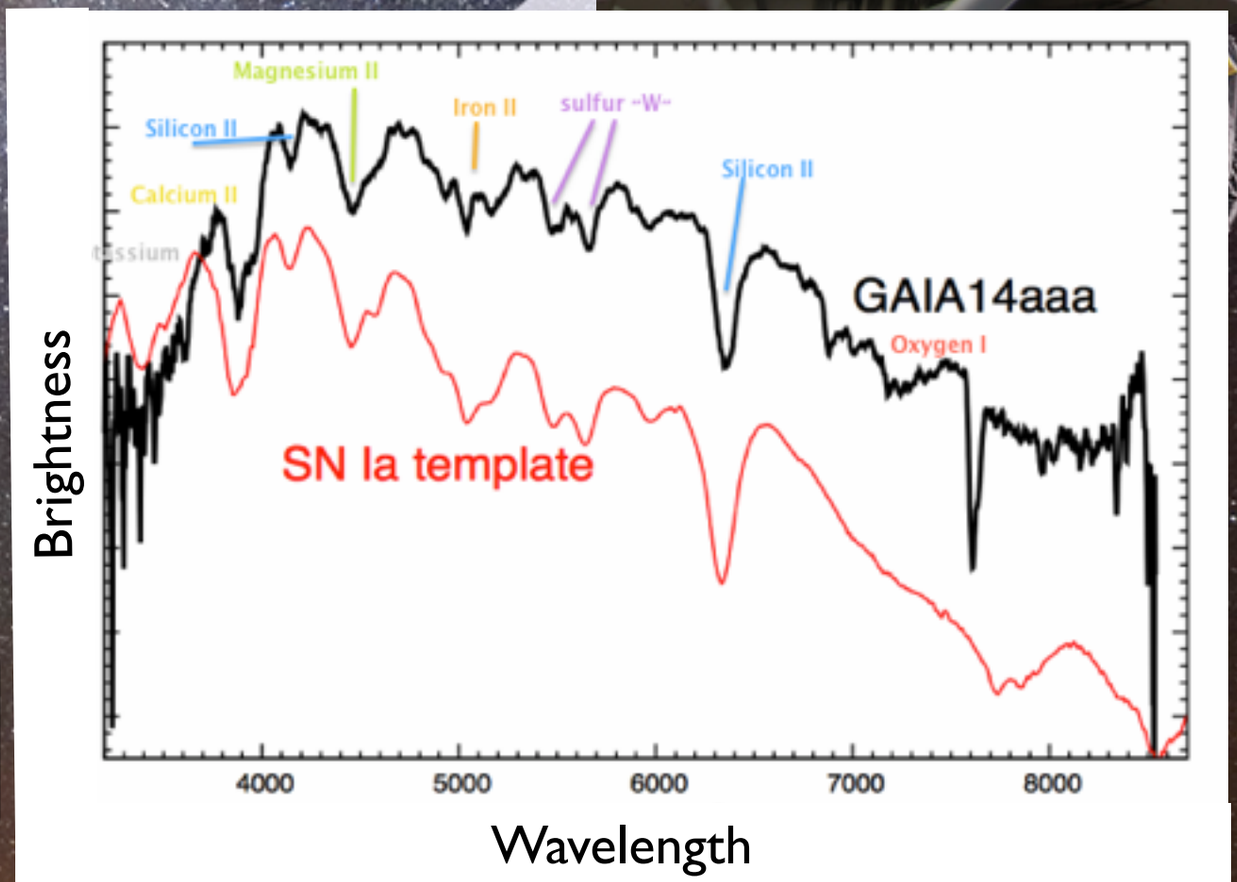
Gaia14aaa- Gaia's first Supernova - Type Ia



Liverpool Telescope, Canary Islands, Image of the supernova

Isaac Newton Telescope, Canary Islands

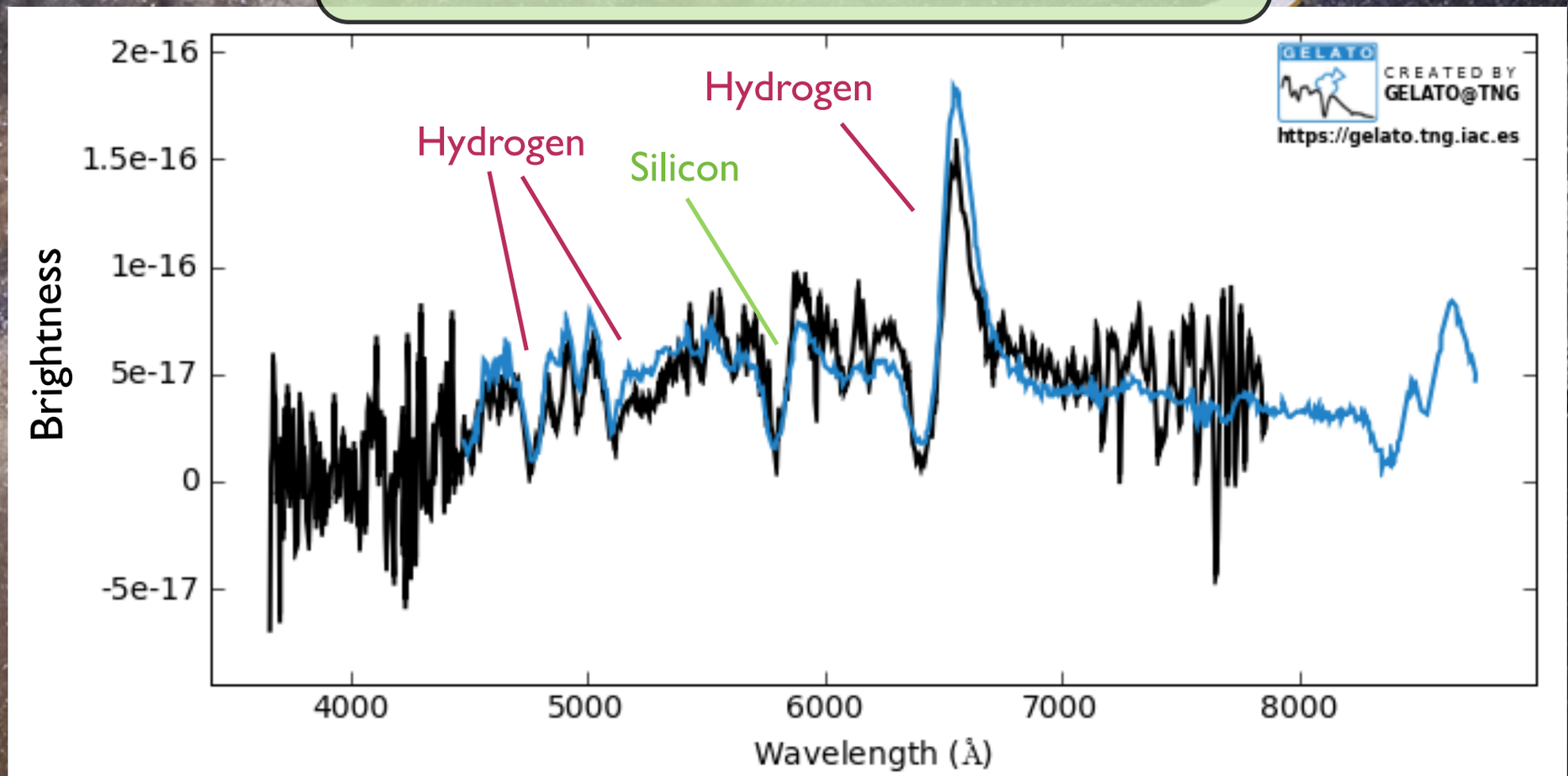
Spectra of the supernova taken on the 3rd September 2014



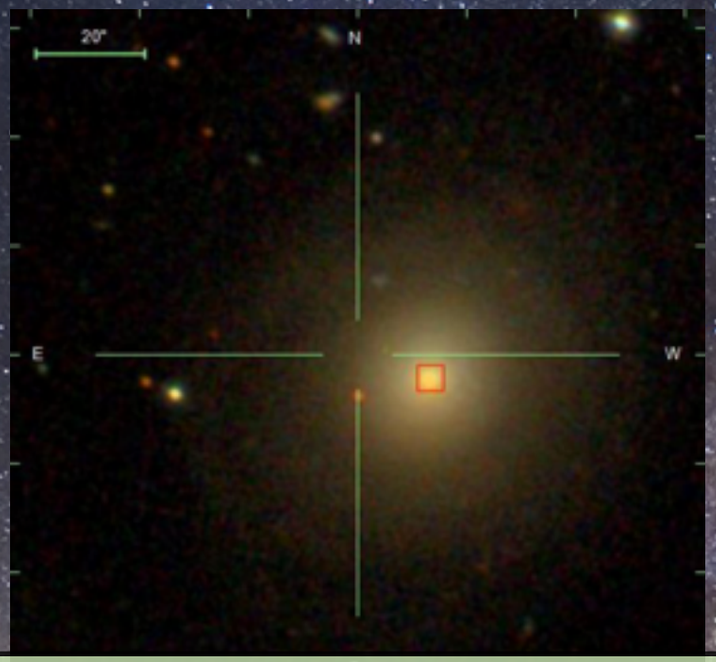
Core Collapse SN: Gaia14act

The broad "bumps" in the spectrum are caused by material which is moving at speeds of thousands of kilometres per second - characteristic of a violent supernova explosion.

Asiago Observatory in the north of Italy.

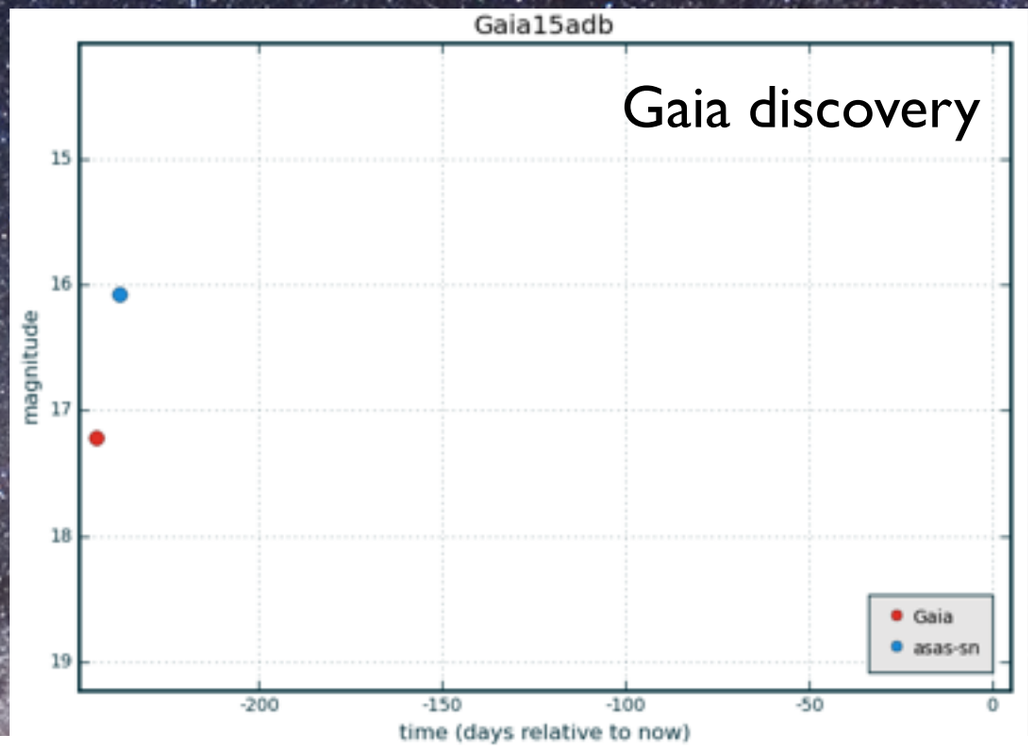


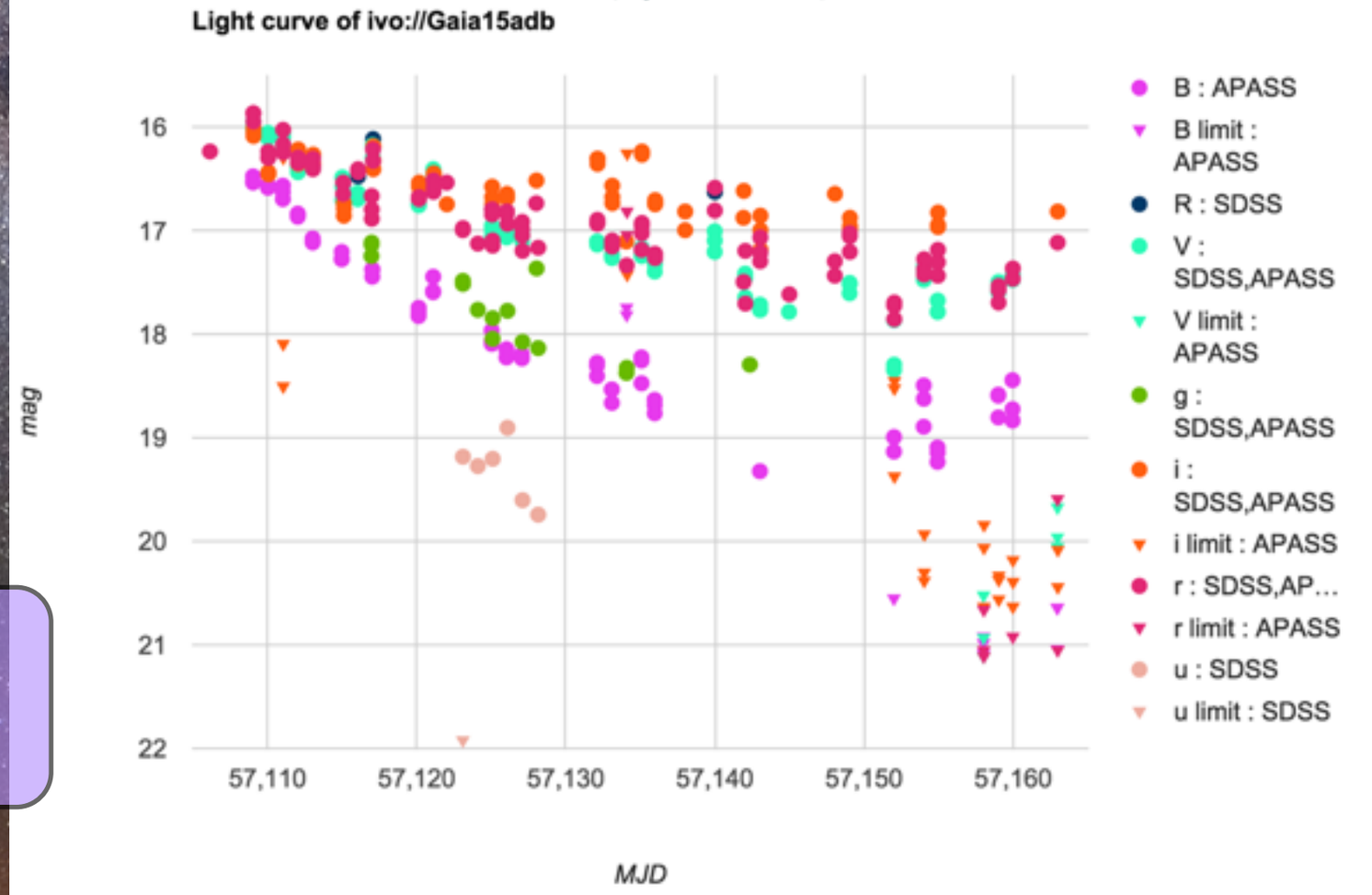
Type Ia SN: Gaia15adb



Position in SDSS host galaxy

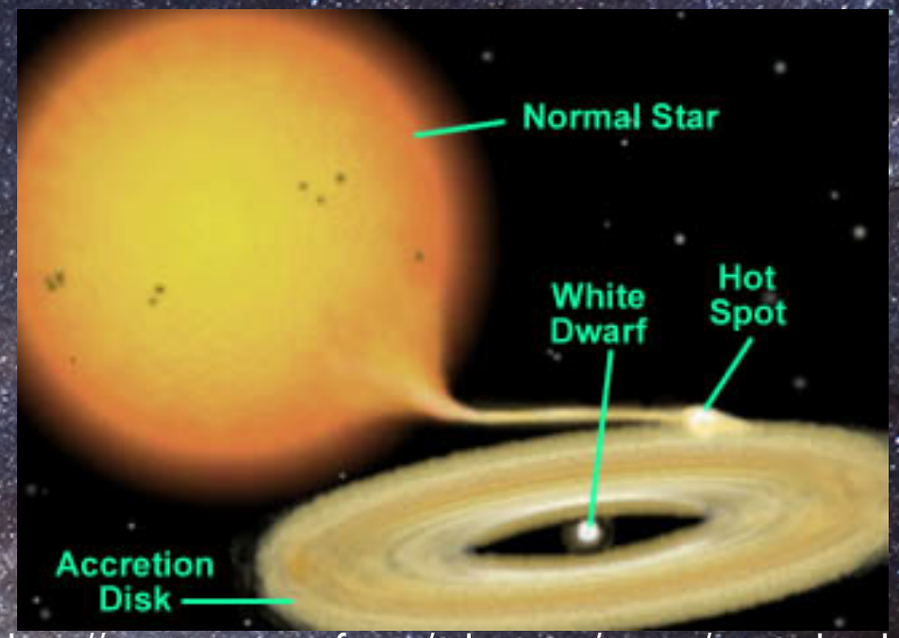
Photometric follow up shows the fall of the light curve





Cataclysmic Variables: Gaia14aco

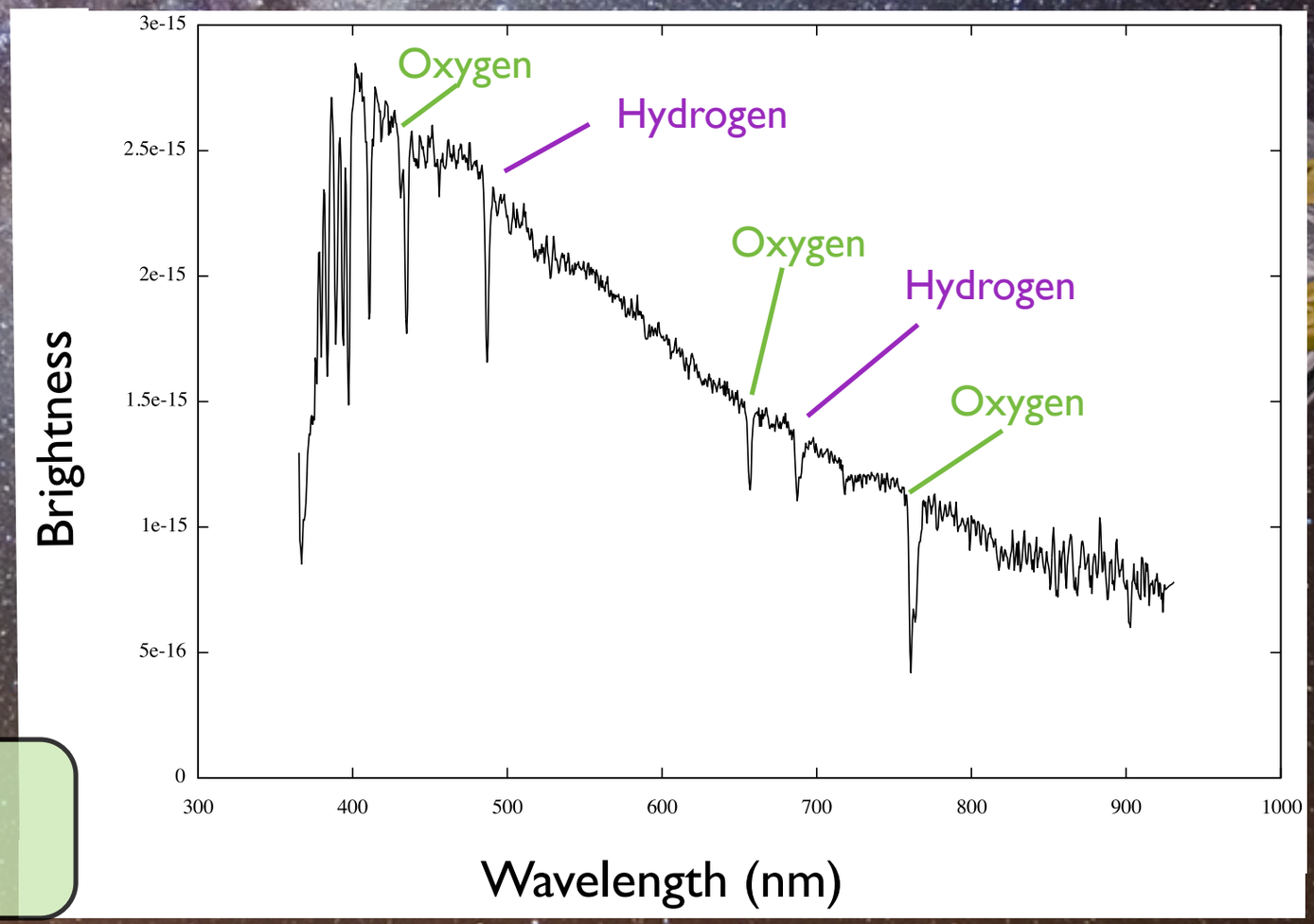
These systems comprise of two stars which are in a binary, one of which (the primary) is pulling material from its companion (the donor).



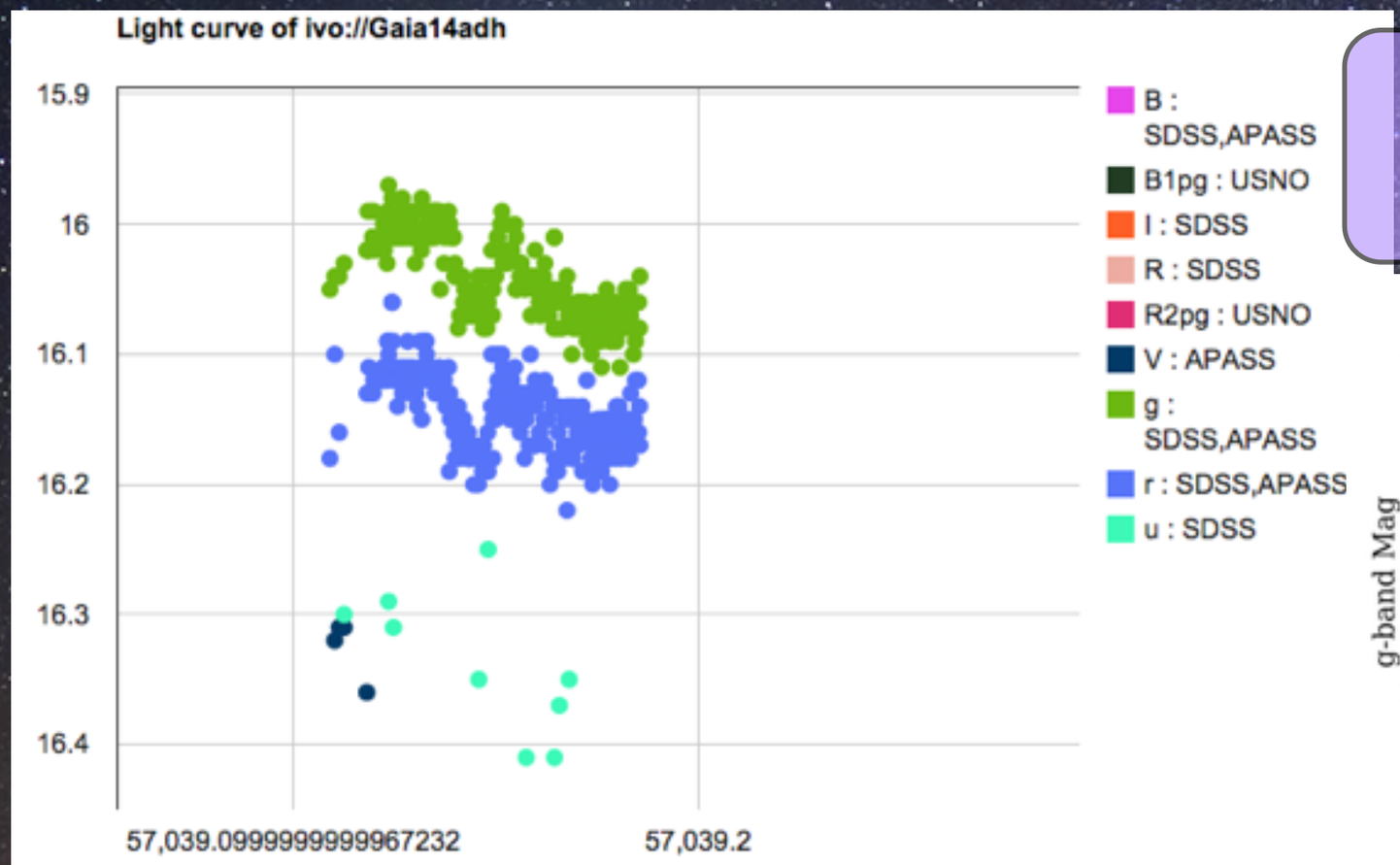
http://www.astrosurf.com/vdesnoux/catvar/catvar.html

System is hot (and hence emits more light at blue wavelengths than red). The spectrum also shows the typical fingerprints of a cataclysmic variable.

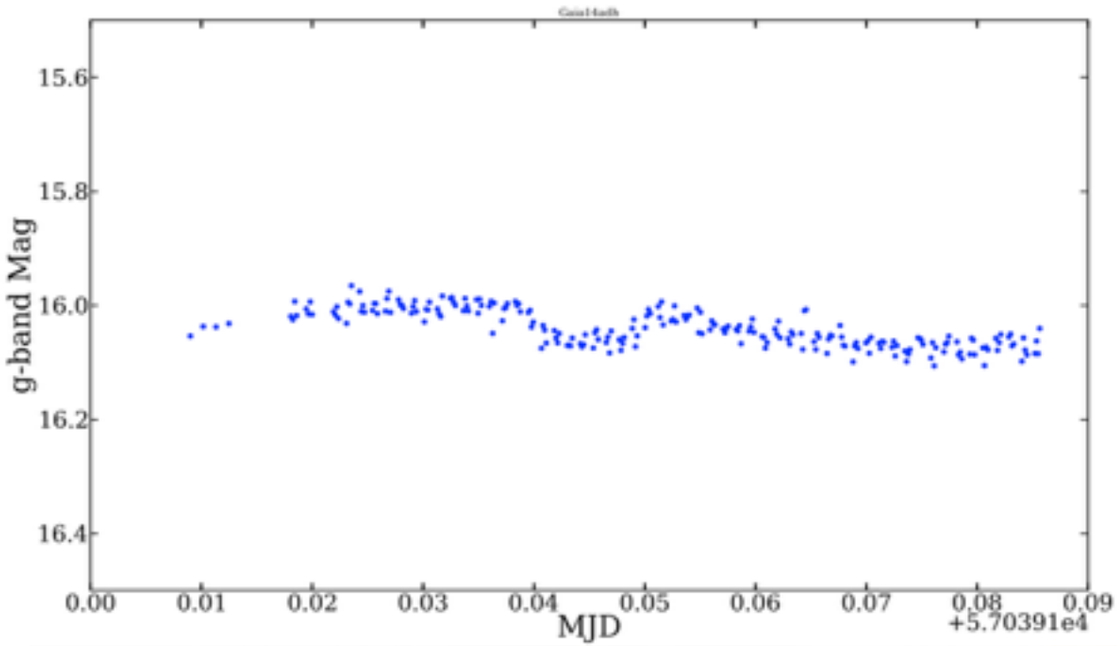
New Technology Telescope at La Silla Observatory in Chile



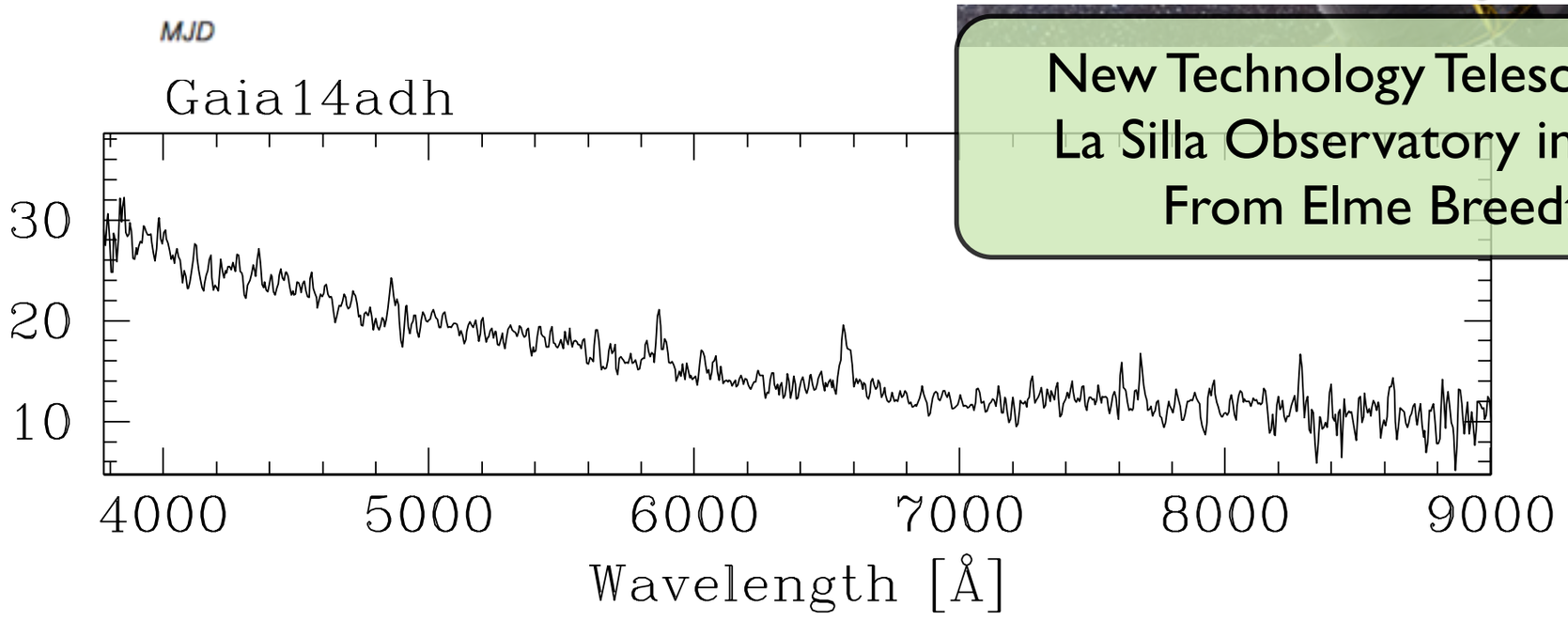
Eclipsing Cataclysmic Variables: Gaia14adh



Photometric follow up reveilles eclipse in the system



New Technology Telescope at La Silla Observatory in Chile From Elme Breedt



Gaia Science Alerts
First Science Discovery Publication

Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

MNRAS **452,** 1060–1067 (2015) doi:10.1093/mnras/stv1224

Total eclipse of the heart: the AM CVn Gaia14aae/ASSASN-14cn

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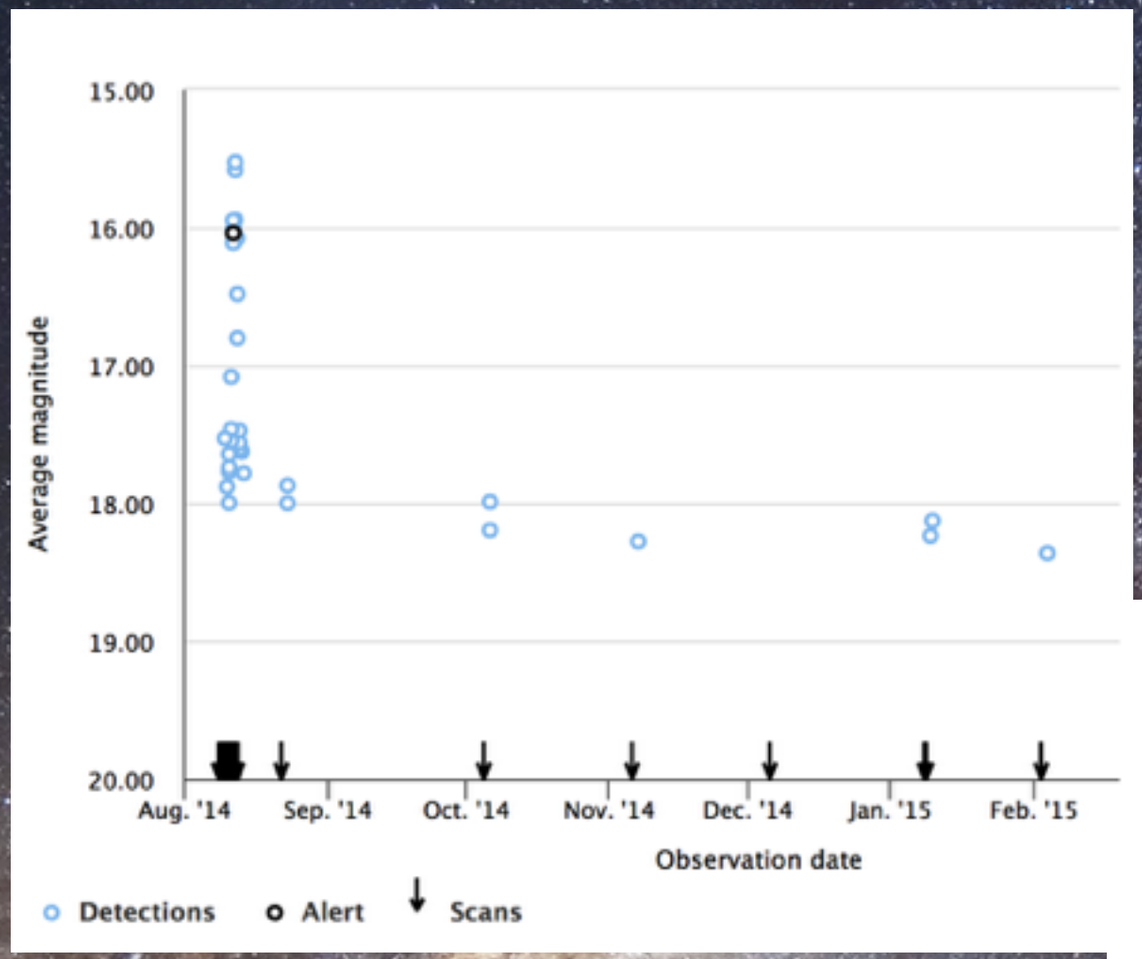
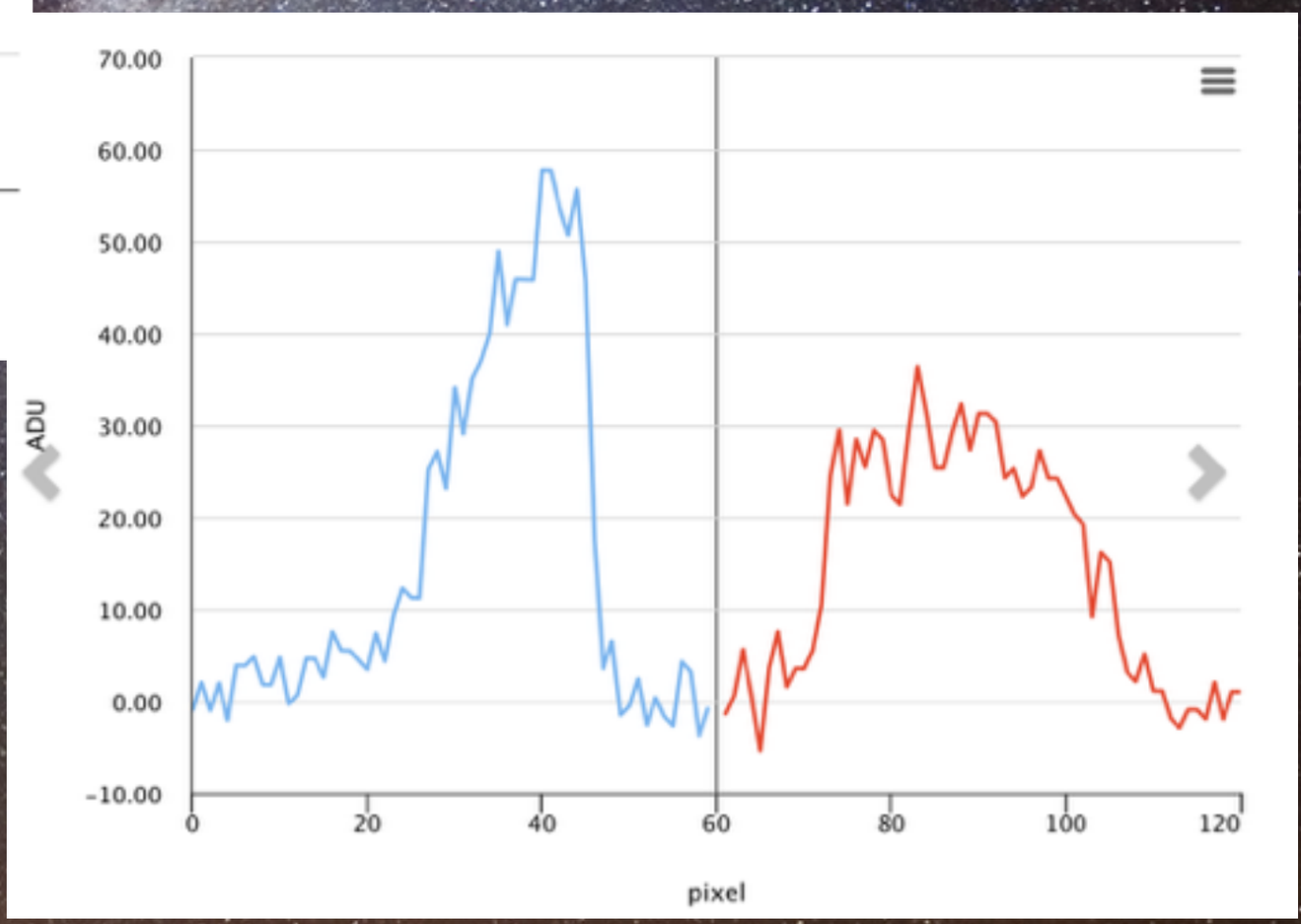
Campbell et al. 2015



BP + RP

Gaia light curve



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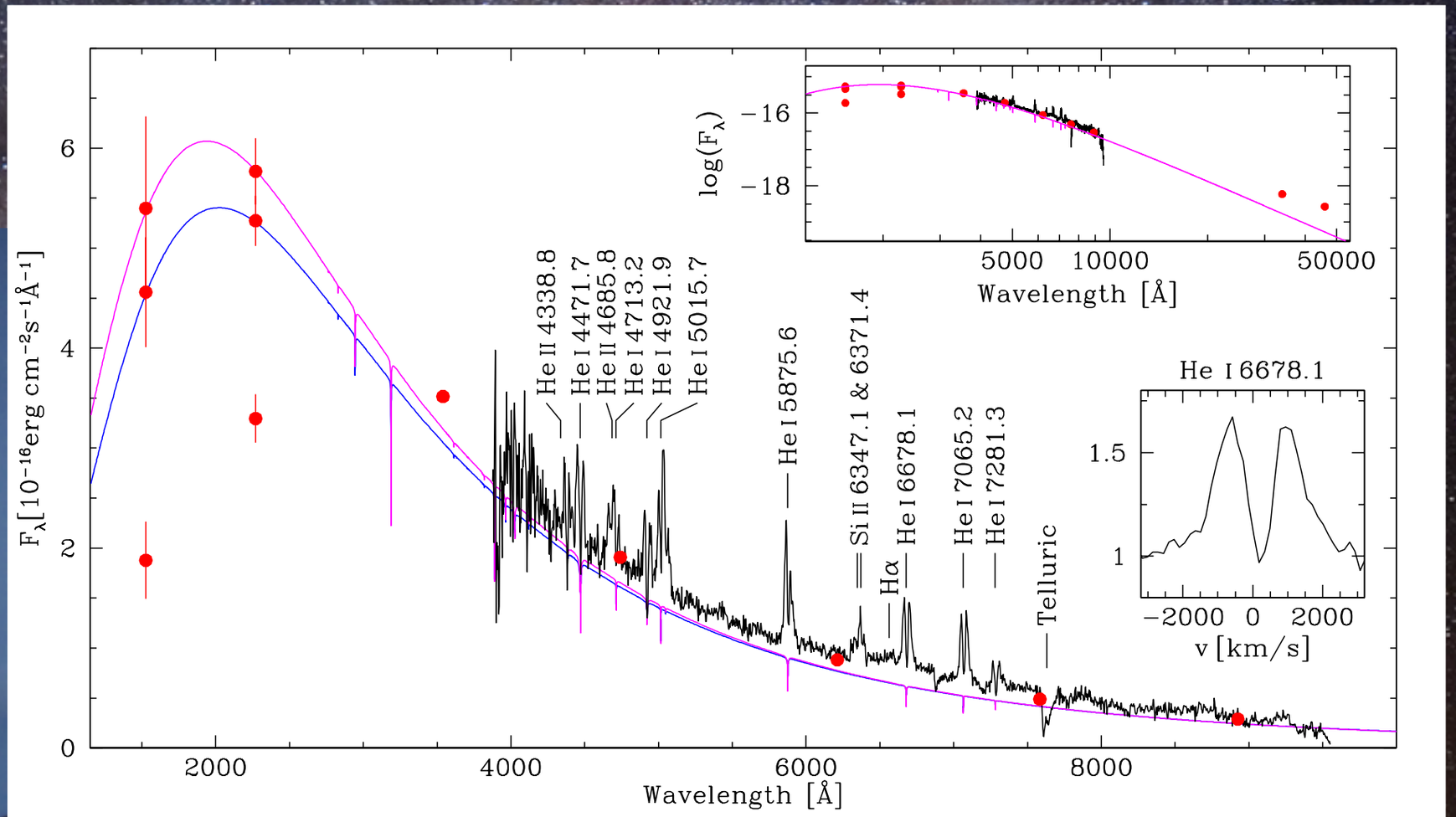
Campbell et al. 2015

WHT spectrum: double-peaked He emission and an absence of H lines.

The historical GALEX, SDSS and WISE photometry

Distance of 225 +- 10 pc.



William Herschel Telescope, La Palma

Teff = 12900 ± 200 K, He-atmosphere models

Accretion rate = 7-8*10^{-11}M yr^{-1} for 0.75M

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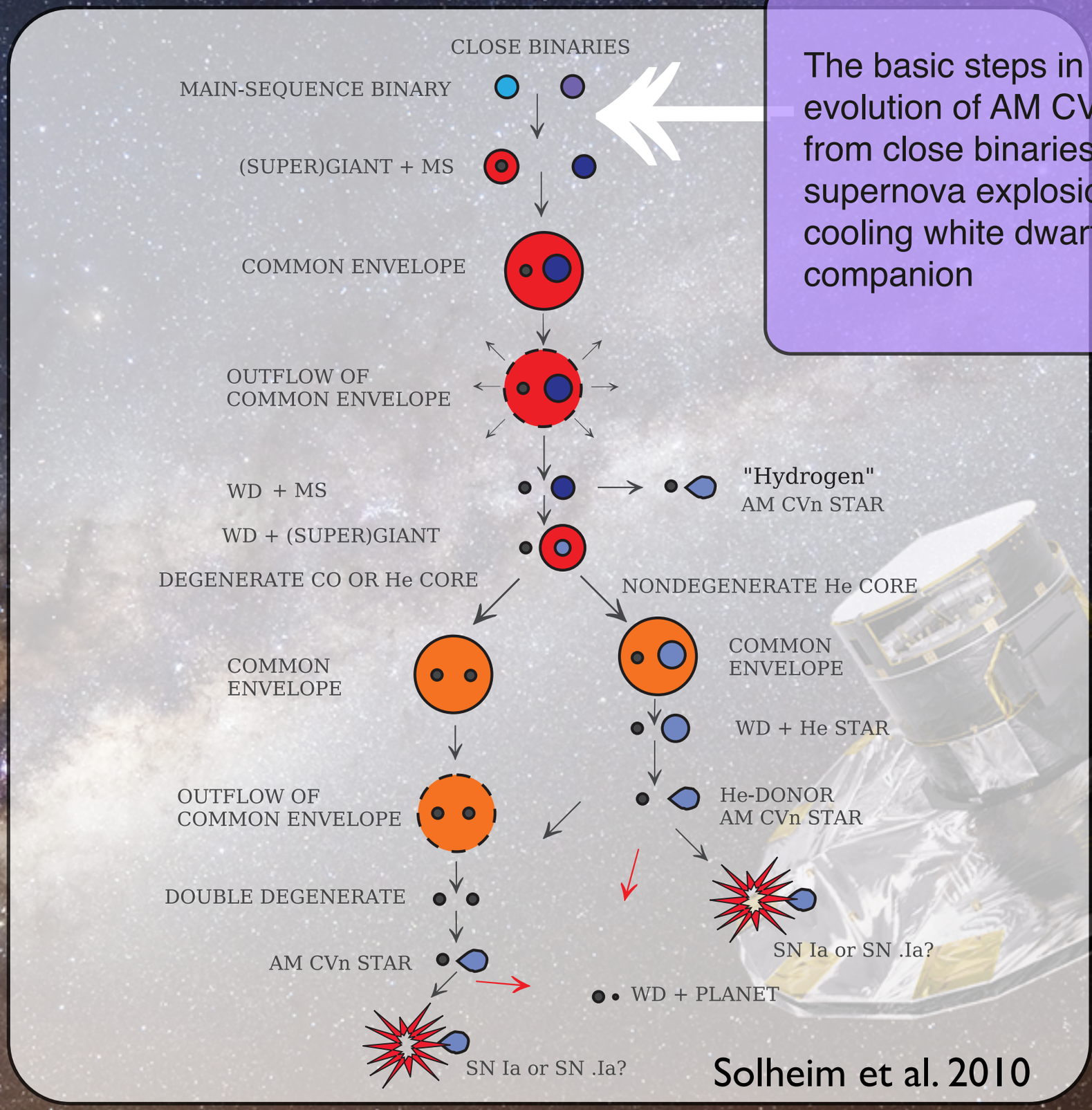


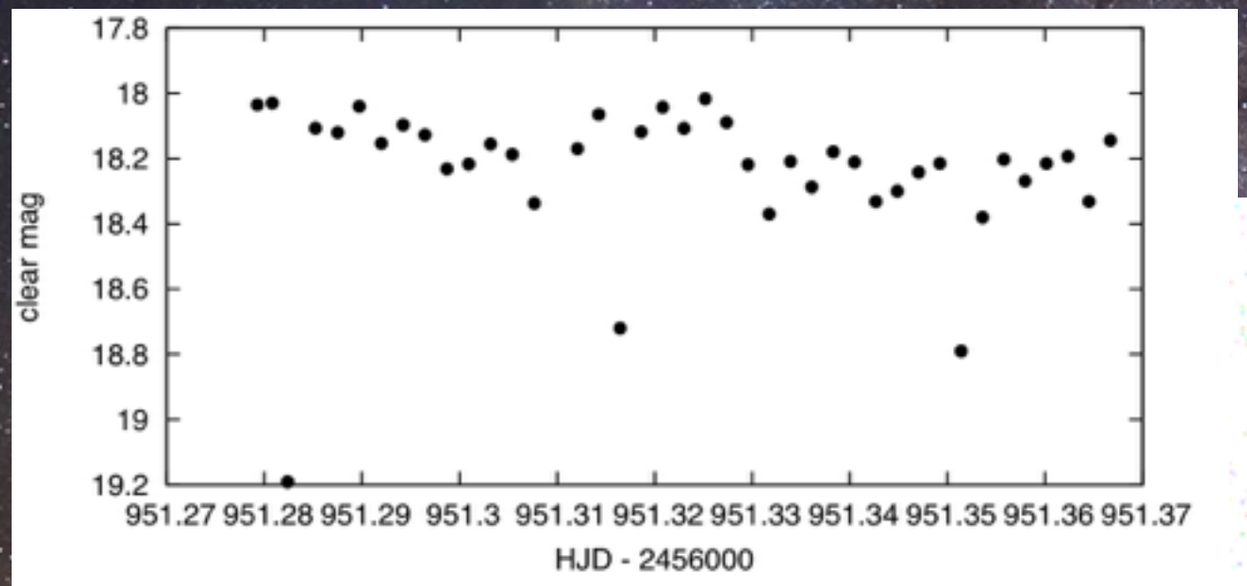
The basic steps in the evolution of AM CVn stars from close binaries to supernova explosions or a cooling white dwarf with a companion

Solheim et al. 2010

Total eclipse of the heart: The AM CVn Gaia14aae / ASSASN-14cn

Campbell et al. 2015

Amateur Astronomers, CBA, light curve
Discovered the eclipses



Run by Joe Patterson, in New York

Center for Backyard Astrophysics

A global network of small telescopes dedicated to photometry of cataclysmic variables.

Dr Heather Campbell, IoA, Cambridge, hcc@ast.cam.ac.uk

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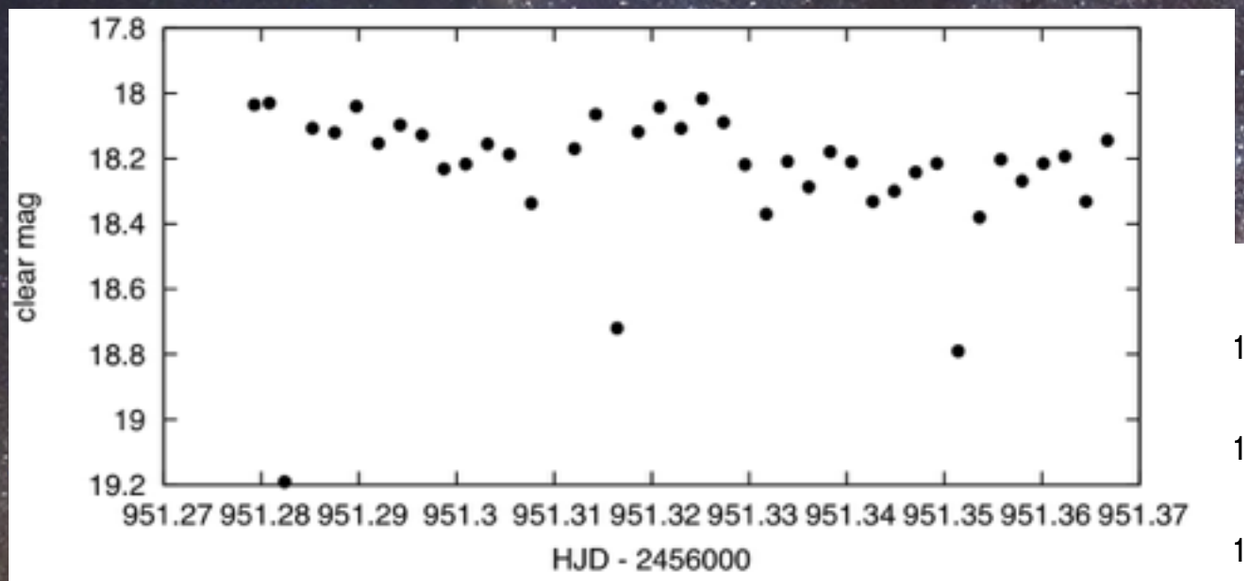
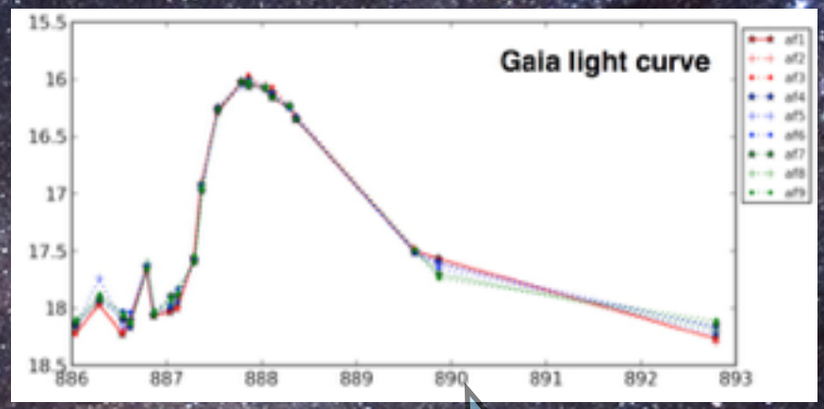
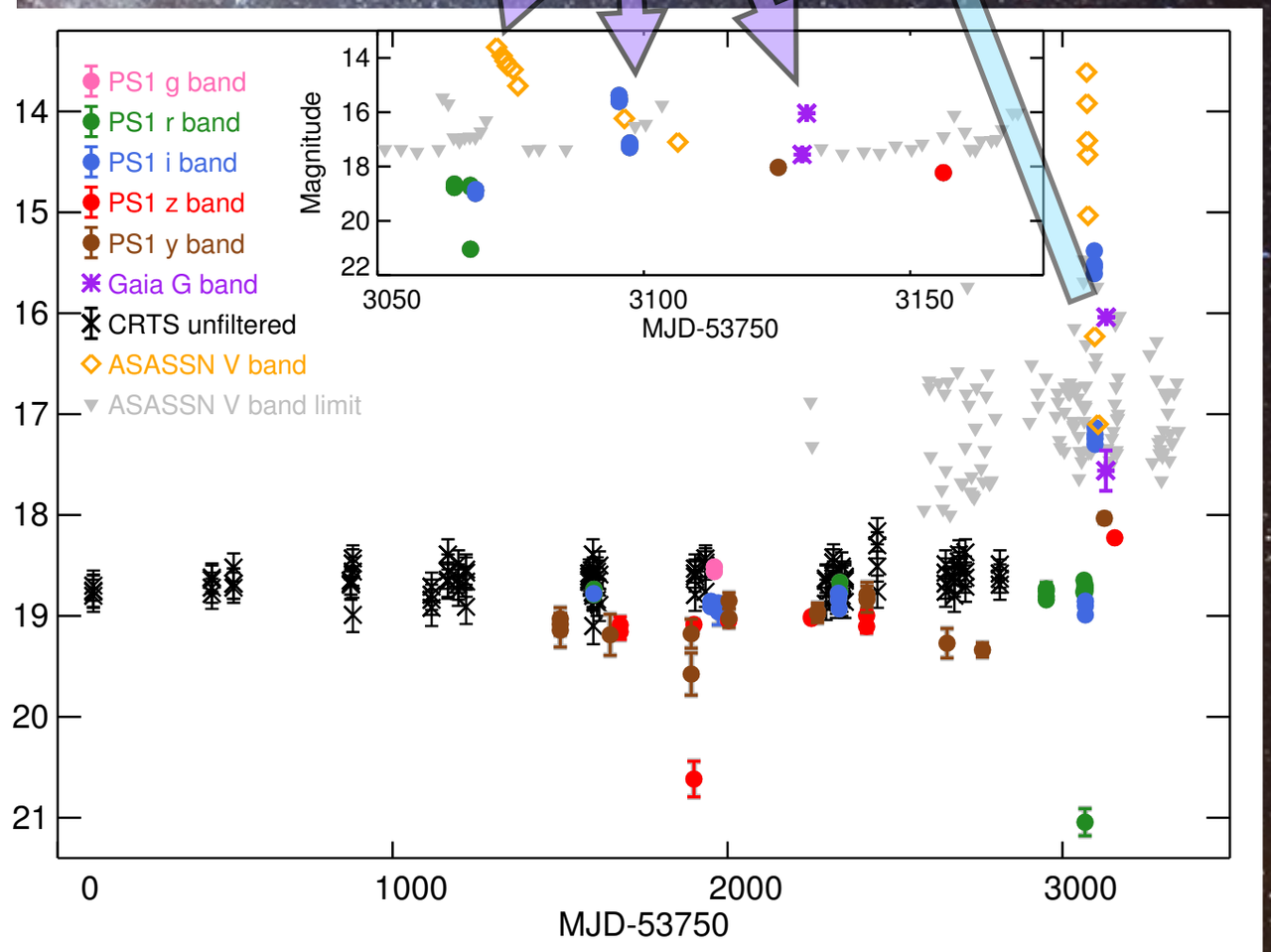




Outbursts



Historic light curve

Dr Heather Campbell, IoA, Cambridge, hcc@ast.cam.ac.uk

Total eclipse of the heart: The AM CVn Gaia14aae / ASSASN-14cn

Campbell et al. 2015

All telescope involved in photometric follow up

Observatory	Obs. date (UT)	Filter	Exposures (s)
Gaia	2014 08 11	*G*	45
ASAS-SN	2012 - 2015	*V*	129×180
Loiano 1.5m Cassini	2014 10 24	*g*	3×300, 91×30
Telescope + BFOSC	2014 10 25	*g*	135×30
Bialkow 0.6m, Poland	2014 10 18	*BV*	30×120
	2014 10 19	*BV*	37×120
CIECEM 0.35m, Spain	2014 10 21 to	clear	40×180, 8×150
	2014 11 18		111×120, 399×90
pt5m, La Palma	2014 10 25	*V*	61×60
	2014 10 22	*V*	36×60, 21×120
0.6m ASV, Serbia	2014 10 21	*BVRI*	6×300
Belogradchik AO 0.6m, Bulgaria	2014 10 21	*BVR*	2× 300
Asiago 1.82m Copernico	2014 12 11	*r*	169×20
	2014 12 12	*g*	169×20
4.2m WHT+ACAM	2014 12 18	*V*	491×5
Mercator	2015 01 15	*g r+i*	232×30
Catalina *(historic)*	2005 - 2014	clear	107×30
Pan-STARRS1 *(historic)*	2010 - 2014	*grizy*	66×30

Bialkow 0.6m, Poland

0.5m, La Palma

0.6m, ASV Serbia

Loiano Observatory

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Campbell et al. 2015

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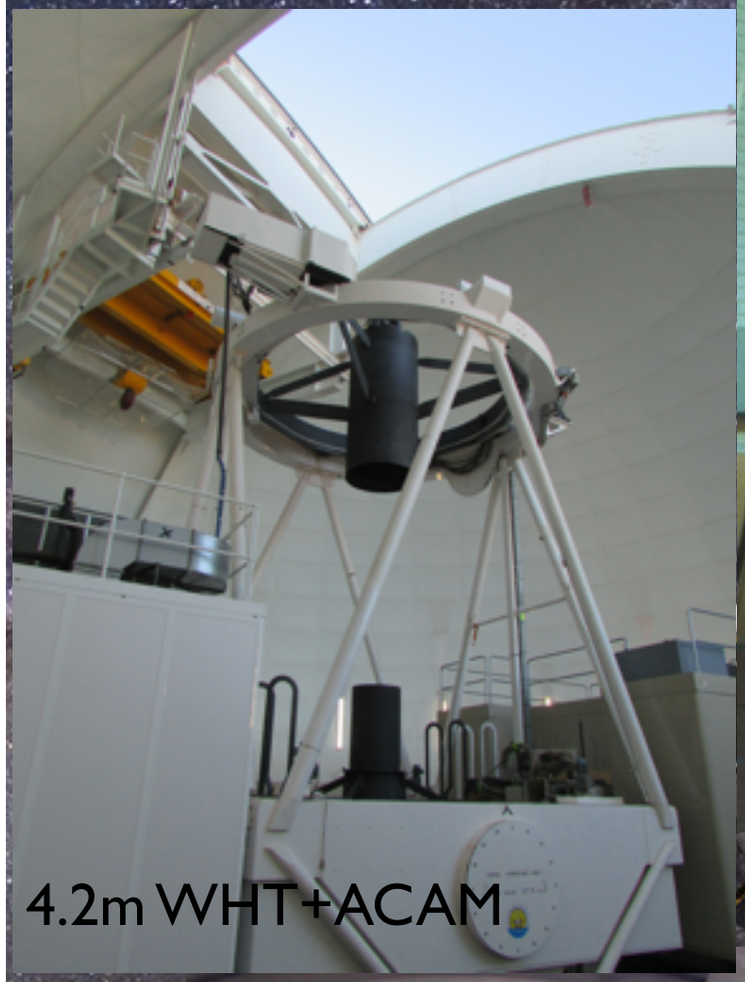
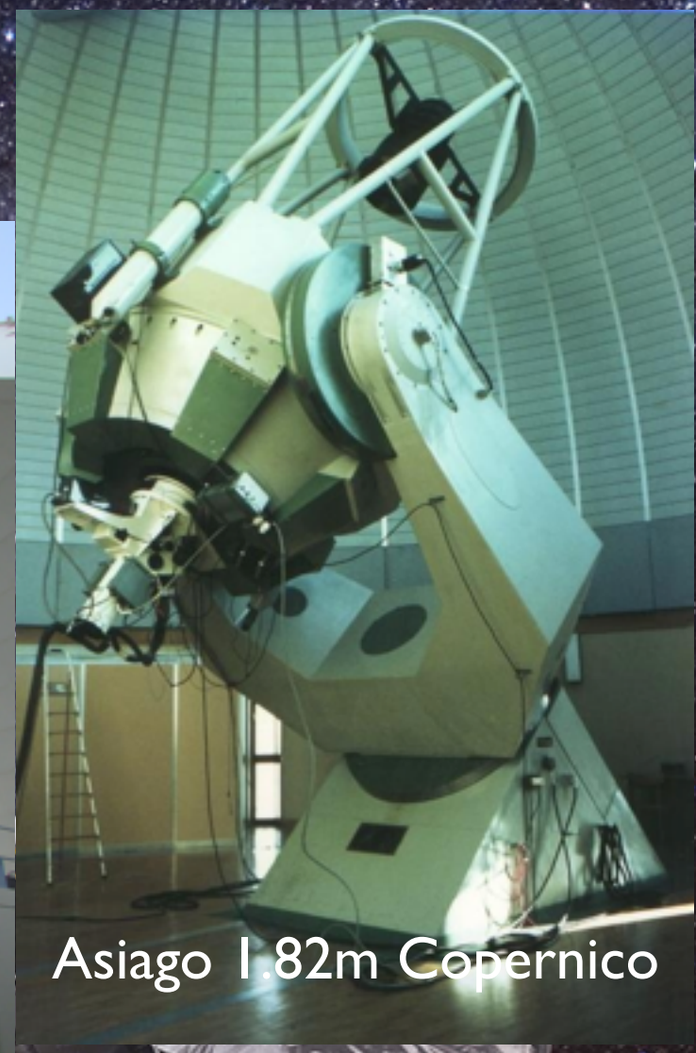


4.2m WHT+ACAM



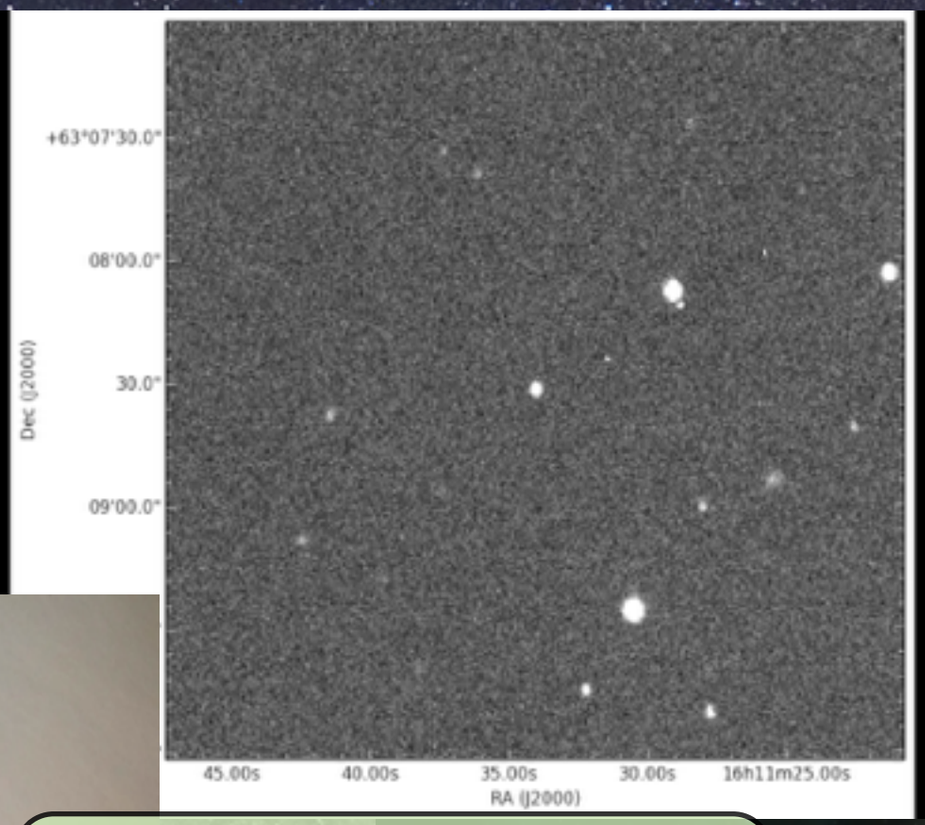
Asiago 1.82m Copernico

Belogradchik AO 0.6m Bulgaria

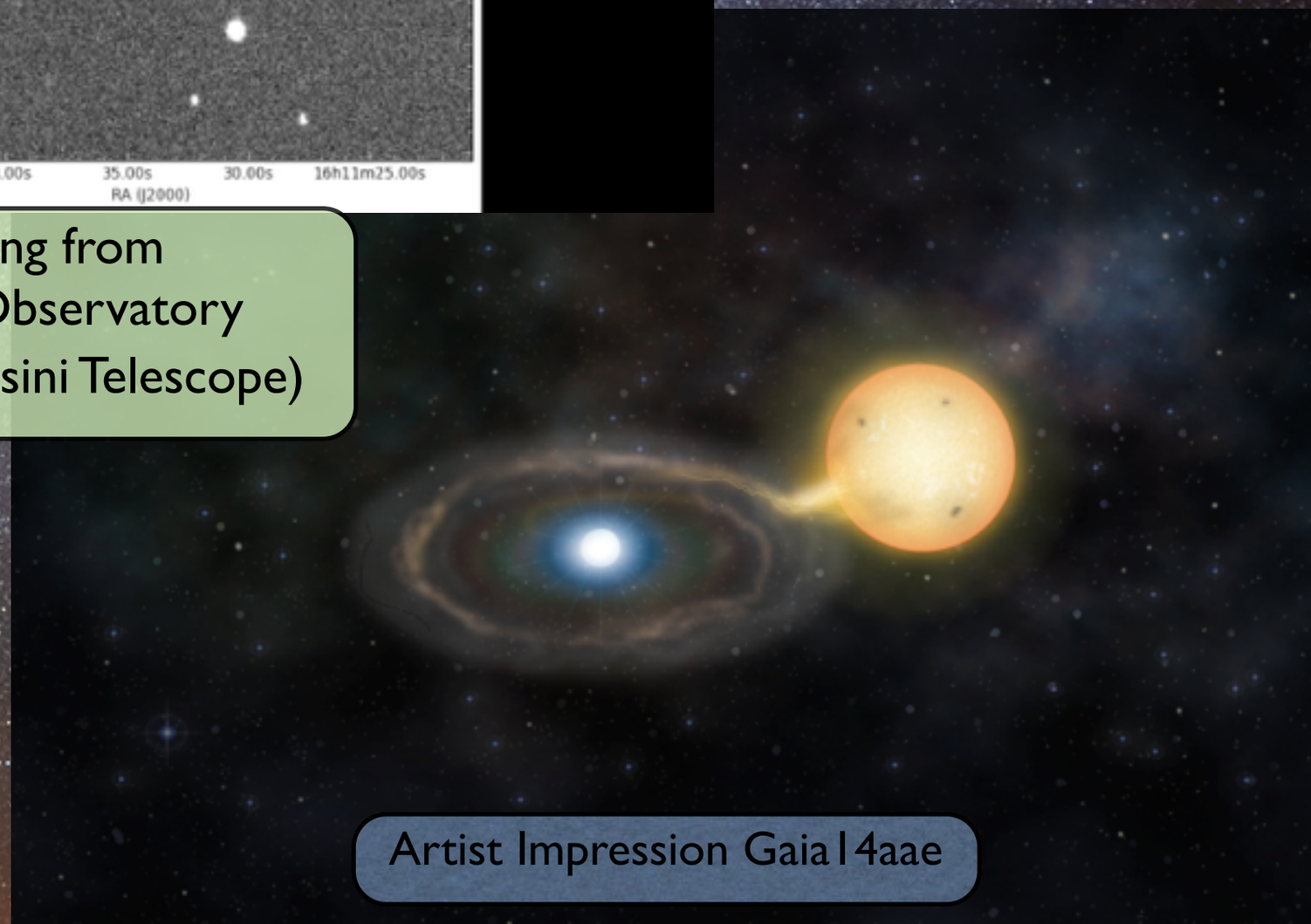
Mercator

Total eclipse of the heart: The AM CVn Gaia14aae / ASSASN-14cn

Campbell et al. 2015



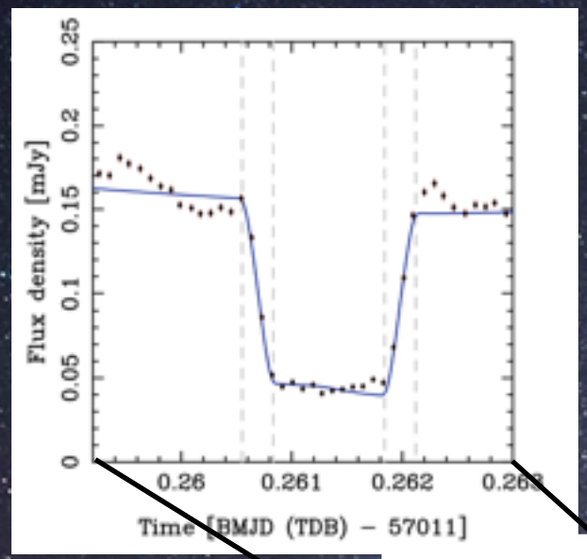
Imaging from
Loiano Observatory
(152cm Cassini Telescope)

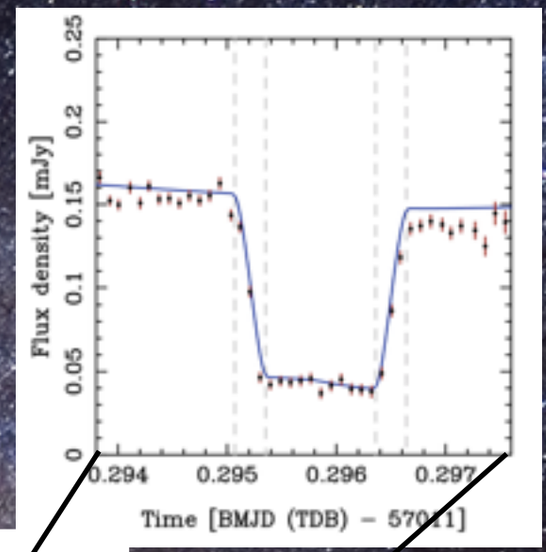


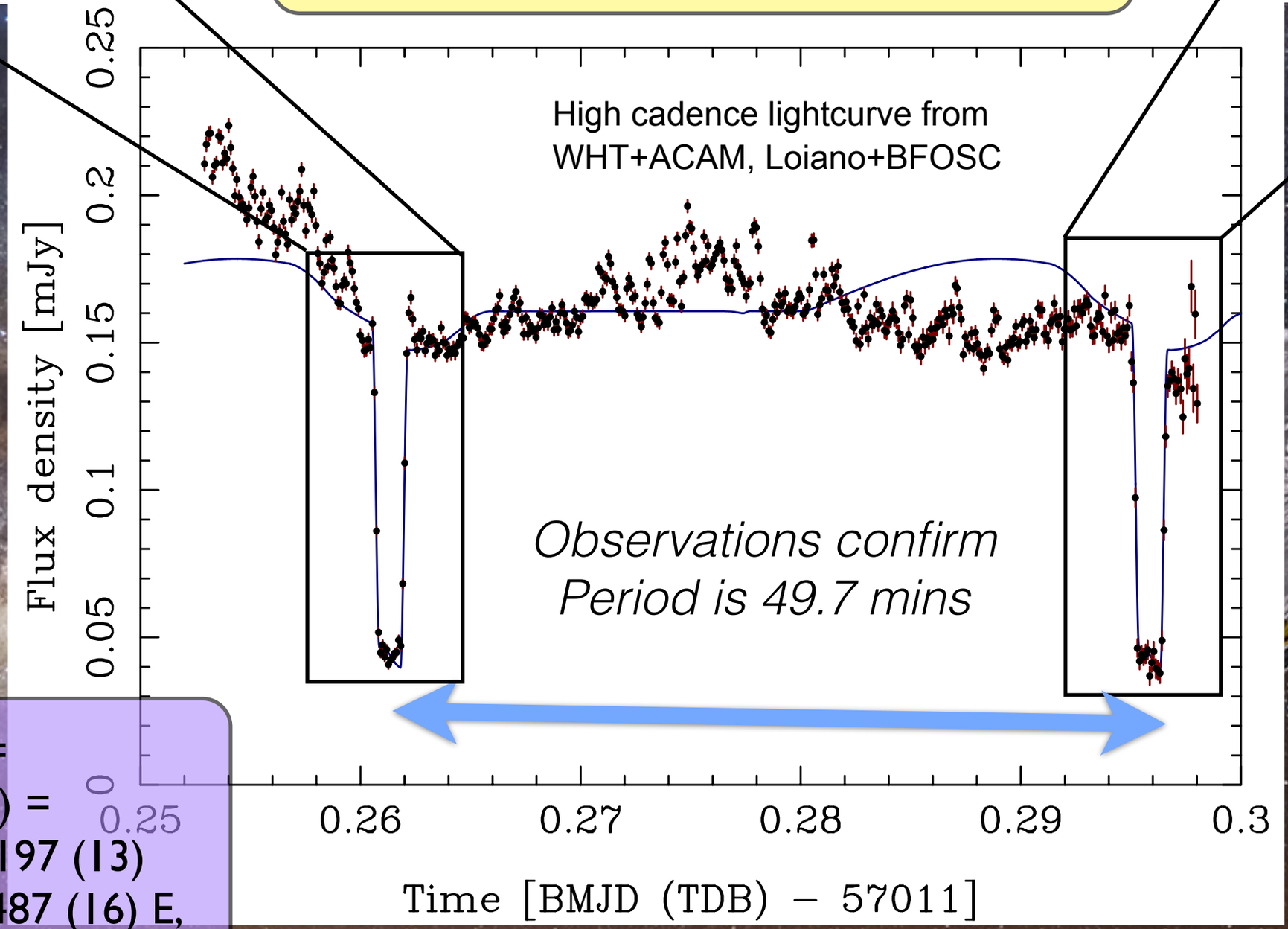
Artist Impression Gaia14aae

AM CVn Gaia14aae

Observed *r*-band WHT light curve. The best fitting model (lines) comprising of a WD, accretion disc and bright-spot where the gas stream hits the disc.



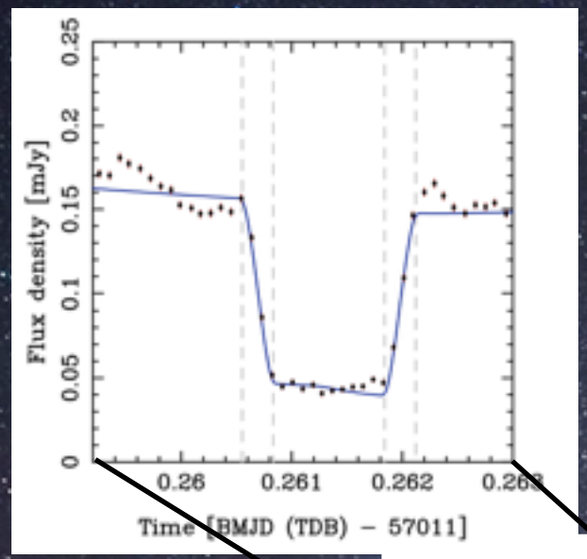


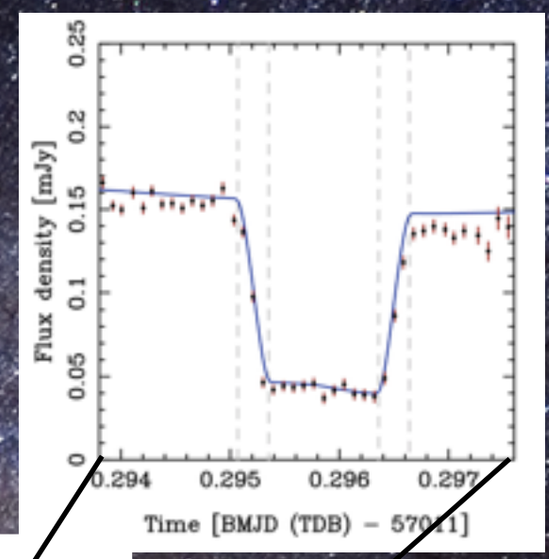


Ephemeris =
BMJD (TDB) =
56980.0557197 (13)
+ 0.034519487 (16) E,

AM CVn Gaia14aae

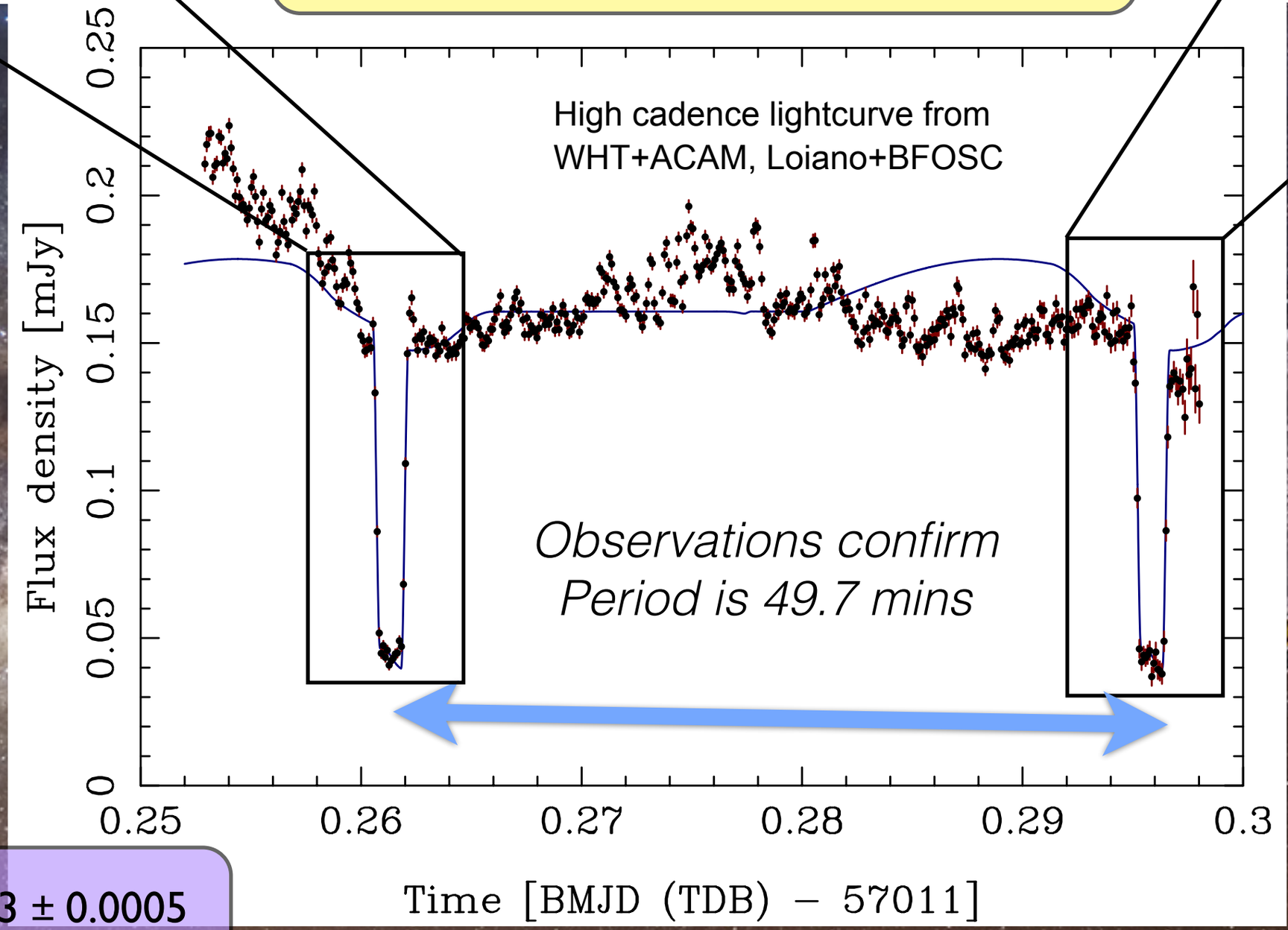
Observed *r*-band WHT light curve. The best fitting model (lines) comprising of a WD, accretion disc and bright-spot where the gas stream hits the disc.





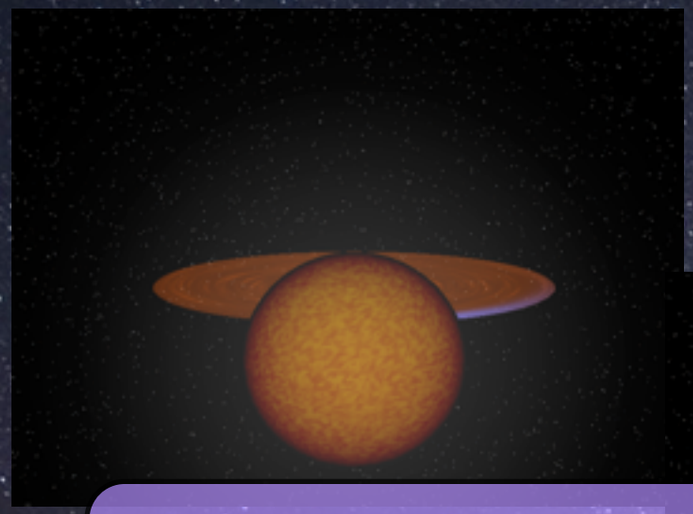
High cadence lightcurve from WHT+ACAM, Loiano+BFOSC

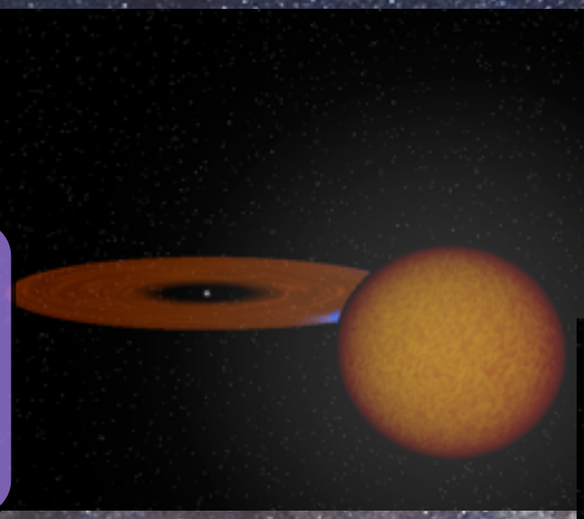
Observations confirm Period is 49.7 mins

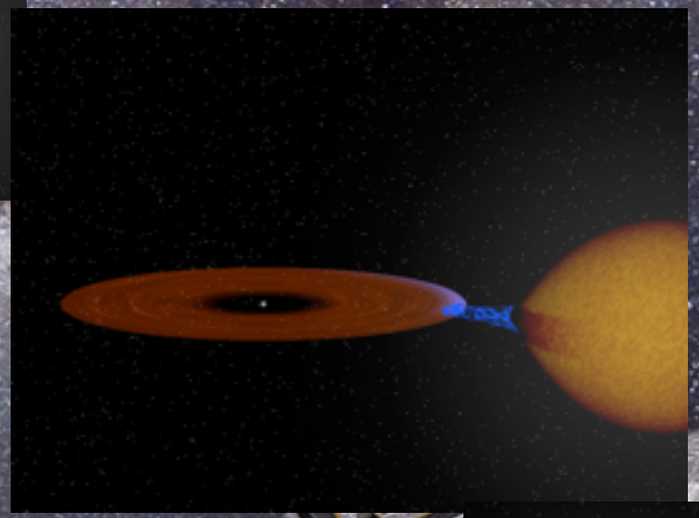


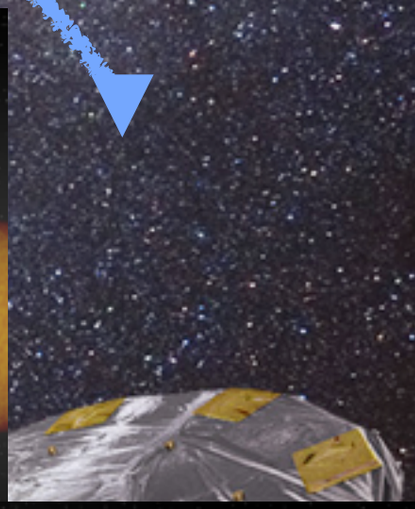
$\Delta\Phi = 0.0373 \pm 0.0005$

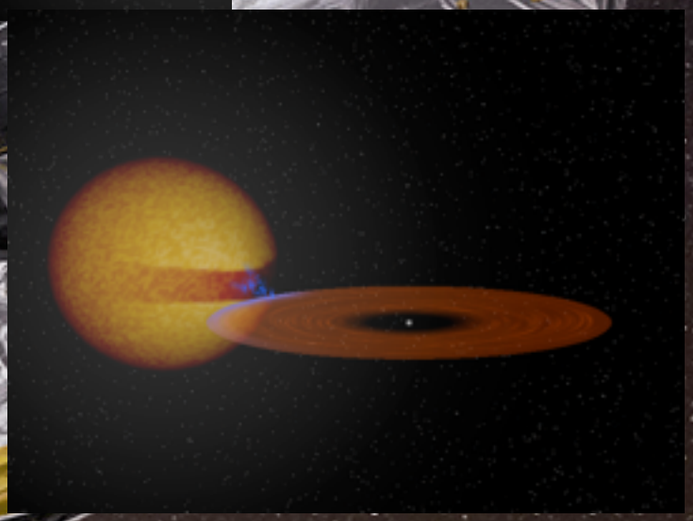
AM CVn Gaia14aae











Eclipse timing reveals orbital parameters, mass of system!

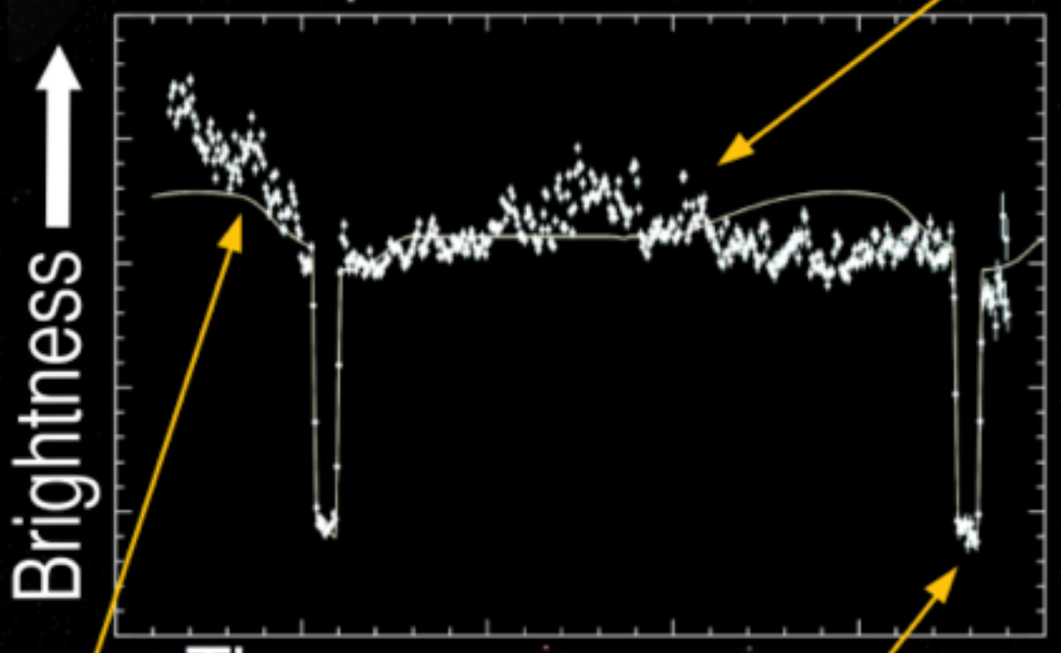
Upperlimit:
i = 80°
q = 0.133
r1 = 0.013
a = 0.488
$M_{primary}$ = 1.159 M_{sun}
Msecondary = 0.154 Msun

Lower limit:
i = 90°
q = 0.019
r1 = 0.026
a = 0.413
$M_{primary}$ = 0.782 M_{sun}
Msecondary = 0.015 Msun

More data is required to break degeneracy - See Elme Breedt's talk tomorrow

Dr Heather Campbell, IoA, Cambridge, hcc@ast.cam.ac.uk

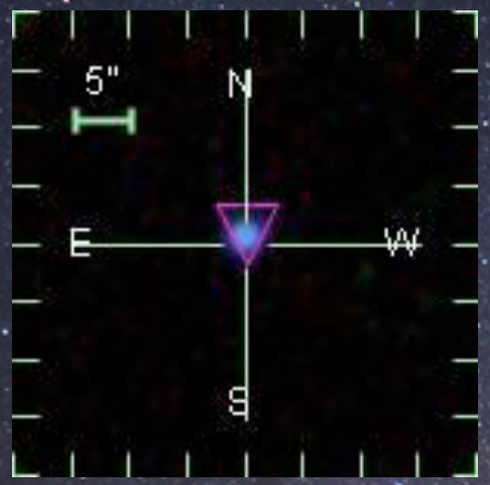
Gaia14aae



Eclipse

Credit: Fraser/Hodgkin/Campbell/BINSIM

AM CVn Gaia14aae



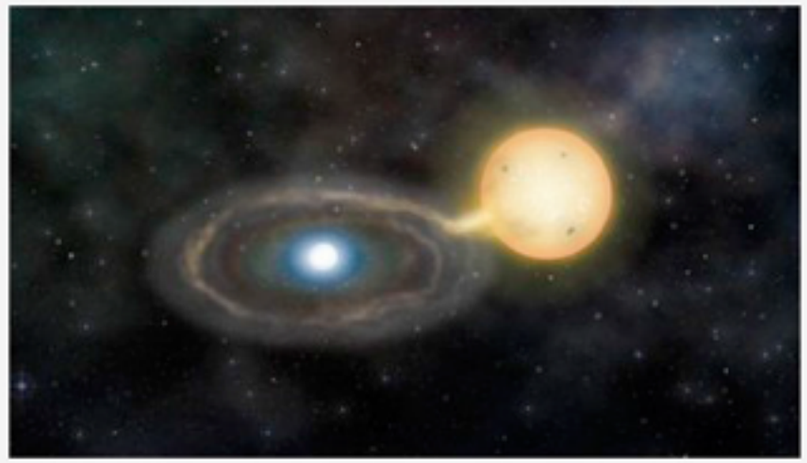
Sloan Digital Sky Survey image of the historic source

Amateurs Help Discover Rare Eclipsing Binary

By: **David Dickinson** | September 1, 2015

Amateur and professional astronomers worked together to discover a rare eclipsing binary system — and a chance to study a supernova before it happens.

A collaboration of amateur and professional astronomers has uncovered a rare variety of eclipsing binaries. The European Space Agency's Gaia satellite first imaged the eclipsing pair, named Gaia14aae, in August 2014. Researchers took notice of Gaia14aae when it suddenly flared five-fold within a single day.

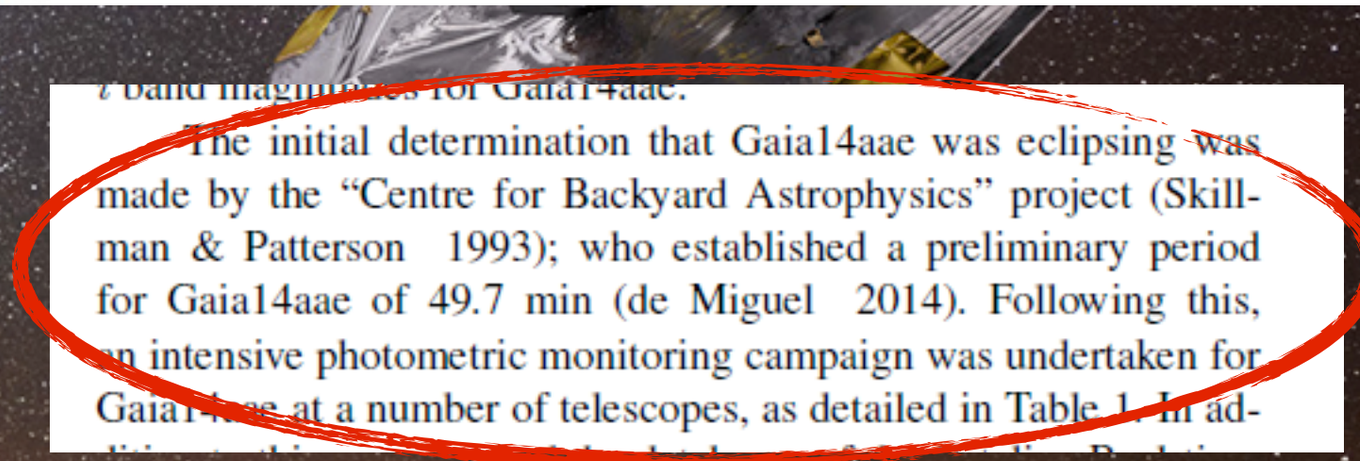


An artist's conception of the Gaia14aae star system.
Marisa Grove / Institute of Astronomy

The Gaia14aae system is composed of a white dwarf in a tight orbital embrace with a larger (by volume) companion. The tilt of orbit is along our line of sight, so observers on and near Earth — such as the Gaia mission in space — see an eclipse of the pair once every 50 minutes.

A worldwide pro-am collaboration carried out follow-up observations of Gaia14aae, cinching its nature as an eclipsing binary star. This effort included the Centre for Backyard Astrophysics (CBA), a group of amateurs who monitor cataclysmic variables using small telescopes in backyards around the world. CBA members kept eyes on the system after Gaia's initial sighting of its outburst, as did a collaboration of 86 professionals based at facilities including the Catalina Real-time Transient Survey, PanSTARRS-1, and ASAS-SN based in Chile and Hawaii.

- Articles around the press release
- Many telescopes involved created there own press releases
- Observer magazine in the Sunday Guardian on the November 22.



band magnitudes for Gaia14aae.

The initial determination that Gaia14aae was eclipsing was made by the "Centre for Backyard Astrophysics" project (Skillman & Patterson 1993); who established a preliminary period for Gaia14aae of 49.7 min (de Miguel 2014). Following this, an intensive photometric monitoring campaign was undertaken for Gaia14aae at a number of telescopes, as detailed in Table 1. In ad-

AM CVn Gaia14aae: Future data

- ★ More precise, high-cadence photometry - average out flickering, which is limiting the analysis of the light curve at present.
- ★ Vital to observe the bright spot in the system, - pin down the orientation,
- ★ Further spectra - may detect the same narrow spikes between the double-peaked emission lines that are seen in other AM CVn stars.
- ★ Spectra will also provide information on the elements present in the system, useful for understanding the evolutionary history of Gaia14aae.
- ★ Gaia will also provide parallax and proper motion
- ★ Long-term precision timing will be needed to detect the expected period change due to gravitational radiation-driven mass transfer.

Conclusions

★ 273 Alerts published

★ 112 classified

★ Mostly supernovae and CVs

★ First ever eclipsing AM CVn star - see Elme Breedt for more

★ Example of how important Amateur

★ More to come in the next few years!