Eruptive stars spectroscopy
Cataclysmics, Symbiotics, Novae, Supernovae

ARAS Eruptive Stars
Information letter n° 9 07-09-2014

News

ASASSN-14fc spectroscopically identified by Tim Lester as a CV in outburst

Symbiotic **AX Per** is in outburst

Contents

Novae

Nova Cyg 2014 : Declining with oscillations at different time scale between 10.8 and 12.2 (V) during August. Appearance of [O III] late august. Spectroscopy of this peculiar nova continues. New. Photometric data from A. Garcia and J. Guarro

Nova Cen 2013 : new spectrum by T. Bohlsen, slow spectroscopic evolution during the nebular plateau phase at mag V ~ 8.2

Nova Del 2013 : long slowly declining plateau phase at mag V ~ 12.5

It is now more than one year since the outburst of V339 Del

Symbiotics

AX Per, AG Peg, BF Cyg, CH Cyg, T CrB, CI Cyg, StHa 190, Z And

Cataclysmics

ASASSN-14fc identification by Tim Lester

Others

Microquasar **SS 433** after its short outburst in july, by P. Dubreuil and D. Boyd

Astrophysics of erupting stars

More on spectra and line formation
Application to symbiotic stars and composite spectra
By Steve Shore

Recent publications about eruptive stars

Extra :
150 years after
the first spectroscopic observation of a planetary nebula
Tribute to Williams Huggins and Margaret Lindsay Huggins

Next issue : zoom on the symbiotic nova (1979) PU Vul

ARAS Spectroscopy

ARAS Web page
http://www.astrosurf.com/aras/

ARAS Forum
http://www.spectro-aras.com/forum/

ARAS list
https://groups.yahoo.com/neo/groups/spectro-l/info

ARAS preliminary data base
http://www.astrosurf.com/aras/Aras_DataBase/DataBase.htm

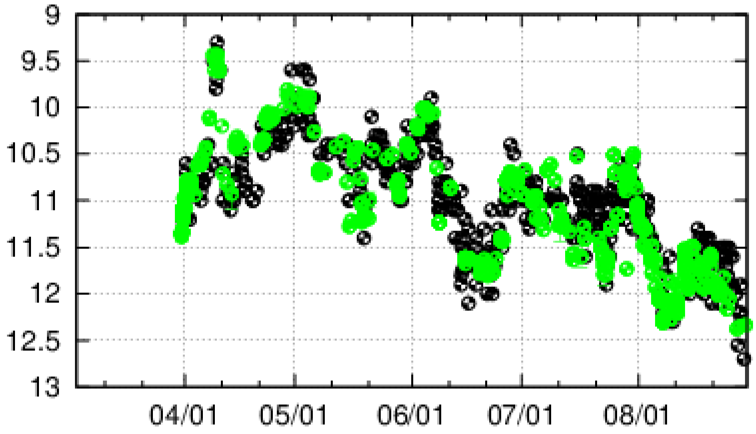
ARAS BeAM
http://arasbeam.free.fr/?lang=en

Aknowledgements : V band light curves from AAVSO photometric data base

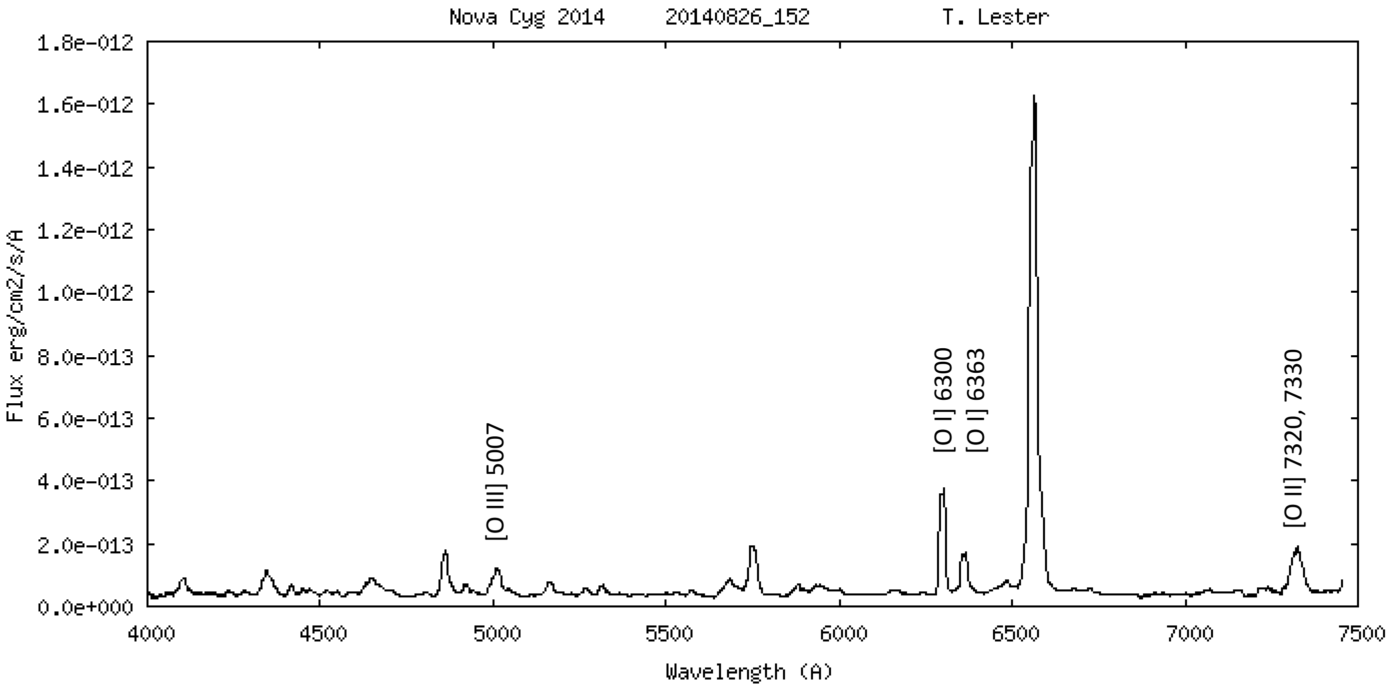
N
O
V
A
E

Nova Cyg 2014

Luminosity
Mag V = 12.3 (30-08-2014)
The nova continue its decline with strong oscillations at different time scales and intensities.



Observing : spectra required for this peculiar nova - One a day



Tim Lester's spectrum late august clearly shows the three degrees of ionization of Oxygen

Observers : Tim Lester | Christian Buil | Paul Gerlach | Olivier Garde | François Teyssier | Jacques Montier | Antonio Garcia | Joan Guarro Paolo Berardi | Franck Boubault | Peter Somogyi | Miguel Rodriguez

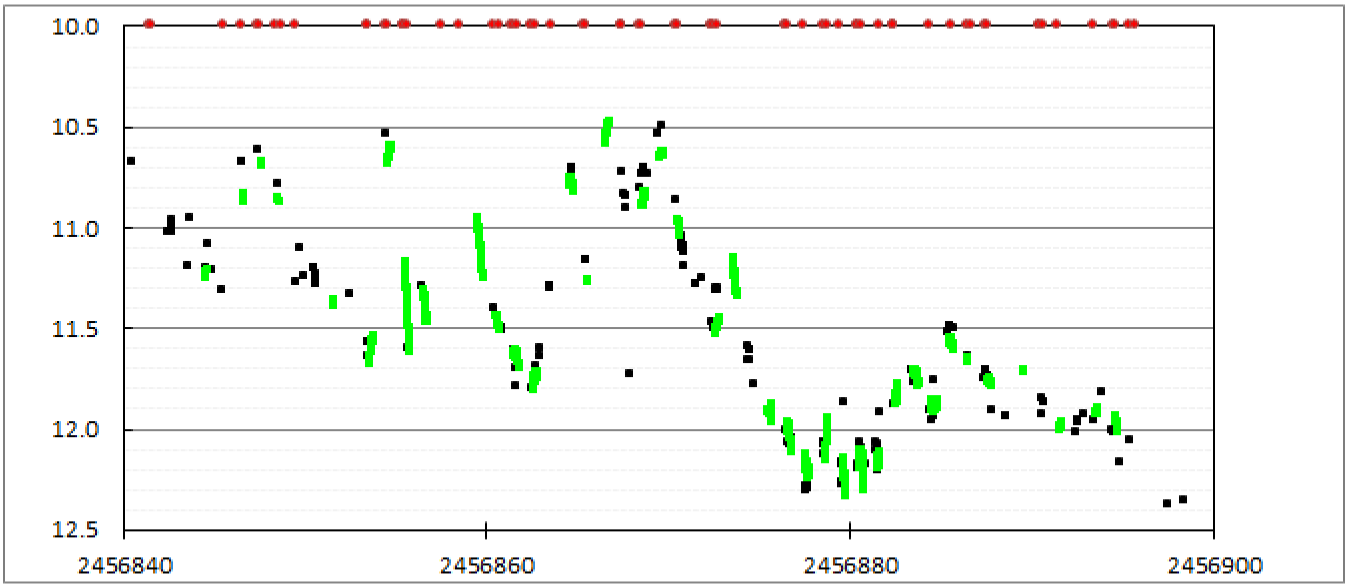
ARAS DATA BASE : 142 spectra http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cyg-2014.htm
Web Page : http://www.astrosurf.com/aras/novae/NovaCyg2014.html

N O V A E

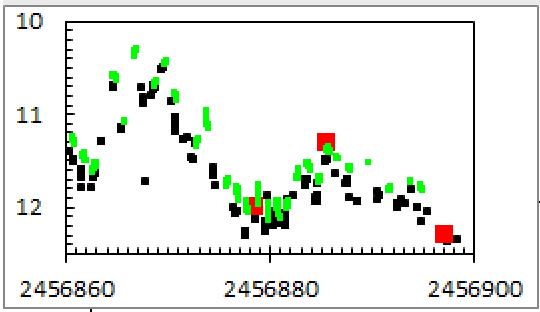
Nova Cyg 2014 Photometry by A. Garcia and J. Guarro

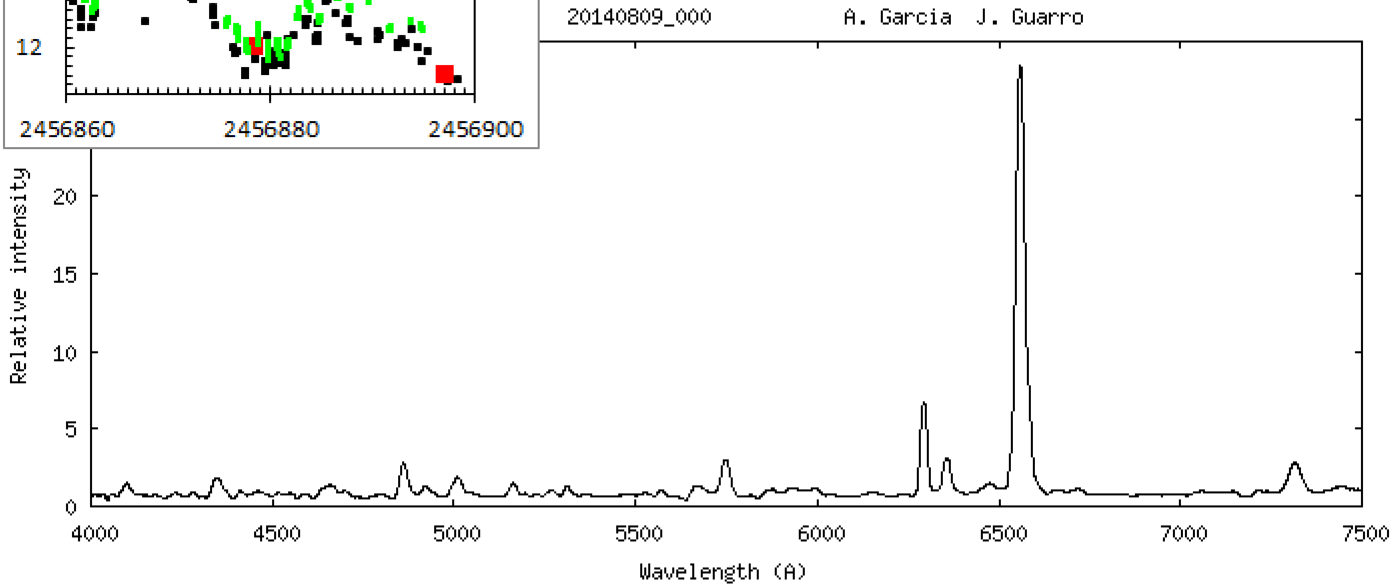
Antonio Garcia and Joan Guarro continued V band photometry time series from their remote observatory of Santa Maria (SP) in august

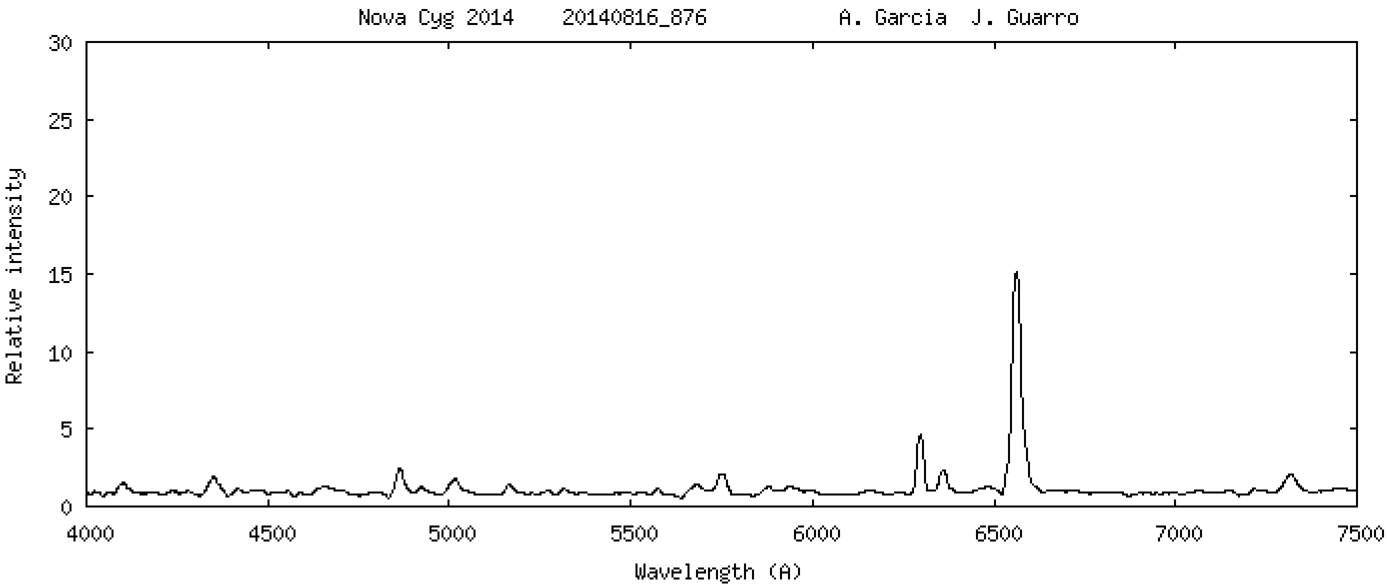
Black squares : AAVSO V Band
Green squares : A Garcia & J Guarro
Red dots : ARAS Spectra

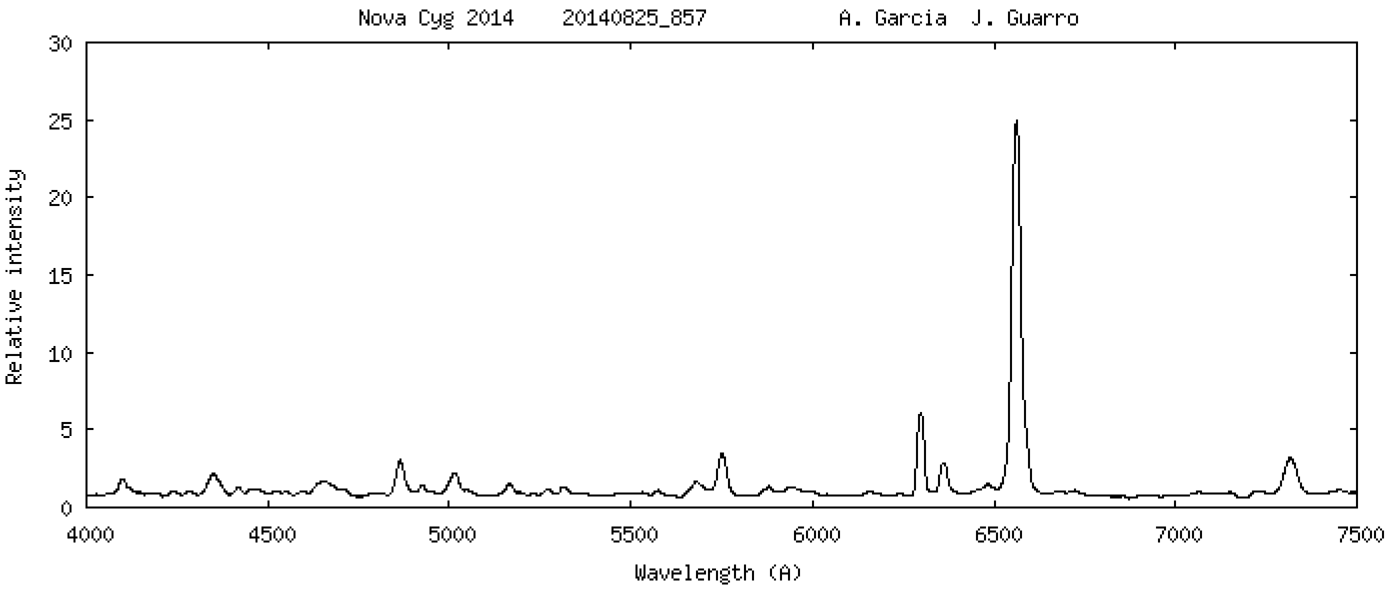


Nova Cyg 2014 evolution in August, 2014 from the series of Antonio Garcia and Joan Guarro

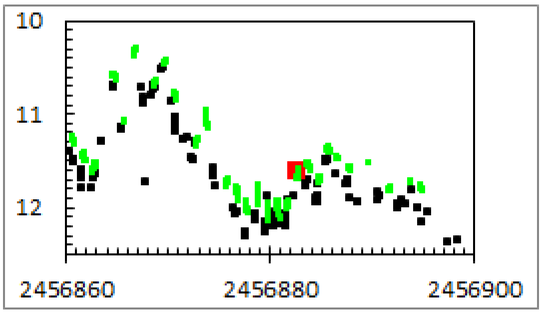




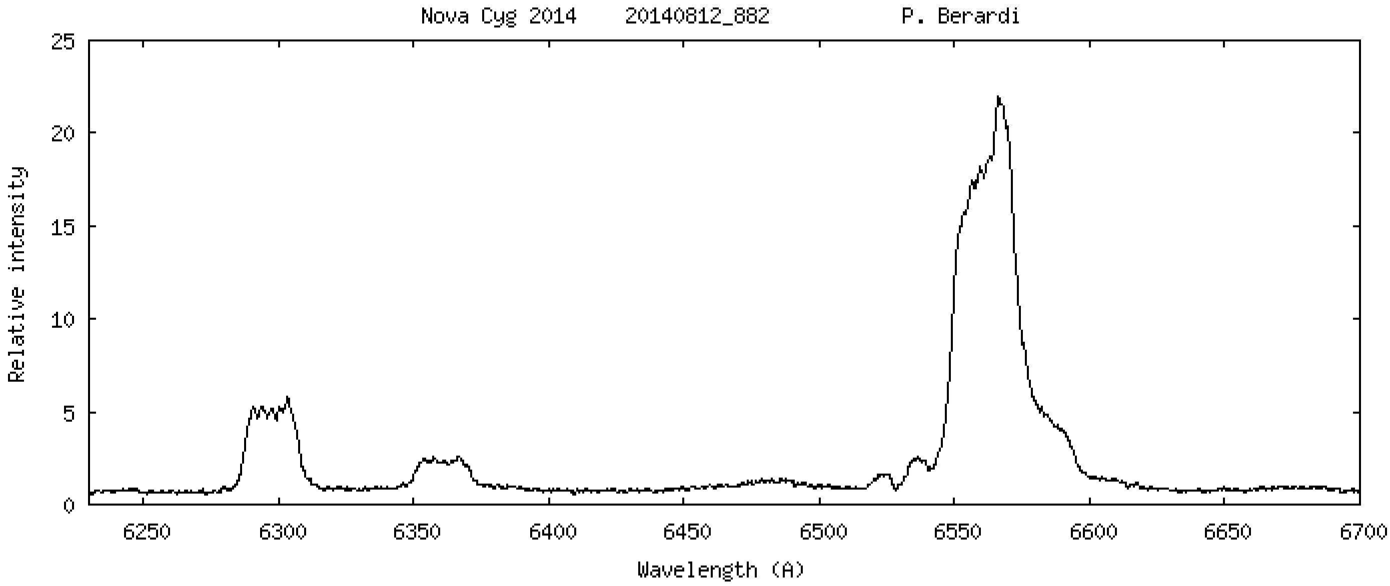


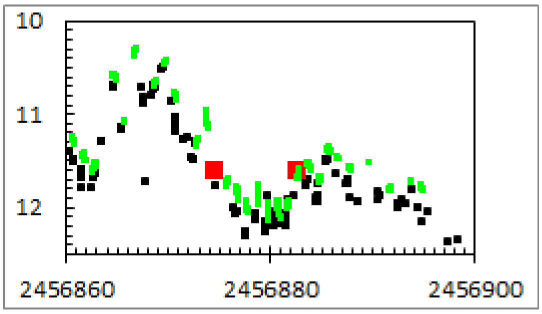


Nova Cyg 2014 evolution

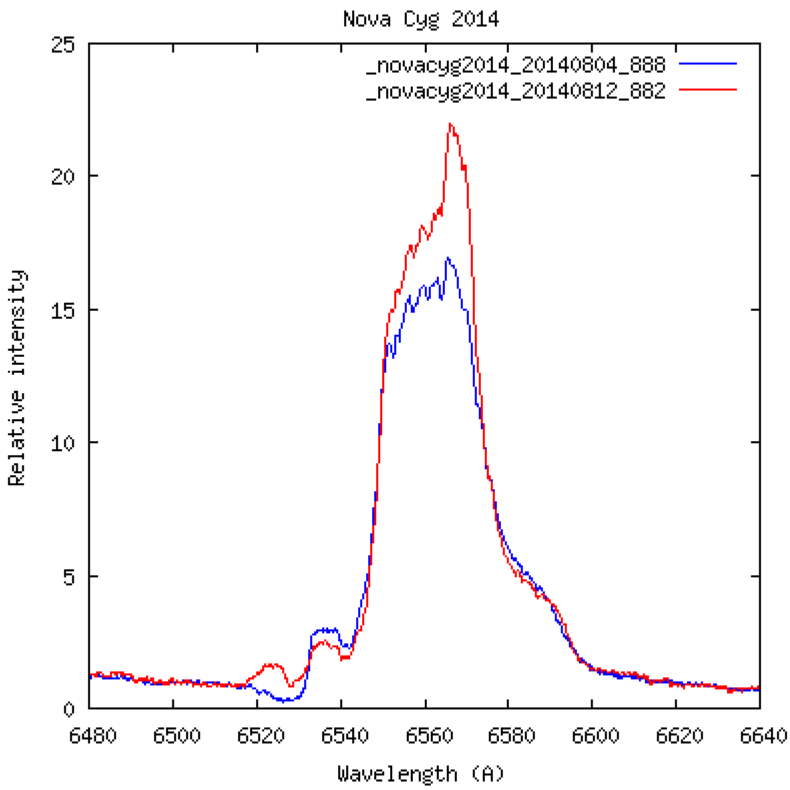


The H alpha region by Paolo Berardi at medium resolution (R = 6000) with a LHIRES 1200 l/mm.
Note the flat top of [OI] 6300, 6363



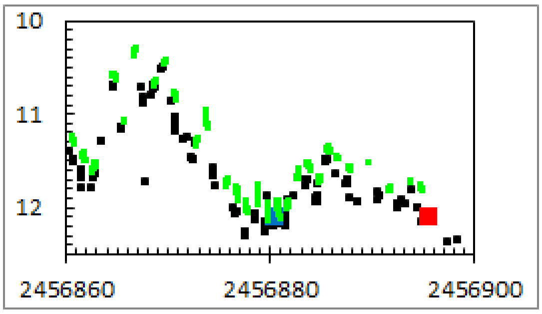


Comparison of H alpha profiles
04-08 and 12-08- 2014
Note the variation of the bluest absorption

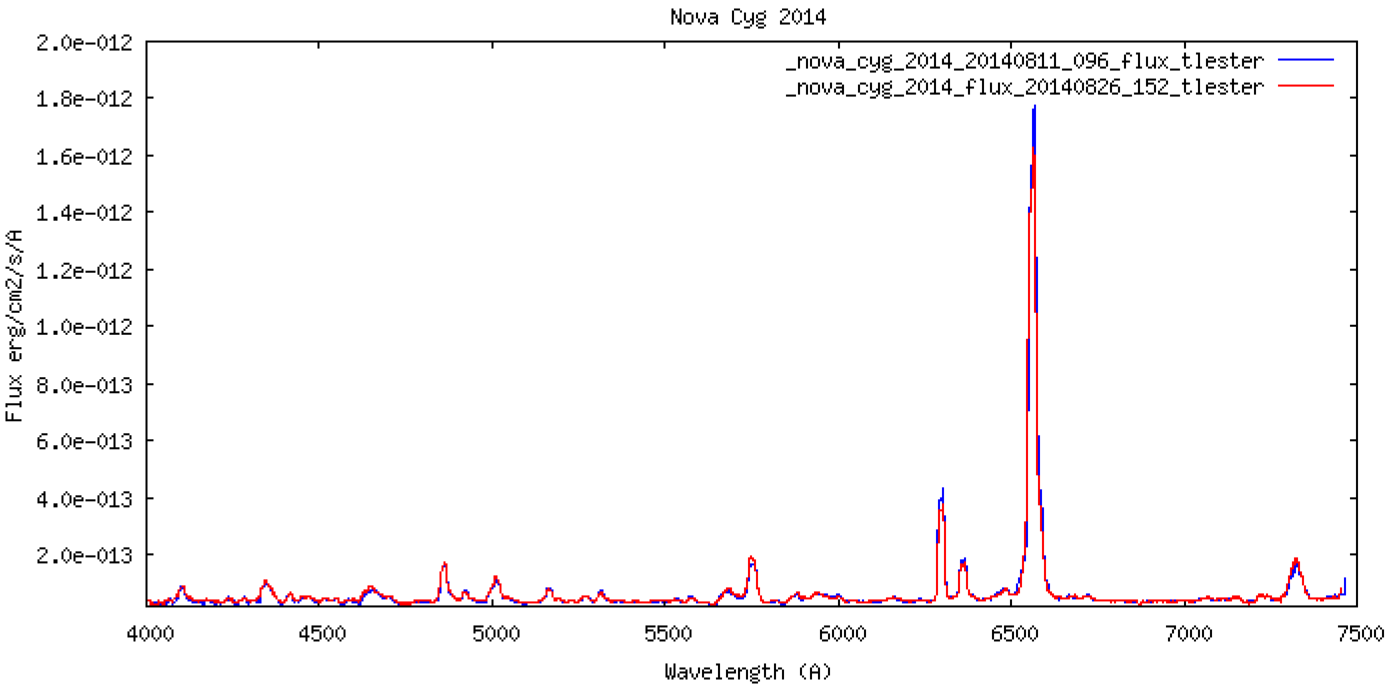


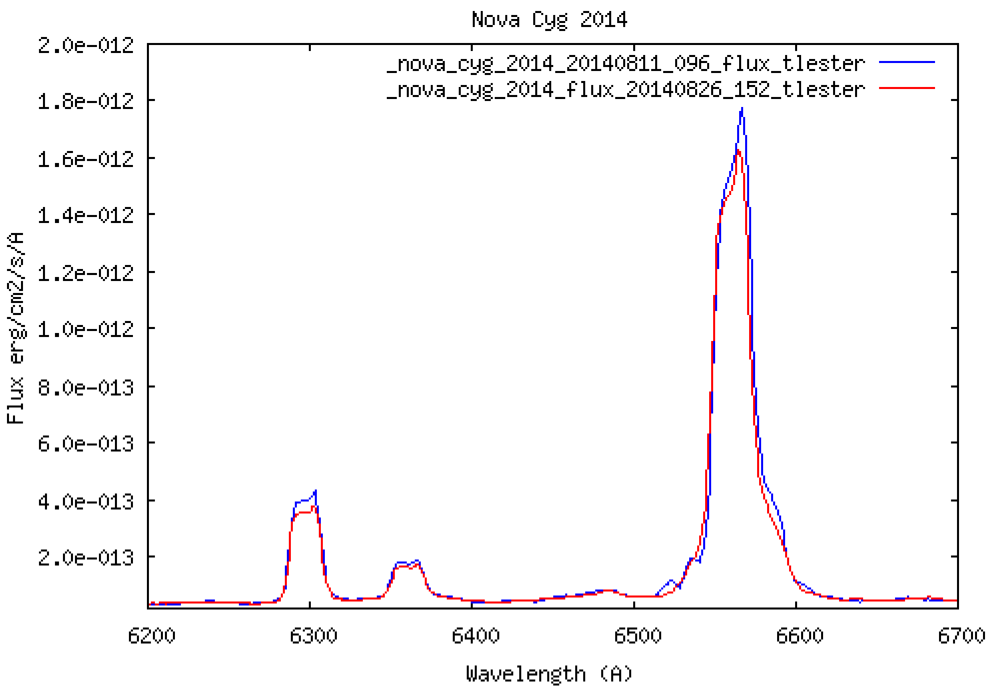
N O V A E

Nova Cyg 2014 evolution



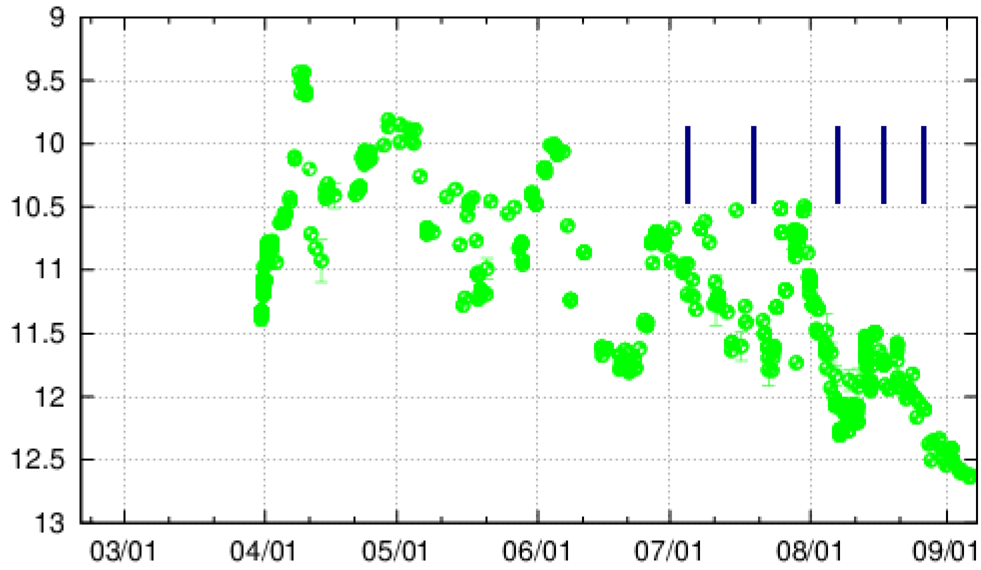
Evolution of the flux calibrated spectrum by Tim Lester. The luminosity in V band is approximately the same. The general shape is unchanged but one can observe the modification of absorption. In the blue part of Hα

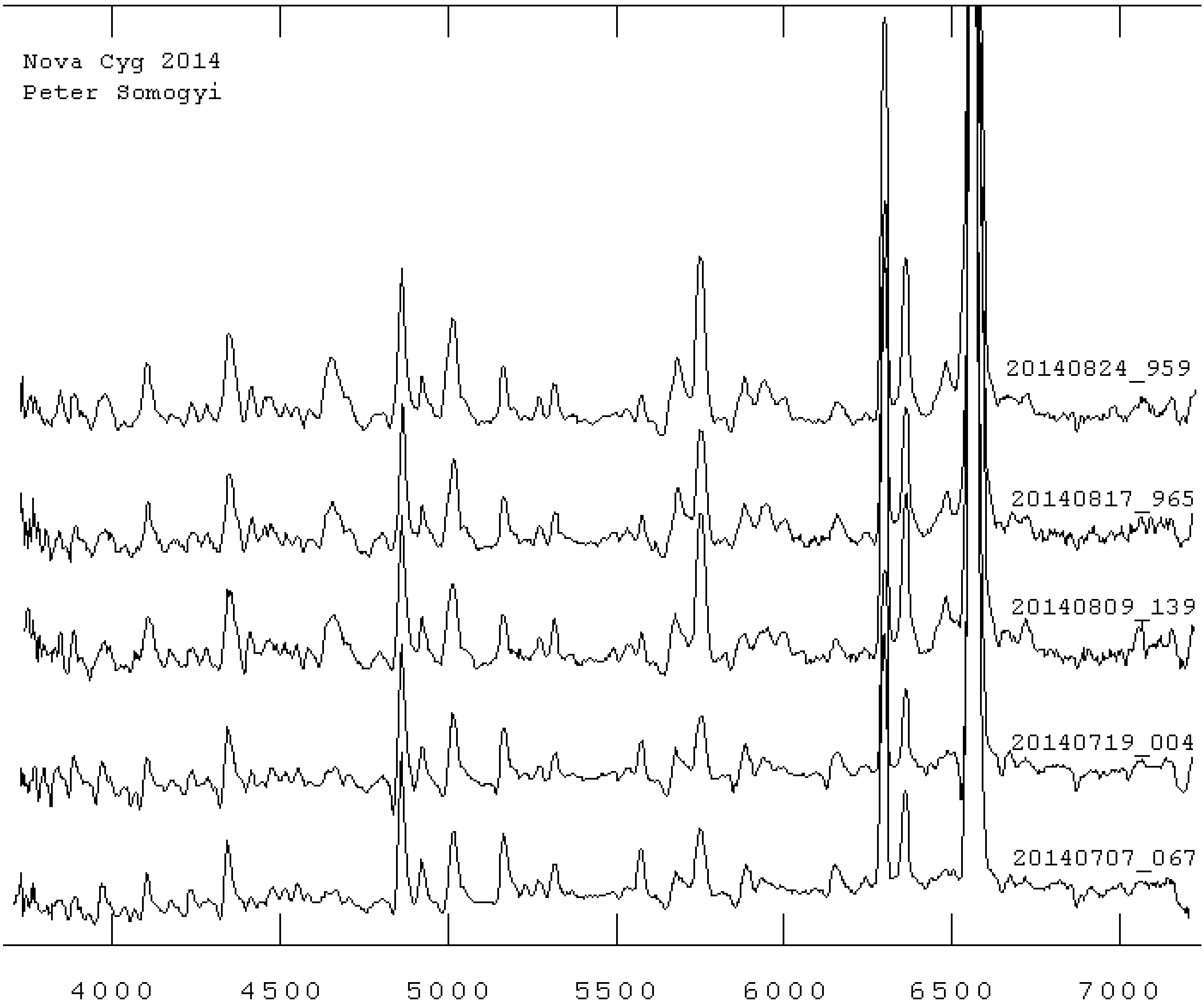




N O V A E

Nova Cyg 2014 evolution at medium resolution in July and August, 2014



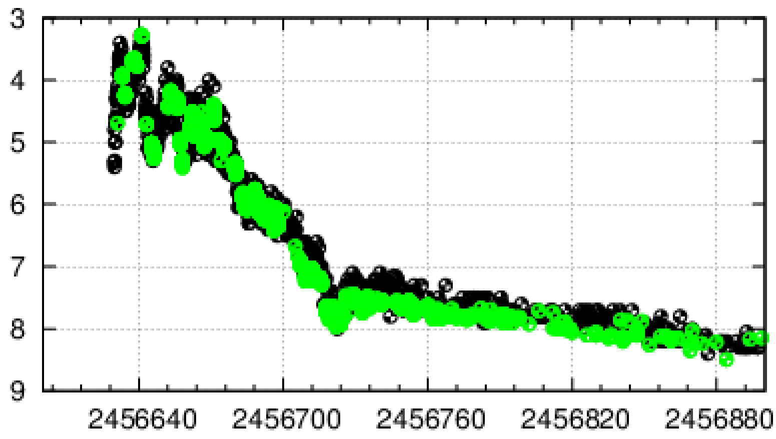


Peter Somogyi, with an Alpy 600 at R = 600

N O V A E

Nova Cen 2013 = V1369 Cen

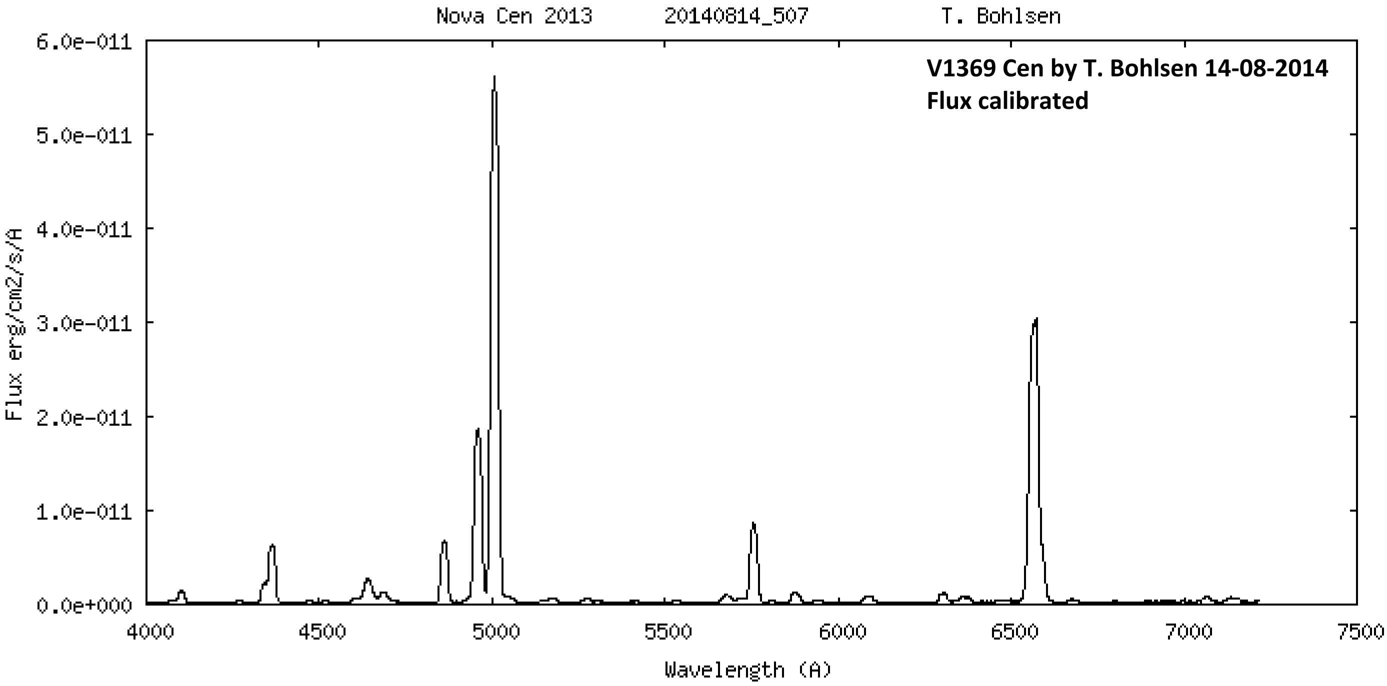
Luminosity
Mag V = 8.2 (29-08-2014)
Almost constant during august, about 4.6 mag under maximum luminosity

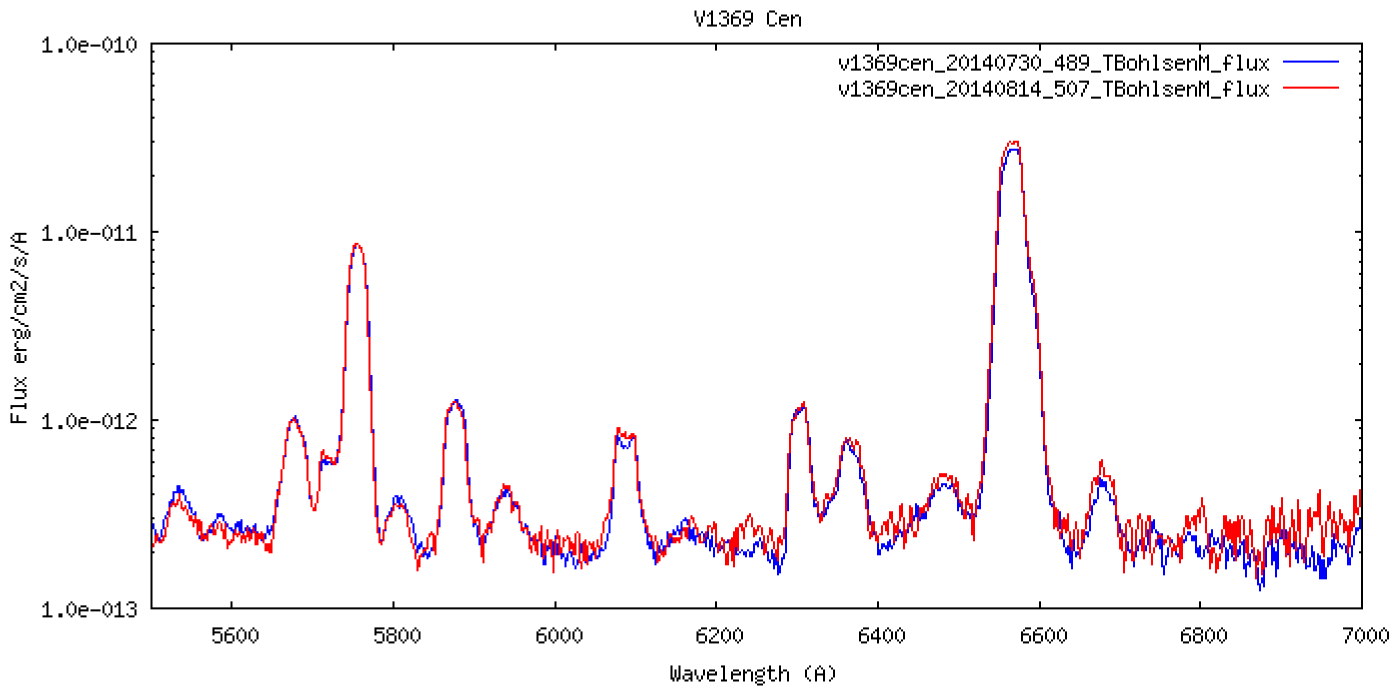


Observing

New spectrum from Terry Bohlsen

No significant evolution from 30th of july to 14th of august





V1369 Cen evolution from 30-07 to 14-08-2014 : very stable

Observers : Terry Bohlsen - Malcom Locke - Jonathan Powles - Ken Harrison - Julian West - Tasso Napoleao - Rogerio Marcon

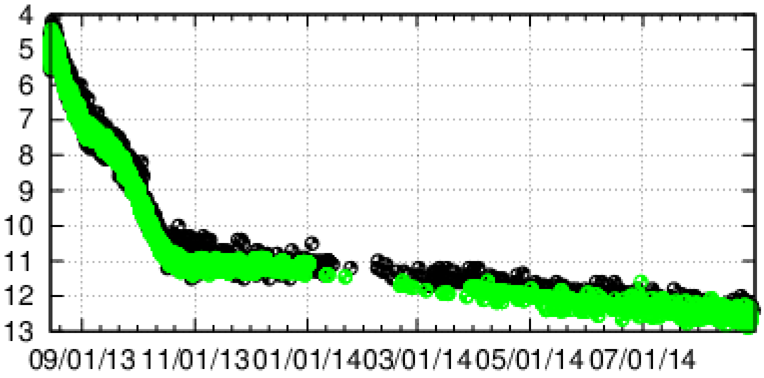
ARAS DATA BASE : 158 spectra **http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cen-2013.htm**

N O V A E

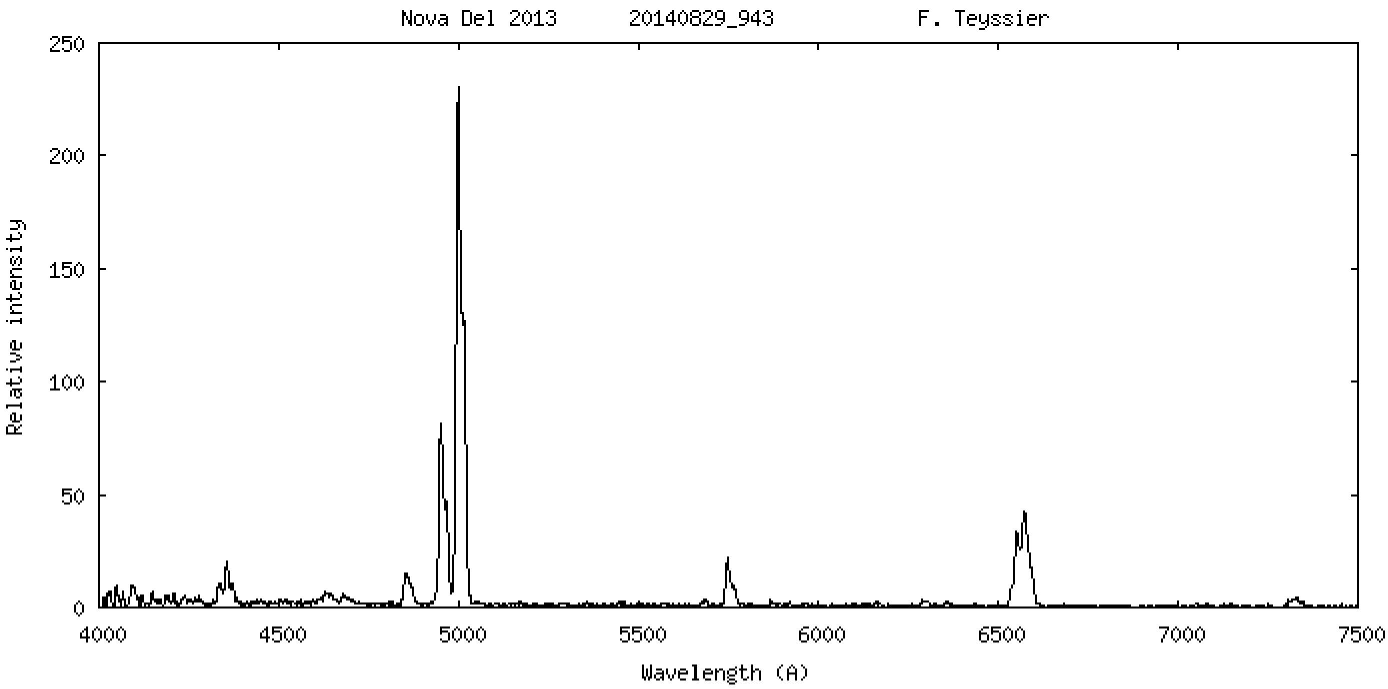
Nova Del 2013 = V339 Del

Luminosity
Mag V ~ 12.5 (30-08-2014)
Slowly declining

Observing
Spectra required (one a week)



It is now one year since Nova Del 2013 (V 339 Del) was detected and its first spectrum obtained in the night of 14th august, 2013.
At date, 1136 spectra have been collected in ARAS Database



Nova Del 2013, in its nebular phase, on year and a few days after its outburst.
The [OIII] 5007/Hβ ratio is > 11

Observers (2014) : C. Buil - T. Lester - F. Teyssier - D. Boyd - A. Garcia O. Garde - T. Bohlsen - P. Berardi - M. Dubs

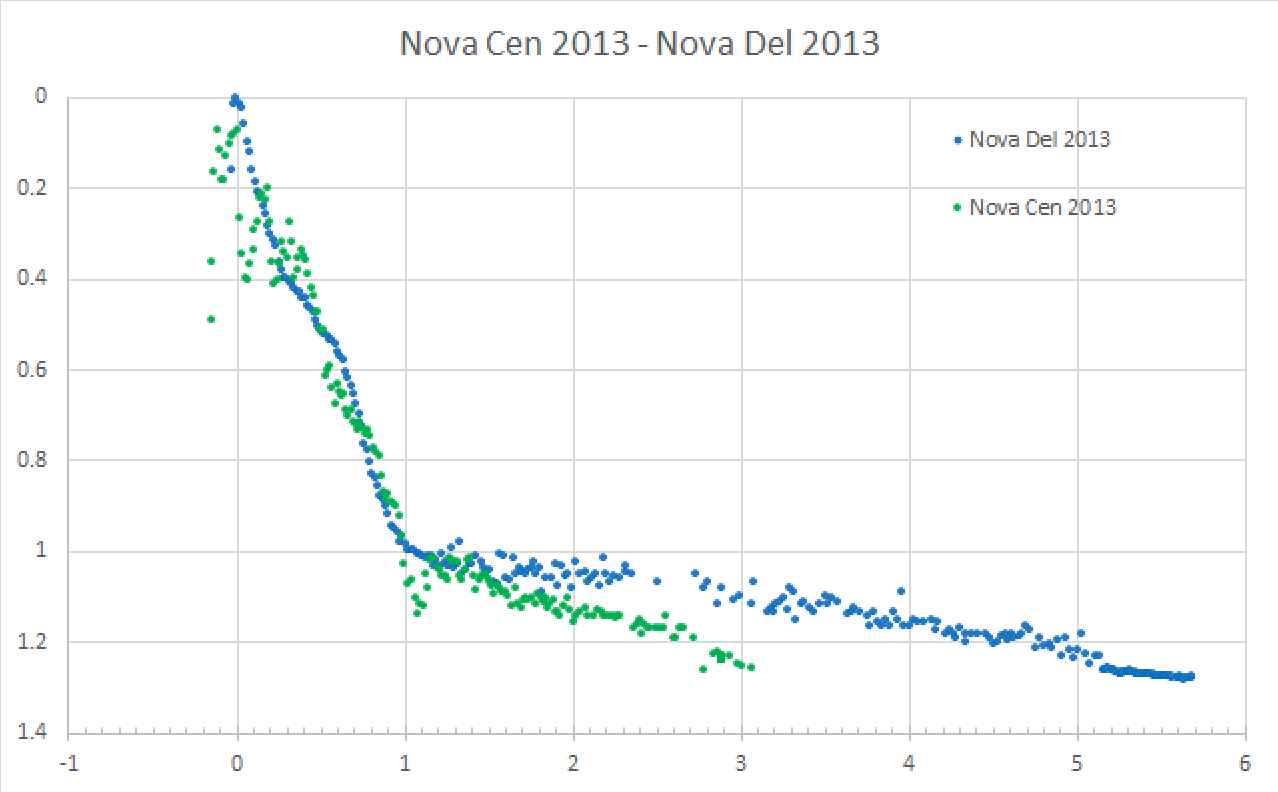
ARAS DATA BASE 2014 | 27 spectra | http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Del-2013_2.htm
ARAS Web Page for Nova Del 2013 : http://www.astrosurf.com/aras/novae/Nova2013Del.html

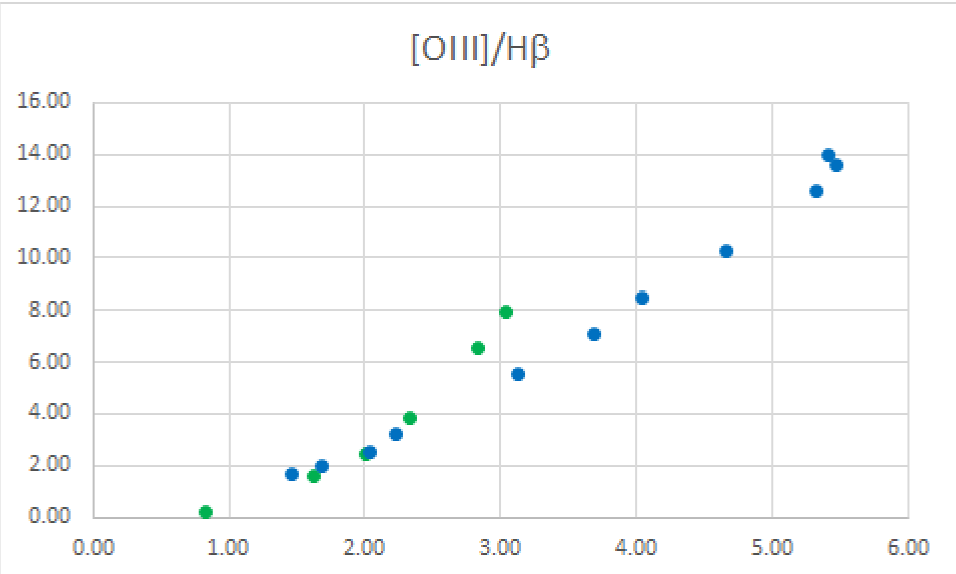
N O V A E

Comparison of the V light curves of Nova Cen 2013 and Nova Del 2013

V band light curves (from AAVSO data)
The origin (0,0) is maximum luminosity
The light curves are normalized : (1,1) is the break point between the first decline and the transition phase

	X = 1	Y = 1
Nova Del 2013	64 days	Δmag = 6
Nova Cyg 2013	76 days	Δmag = 3.8





[OIII] / Hβ ratio
for Nova Del 2013 (blue) and Nova Cen 2013 (green)
Abcissa axis in normalized unit defined for V light curves

Selected list of bright symbiotics stars of interest

Target						Refrence Star					
#	Name	AD (2000)	DE (2000)	Mag V *	Interest	Name	AD (2000)	DE (2000)	Mag V	E(B-V)	Sp Type
1	AX Per	1 36 22.7	54 15 2.5	11.6	++	HD 6961	01 11 06.2	+ 55 08 59.6	4.33	0	A7V
2	UV Aur	5 21 48.8	32 30 43.1	10		HD 39357	05 53 19.6	+ 27 36 44.1	4.557		A0V
3	ZZ CMi	7 24 13.9	8 53 51.7	10.2		HD 61887	07 41 35.2	+ 03 37 29.2	5.955		A0V
4	BX Mon	7 25 24	-3 36 0	10.4	+	HD 55185	07 11 51.9	- 00 29 34.0	4.15		A2V
5	V694 Mon	7 25 51.2	-7 44 8	10.5	++	HD 55185	07 11 51.9	- 00 29 34.0	4.15		A2V
6	NQ Gem	7 31 54.5	24 30 12.5	8.2		HD 64145	07 53 29.8	+ 26 45 56.8	4.977		A3V
7	T CrB	15 59 30.1	25 55 12.6	10.4	++	HD 143894	16 02 17.7	+ 22 48 16.0	4.817	0	A3V
8	AG Dra	16 1 40.5	66 48 9.5	9.7	++	HD 145454	16 06 19.7	+ 67 48 36.5	5.439	0	A0Vn
9	RS Oph	17 50 13.2	-6 42 28.4	10.4	++	HD 164577	18 01 45.2	+ 01 18 18.3	4.439	0	A2Vn
10	YY Her	18 14 34.3	20 59 20	12.9	++	HD 166014	18 07 32.6	+ 28 45 45.0	3.837	0.02	B9.5V
11	V443 Her	18 22 8.4	23 27 20	11.3	++	HD 171623	18 35 12.6	+ 18 12 12.3	5.79	0	A0Vn
12	BF Cyg	19 23 53.4	29 40 25.1	10.8	++	HD 180317	19 15 17.4	+ 21 13 55.6	5.654	0	A4V
13	CH Cyg	19 24 33	50 14 29.1	7	+	HD 184006	19 29 42.4	+ 51 43 47.2	3.769	0	A5V
14	CI Cyg	19 50 11.8	35 41 3.2	10.5	++	HD 187235	19 47 27.8	+ 38 24 27.4	5.826	0.02	B8Vn
15	StHA 190	21 41 44.8	2 43 54.4	10.3	+	HD 207203	21 47 14.0	+ 02 41 10.0	5.631	0	A1V
16	AG Peg	21 51 1.9	12 37 29.4	8.6	++	HD 208565	21 56 56.4	+ 12 04 35.4	5.544	0	A2Vnn
18	Z And	23 33 39.5	48 49 5.4	9.65	++	HD 222439	23 40 24.5	+ 44 20 02.2	4.137	0	A0V
19	R Aqr	23 43 49.4	-15 17 4.2	9.9	++	HD 222847	23 44 12.1	- 18 16 37.0	5.235	0	B9V

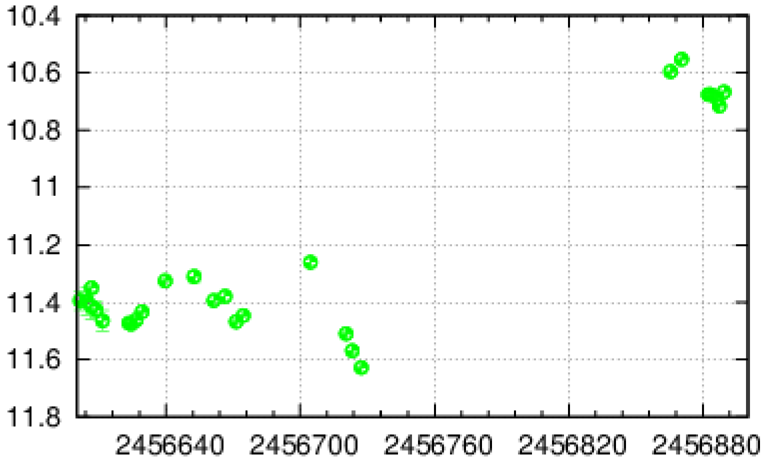
Mag V * : 01-04-2014

Observations
from 01-08 to 31-08-2014

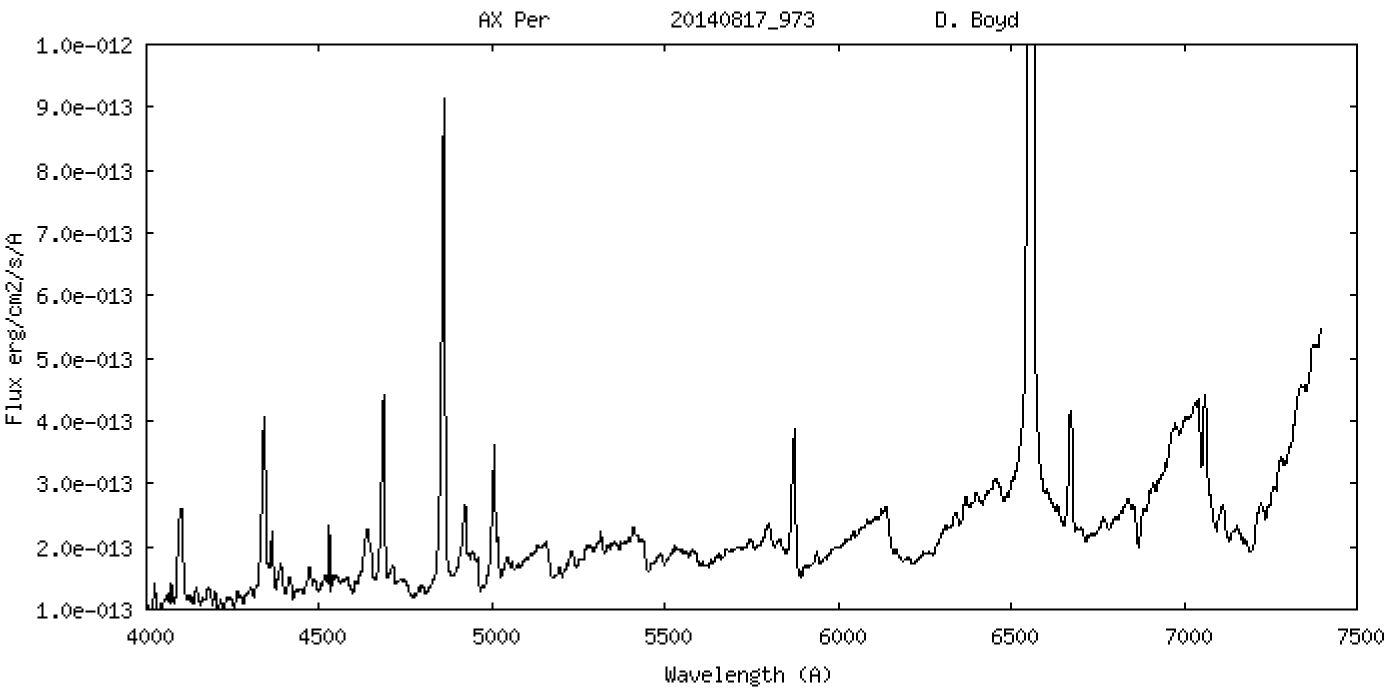
New spectra
AG Peg
AX Per
BF Cyg
CH Cyg
CI Cyg
PU Vul
StHa 190
Z And
T CrB

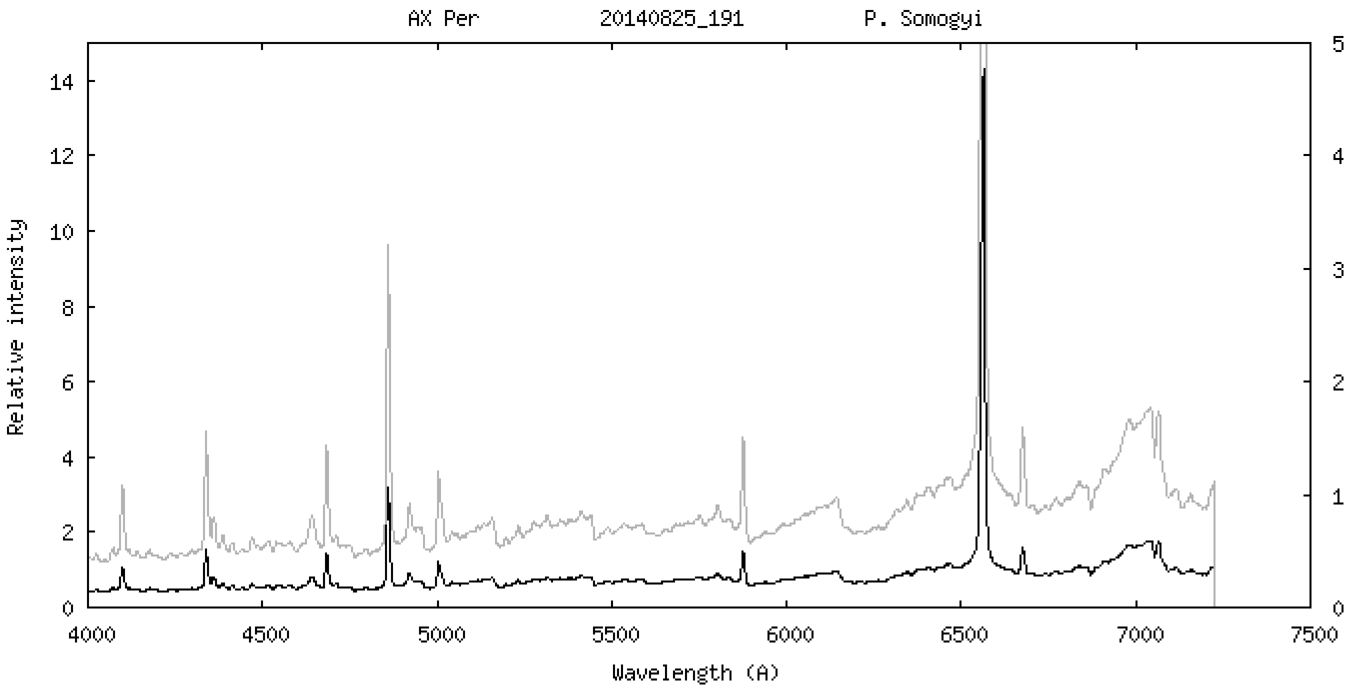
AX Per Outburst

The prototype Symbiotic **AX Per** has been detected in outburst by ANS collaboration
See ATel #6382
The current mag is about 10.7 (declining)
Spectra of this event are welcome for ARAS data base Data Base AX Per
Aras topic for exchanges Forum



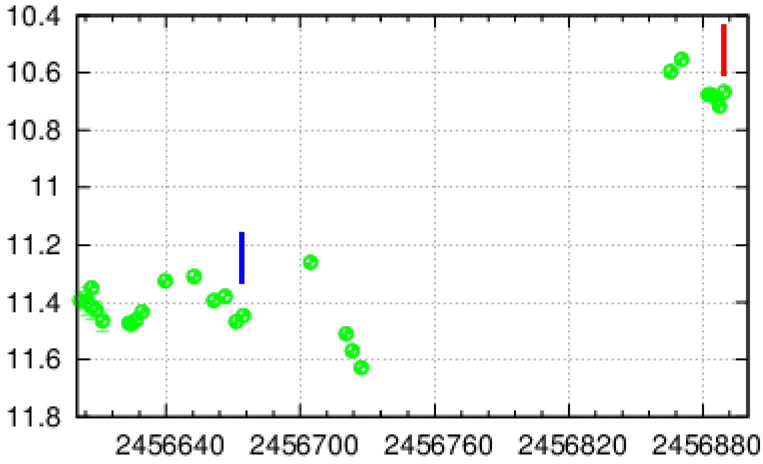
Coordinates (2000.0)	
R.A.	01 h 36 m 22.7 s
Dec.	+54° 15' 2.5"

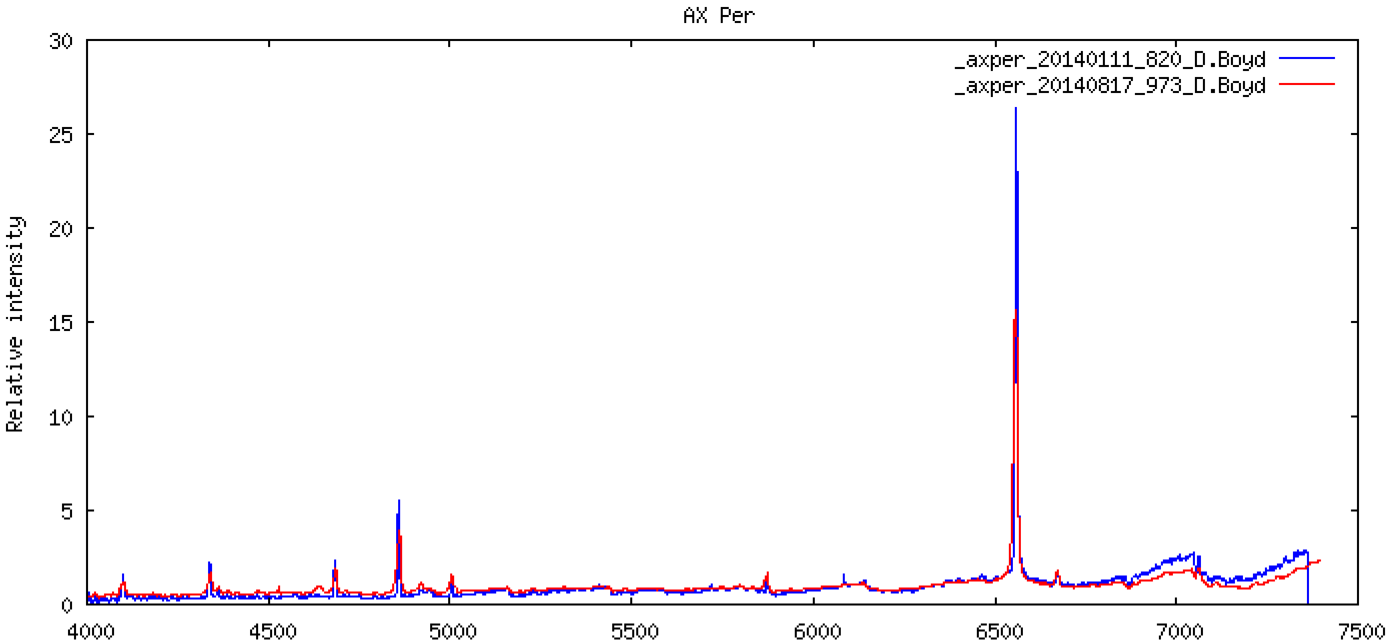


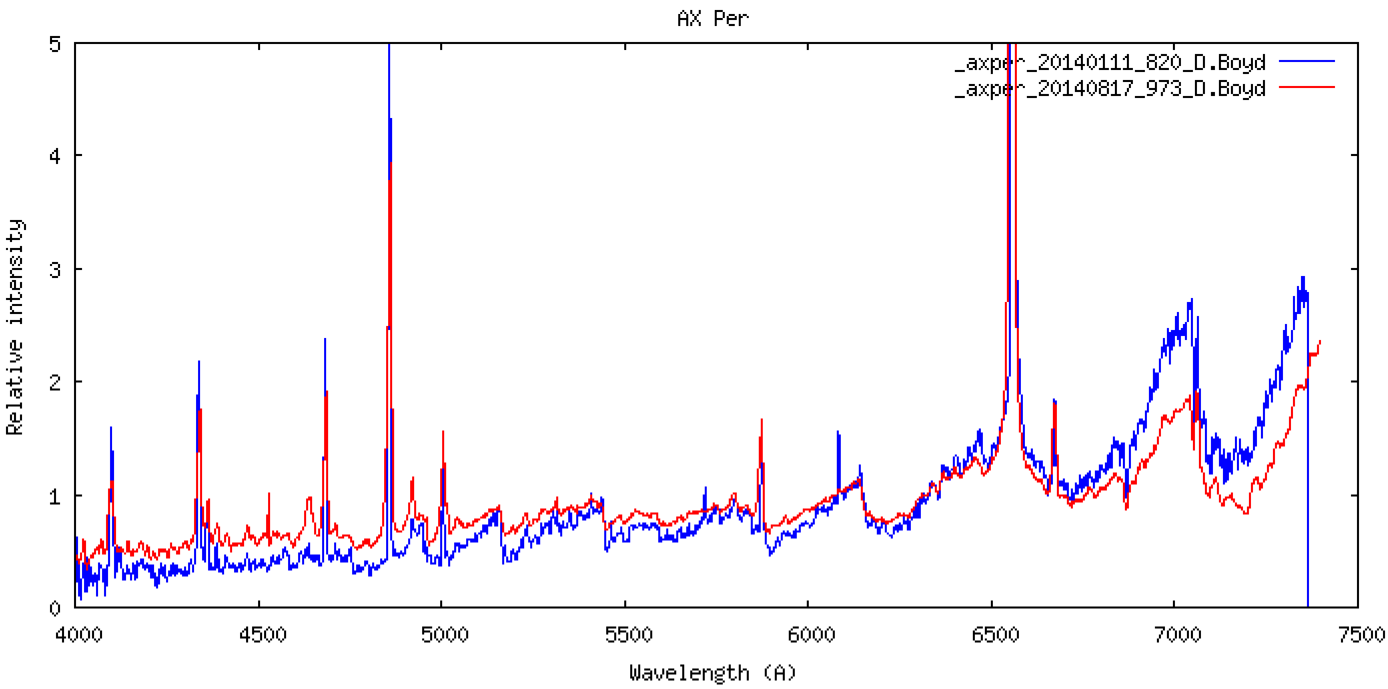


AX Per Outburst

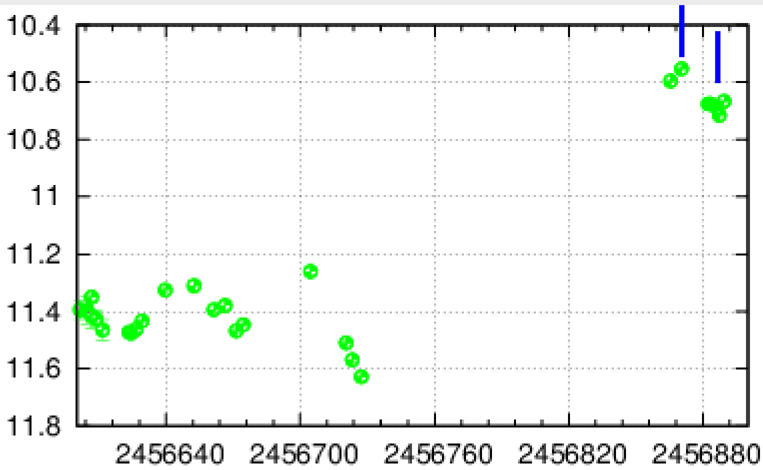
Comparison of low (11-01-2014) and high state (17-08-2014) throw spectra of David Boyd. Note the fading of TiO bands, the disappearance of [Fe VII] 5721, 6087 lines (cooling of the hot star during the outburst), development of CIII/NIII 4640-4650 blend.



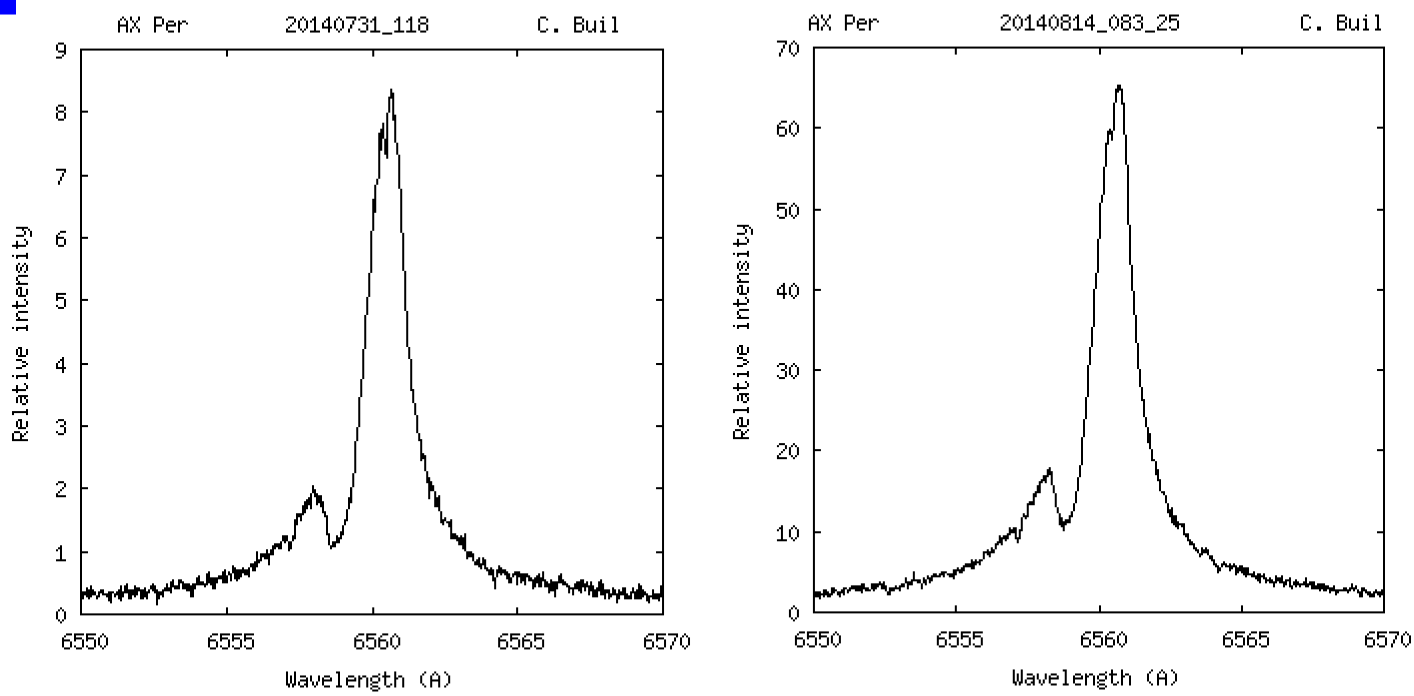




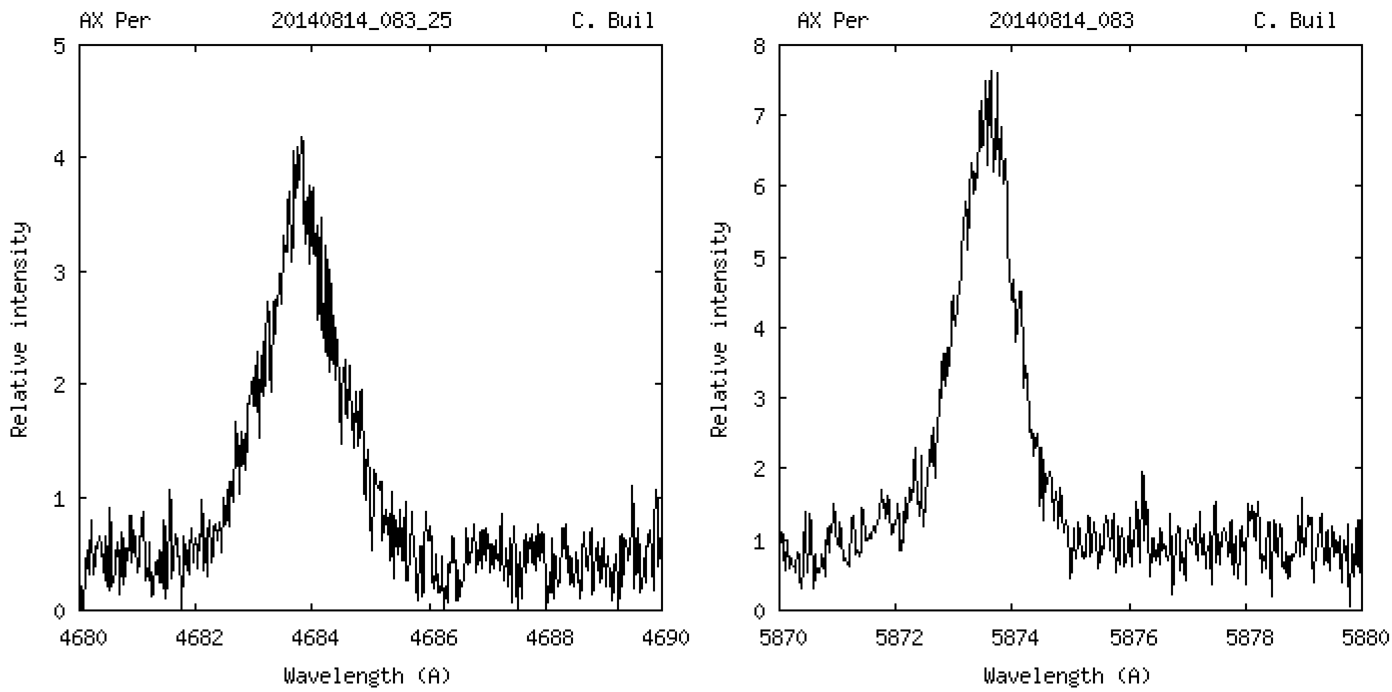
AX Per Outburst Very high resolution spectra (R = 50 000) by C. Buil



AX Per at very high resolution during its outburst
No significant change in Ha profile from 31-07 to 14-08

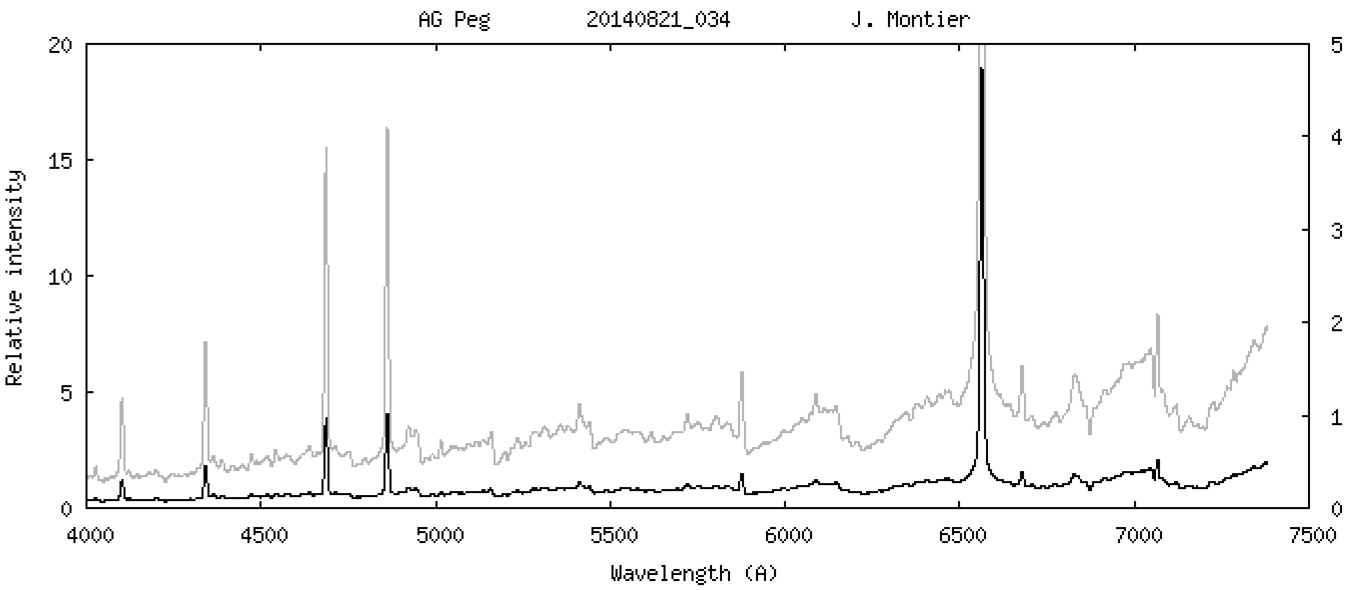


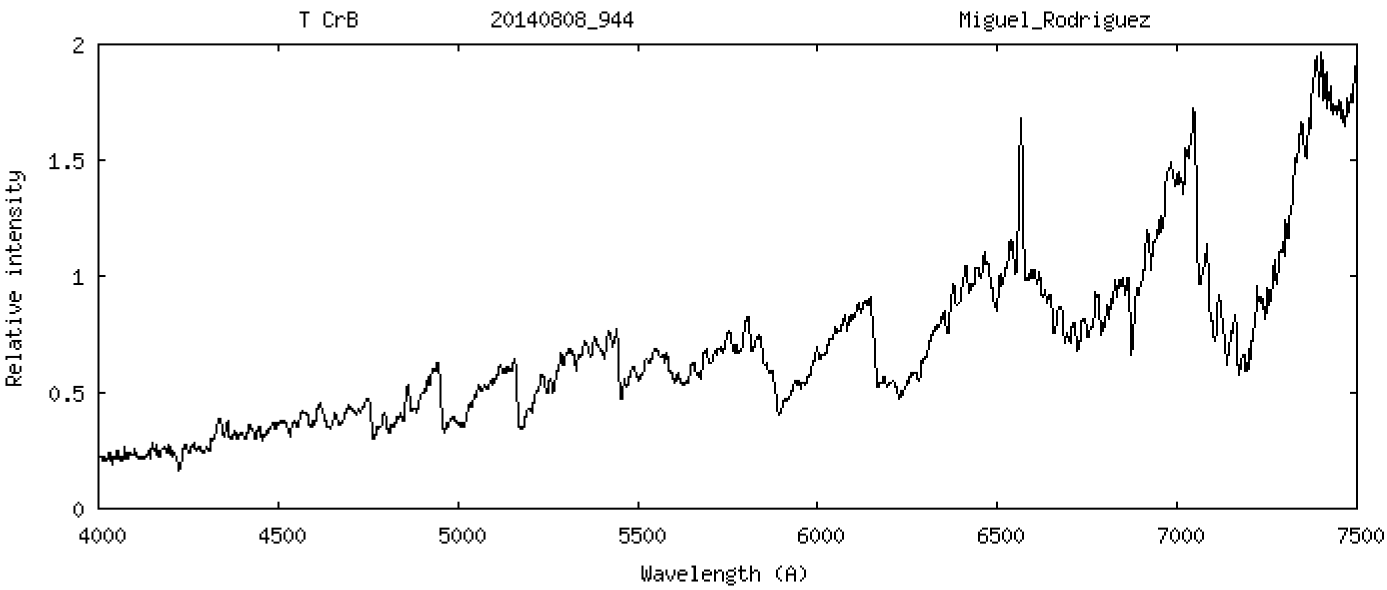
H alpha 31-07.118 at maximum luminosity (V = 10.55) and 14-08.083 (V = 10.7)

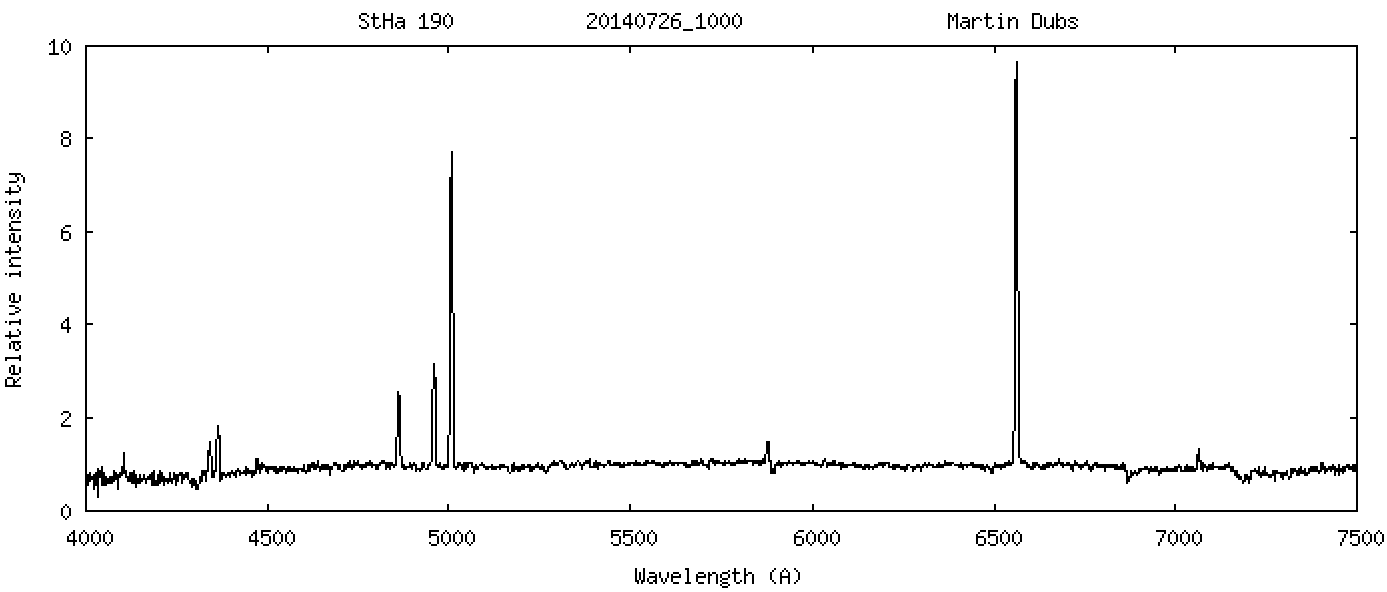


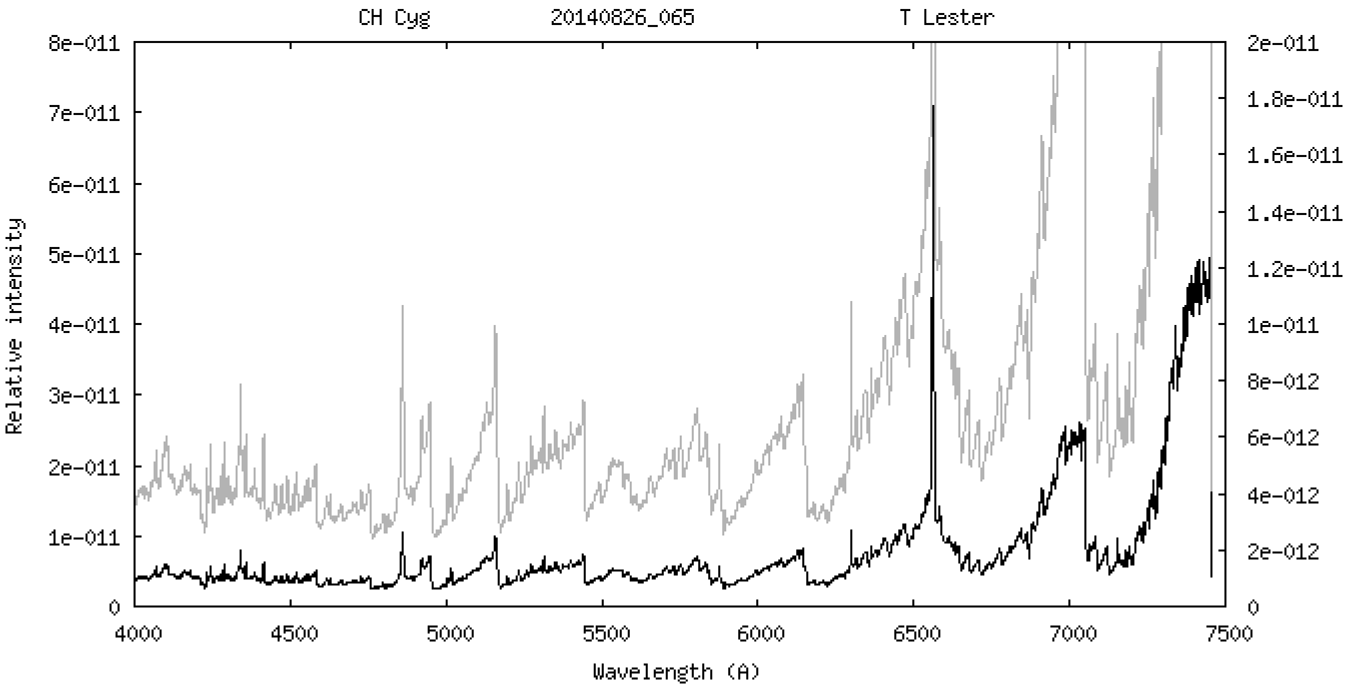
He II 4686 and He I 5876 14-08.083 (V = 10.7)

AG Peg T CrB StHa 190

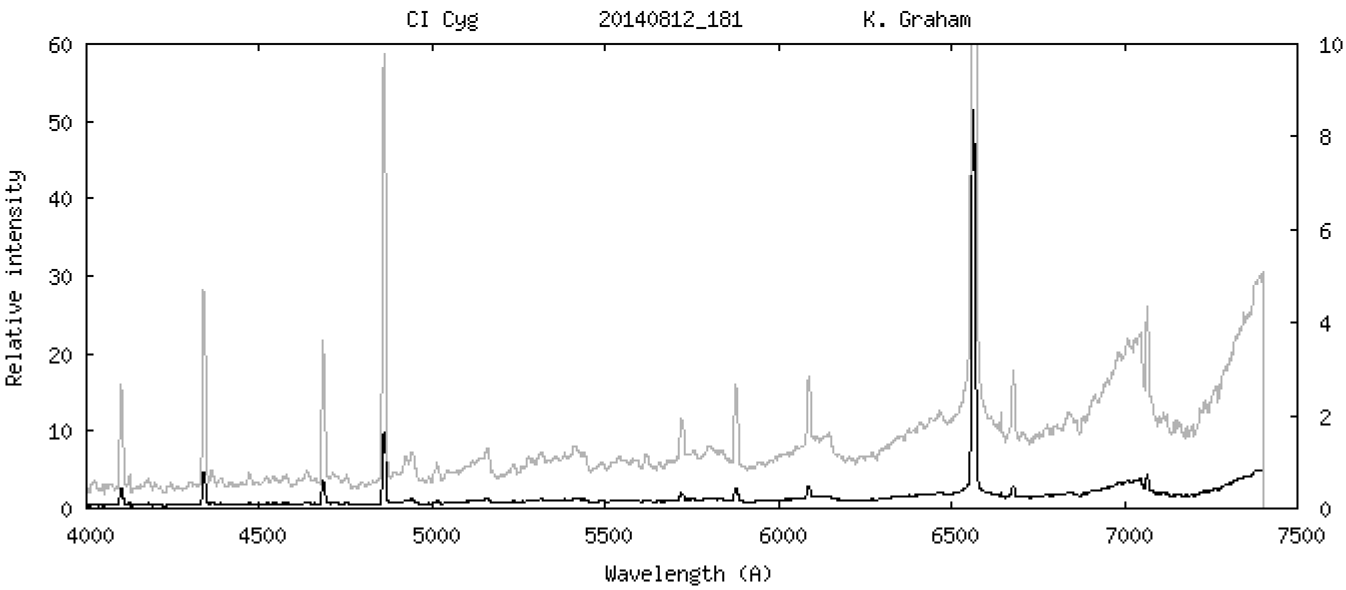






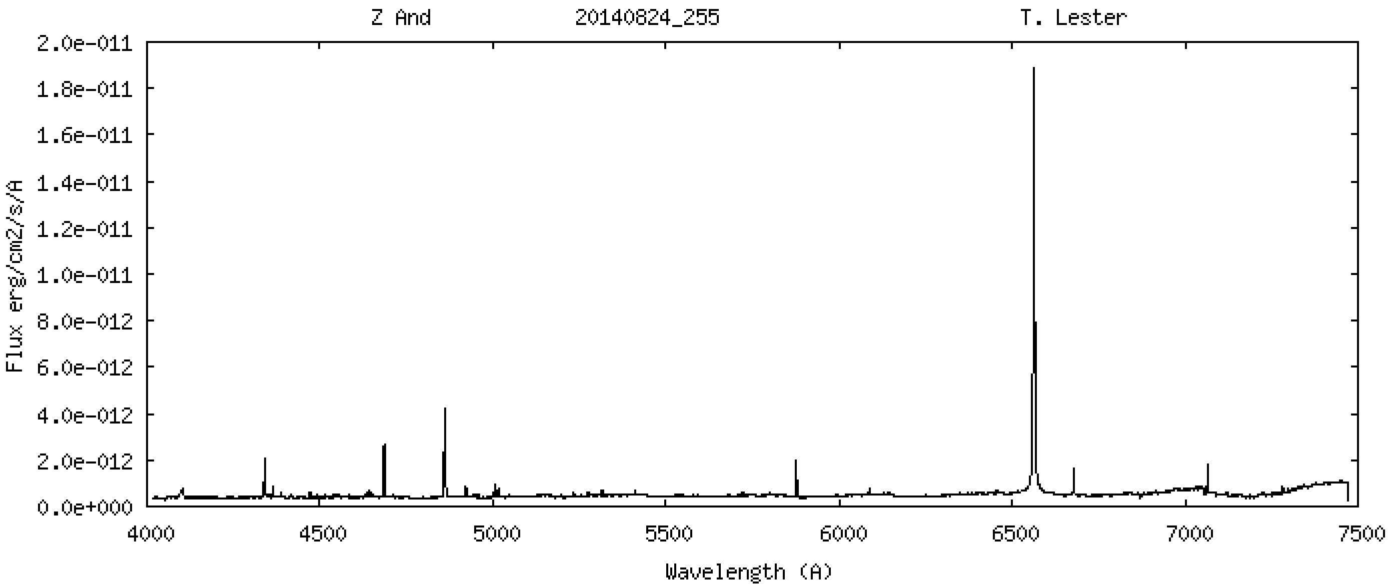


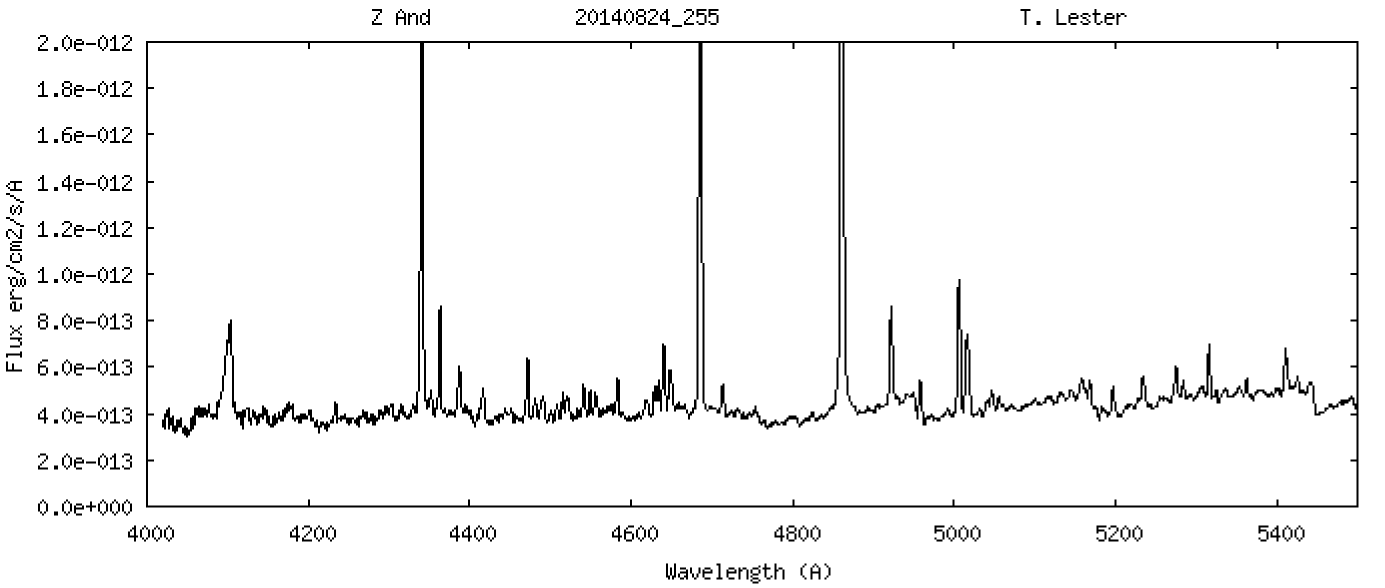
CH Cygni - 2014-08-26.065 - Tim Lester - Home made spectroscop - R = 1800

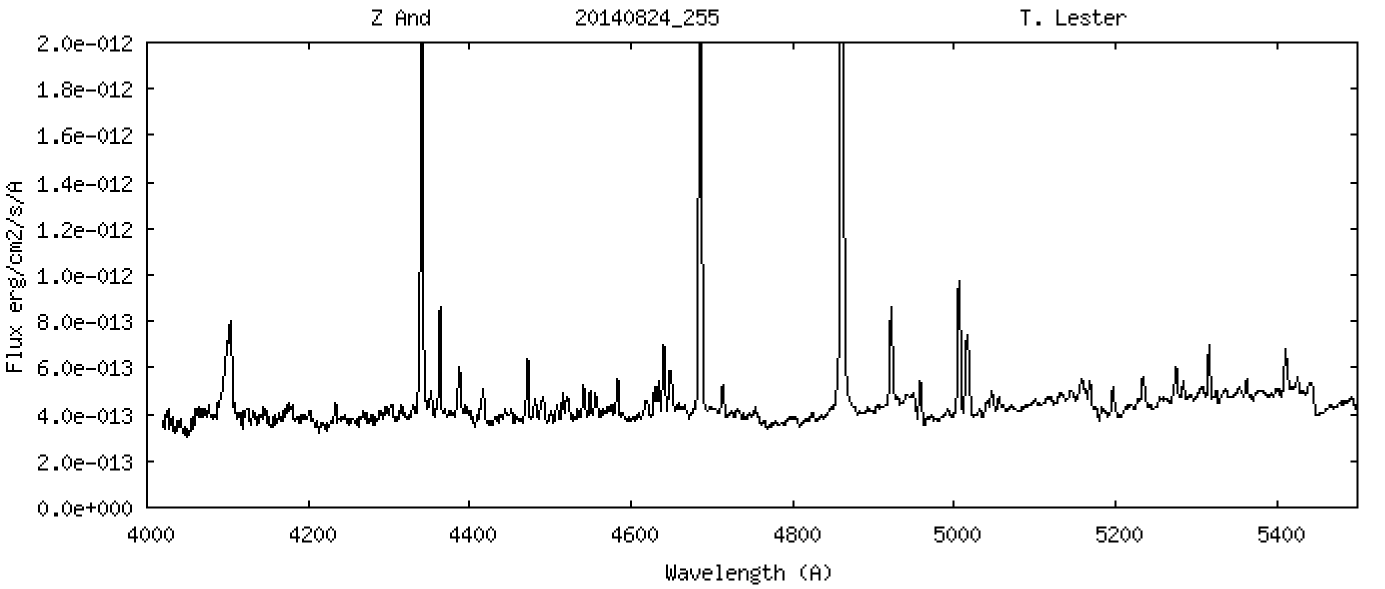


CI Cygni - 2014-08-12.81 - Keith Graham -Alpy 600 - R = 600

Z And


Z And
20140824_255
T. Lester
Flux erg/cm2/s/A
Wavelength (A)

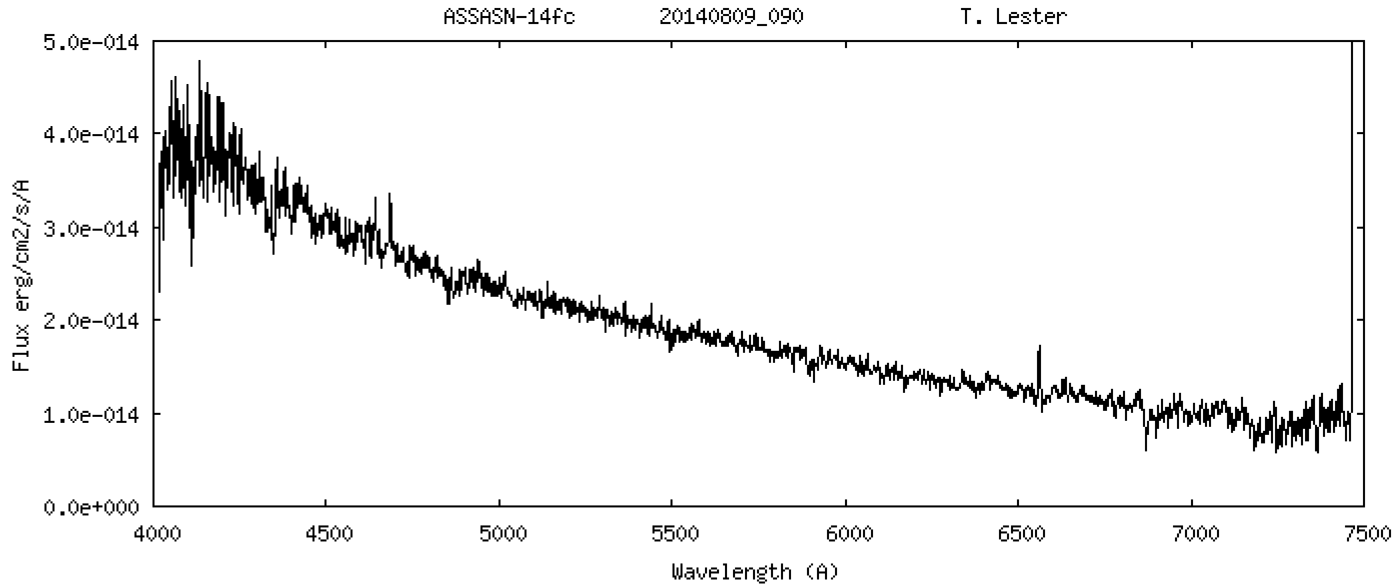

Z And
20140824_255
T. Lester
Flux erg/cm2/s/A
Wavelength (A)


Z And
20140824_255
T. Lester
Flux erg/cm2/s/A
Wavelength (A)

ASASSN-14fc

Coordinates (2000.0)	
R.A.	19 11 49.57
Dec.	+04 58 57.8

ASASSN-14fc has been detected on 2014-08-5.24 at mag 15.1 as a CV candidate.
(see http://www.astronomy.ohio-state.edu/~assassin/transients.html)
Tim Lester confirms spectroscopically the nature CV of ASASSN-14fc with a spectrum obtained on 2014-08-09.090



The Astronomer's Telegram

Spectroscopic classification of ASASSN-14fc as a cataclysmic variable in outburst

ATel #6381; ***Tim Lester (ARAS)***
*on **11 Aug 2014; 12:59 UT***
Credential Certification: Krzysztof Stanek (stanek.32@osu.edu)

We obtained a low-resolution optical spectra of ASASSN-14fc (vsnet-alert 17605) on Aug 9.09 UT using a 0.31-m DK telescope, slit spectroscope 600 l/mm (400-750 nm, resolution 0.5 nm, 12 x 1200 sec exposures). The strong blue continuum and narrow emissions for H-alpha and HeII 4686 confirm that the object is a dwarf nova outburst.

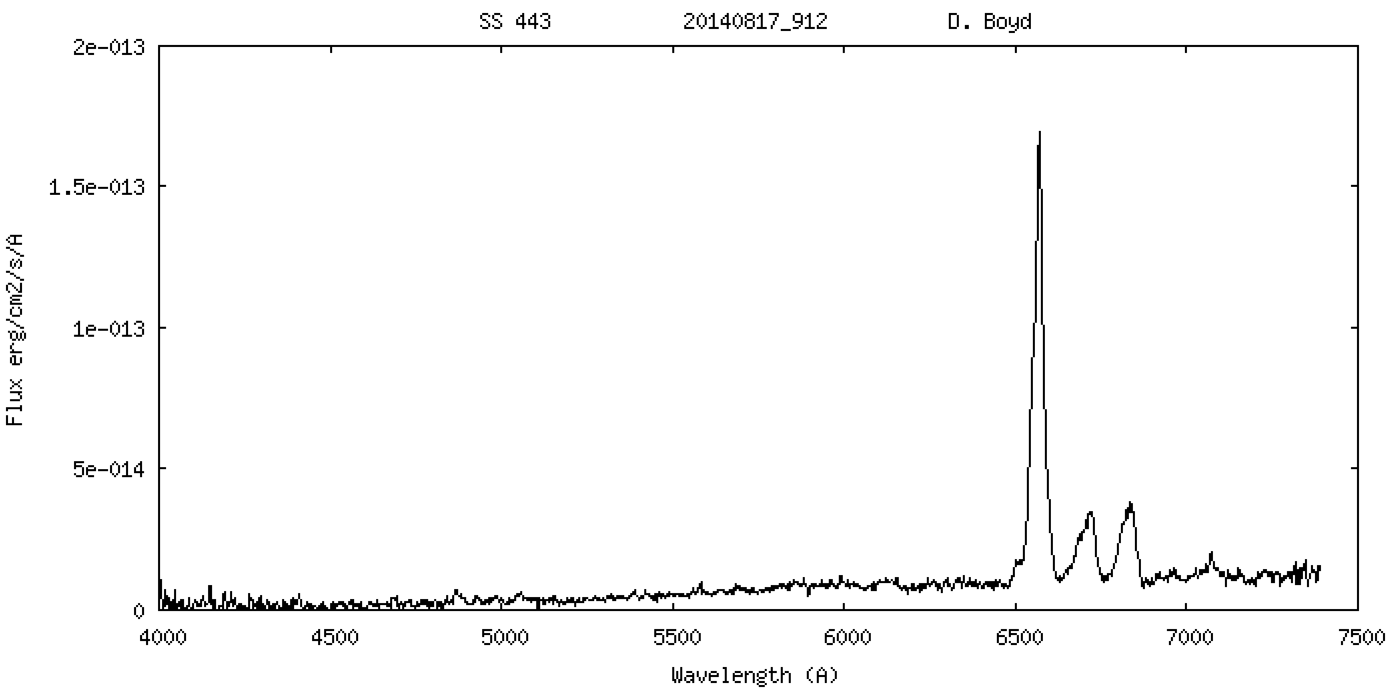
The spectra can be downloaded from ARAS (Astronomical Ring for Access to Spectroscopy) database using this link.

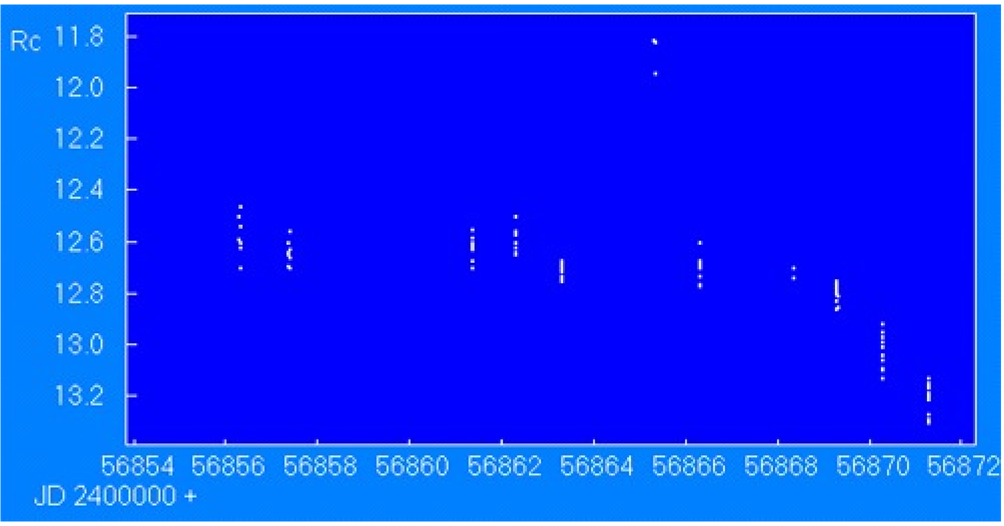
M
i
c
r
o
Q
u
a
s
a
r
s

SS 443 after its Optical flare late July, 2014

Coordinates (2000.0)	
R.A.	19 11 49.57
Dec.	+04 58 57.8

A bright flare of the microquasar SS 443 has been detected on July 26.778
See Information Letter# 8
Pierre Dubreuil and David Boyd continued the survey of SS 443 in august



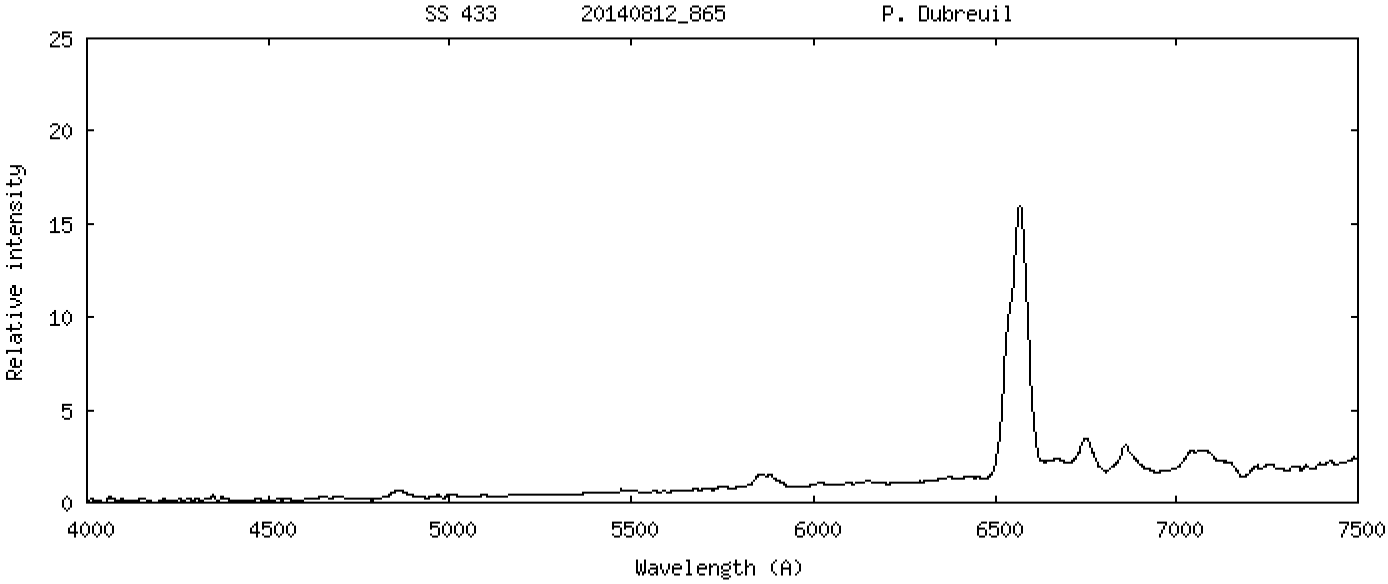


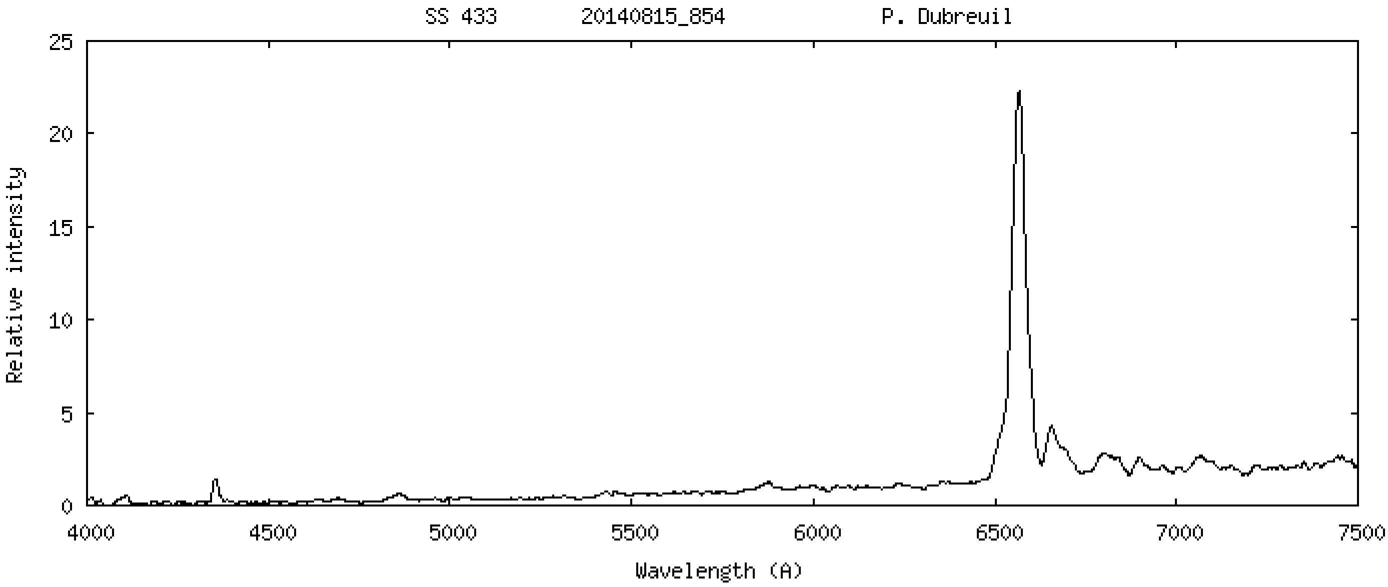
The optical flare has been detected on 2014 July 26.778 UT, at mag R = 11.8 (V. P. Goranskij , O. I. Spiridonova, ATel #6347).
SS 443 returned to quiescent level on August 1 (Sokolovsky K. V. & Al., ATel #6364)

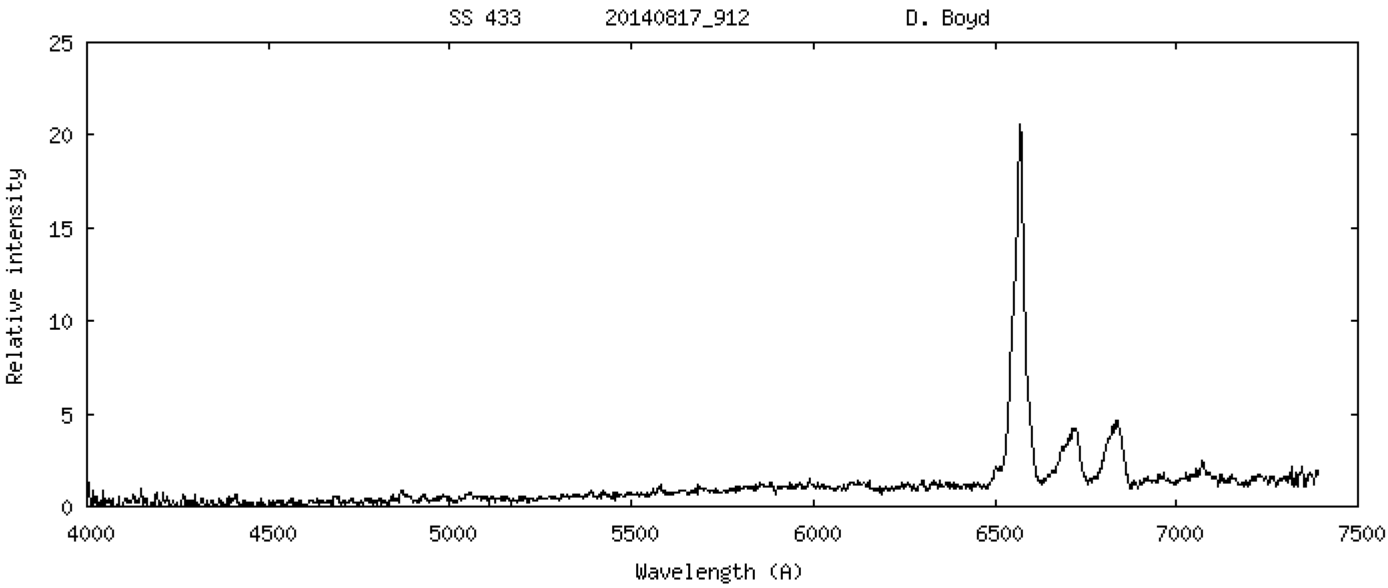
Rc light curve

Spectra :
http://www.astrosurf.com/aras/Aras_DataBase/Microquasars/SS443.htm
See ARAS Forum topic :
http://www.spectro-aras.com/forum/viewtopic.php?f=5&t=875

SS 443 After its Optical flare late July, 2014







Now armed with mutliplets, profiles, and ionization states, it's time to deal with a few real world examples of how to approach a spectrum. Since they are about the most complete example of just about everything we've been discussing, and since many of you are following these easts, we'll start with *symbiotic stars*.

Schematic view of a symbtiotic star during a talk of Steve Shore (OHP meeting July 2014)

First, an aphorism for context: **spectra never lie and are only apparently contradictory ... so if something seems paradoxical it's because you're missing something**. This has proven a wonderful guide in astrophysics. Too often, it seems, we forget that stars are big and space is vast and there are lots of things that can reside in a point-like source. Galaxies are composite environments, galactic nuclei even more so, binary stars are wide and separated, and even ionized regions can live around stars -- all unresolved and, in angle, unresolvable from the Earth. But because the different excitation and ionization states of the gas are sensitive to local {\it *and*} distant influences -- local for kinetics, distant for photon processes -- you can use these contradictions to dis-entangle the sources. The greats, for instance Payne-Gaposchkin, McLaughlin, Bidelman, Merrill, Herbig, Wallerstein, Slipher, Osterbrock, Kraft --to name just a few of the founders -- kept this principle in mind always. Spatial structure is revealed by different dynamics from different spectral signatures, from ionization states that cant reside in the same place. If you think something can't be coming from one object, o with that intuition. We've been exploiting it successfully for discussing novae and cataclysmic binaries, now we'll pass to the ``mother of all paradoxes'', the symbiotic binary stars.

One last word before we get started: I hope these notes, and those following, will give a sense of how to interpret a complicated spectrum. This is much different than what you'll find in descriptions of stellar atmospheres, for instance. In those cases most of the line formation is in a stable temperature and pressure gradient environment, governed by mechanical equilibrium and lying on the outside of a stable star. Then the decrease in pressure, density, and temperature outward produces an absorption spectrum that shows ions whose relative strength is the main diagnostic of pressure and abundance. There are no emission lines if the medium is dense enough, the atmosphere is compact (if the surface gravity is high enough) and you get the familiar sequence of spectral types. Because so many of you are interested in the freaks of the universe, things that vary, show emission lines, show strange combinations of ionization and excitation, this time I'll go into more details about how to ``read'' a sample spectrum.

... so now forewarned, bring in the patient ... (sorry, I can't help thinking of *astrophysicien*} as a ``star-doctor'')

The first cases discovered are as old as astronomical spectroscopy, AG Dra was described by Fleming in her surveys before the HD catalog. The group we now call ``symbiotics'' was identified by its bizarre, distinct, anomalous combination of spectral properties: in the same spectrum you see the continuum of a very cool star (typically an M giant), Balmer emission lines (often with widths of tens or more km.s^{-1}, He I, He II (sometimes), and [O III] and [N II]. In some respects, these resemble the active galactic nuclei called Seyfert galaxies but that they are clearly stellar and *Galactic*, not extragalactic objects. The name was actually a sort of hypothesis, that the spectrum is composite. That is, there is more than one source present and this is actually some sort of unresolved binary system. The [O III] lines are well known from planetary nebulae and H II regions. Since the [OII] 4363, 4859, 5007 Å triplet are forbidden lines, and therefore fundamental density and temperature diagnostics, they indicate the presence of a strong ultraviolet ionizing source surrounded by a very low density medium. The same holds for the isoelectronic [N II] 5755, 6548, 6583 Å lines. But these stars are not, usually, imbedded in extended nebulosity (one of the exceptional cases is R Aqr, more on this later), and the luminosity class of the red continuum contributor is a giant, not supergiant. So it's unlikely that these are planetaries that are simply too distant to be resolved or that there is some local star forming region in which they're imbedded. Another clue comes from the pair of features that is uniquely associated with these objects, the 6825, 7083 Å lines that were identified in the 1980s as Raman scattered O VI 1038, 1042 Å from Lyβ. The last indication that something must be composite is the strong He II 4686Å line. This is a recombination line, the result of ionization by a continuum in the far UV that cannot be just a non-equilibrium effect. The He I lines, especially 5876, 6678, 7065 also indicate the presence of hot gas but these could be from a chromosphere (in principle). The He II is more difficult to produce. There are other indicators of something composite, especially the so-called coronal transitions. These, e.g. [Fe VII] 5721, 6087 Å, are ground state transitions with very low density thresholds and also require a very strong far UV or XR source as an ionizing agent. The resolution comes from observations in the UV below 3000 Å where the continuum of the ionizing star is directly observed (especially with IUE for which a very large number of spectra are available). Thus, the combination of indicators points to a composite origin and that can be explained by a hot (> 6.10^4 K source with moderate luminosity (about the same as the giant, a few hundred solar luminosities, that is imbedded in the wind of the companion red giant with a wide enough orbit that he radiation is able to ionize a substantial volume of the wind.

Let's get down to specifics. The [O III] lines don't directly provide the temperature of the gas, their presence is first an indicator of the ``hardness'' of the incident radiation. If there is no strong UV continuum, collisions alone are insufficient to produce this emission if it is not a very hot gas. The Balmer and He I lines coming from the same region as the O^{+2} is an argument against this. If the gas (kinetic) temperature is low, then the process must be predominantly *photoionization.* Then the line widths, if more than a few $km.s^{-1}$, are likely dynamical (that is, due to Doppler widths from flows rather than turbulence or thermal broadening). The O^{+2} ion is very pretty, having a set of three states

4363 Å: $2s^2 2p^2\ {}^1D_2$ - $2s^2 2p^2\ {}^1S_0$

4959 Å: $2s^2\ 2p^2\ {}^3P_1$ - $2s^2\ 2p^2\ {}^1D_2$

5007 Å: $2s^2\ 2p^2\ {}^3P_2$ - $2s^2\ 2p^2\ {}^1D_2$

that have the 4363 Å line feeding the upper states of the strongly forbidden doublet. The respective transition probabilities are 1.7E0, 6.21E-3, 1.8E-2 s^{-1}. OK, this is getting technical but the contrast is the transition rate for *permitted* lines such as the Balmer series for which the numbers are more like $10^6\ s^{-1}$ or higher. In other words, at far lower densities than for the Balmer lines collisions succeed in de-exciting the upper state of the 4363 Å line without producing the pair so the flux ratio *F(4363)/F(4959+5007)* is a temperature and density diagnostic. This is because the rate of collisional damping depends on the density and temperature since the higher the temperature the higher the thermal speed and the more frequent the collisions. On the other hand, the rate of emission depends only on the transition probabilities (the radiative rates) so the stronger the lower pair, he lower the density. The same holds for the [N II] lines. In the low density limit, you can estimate that seeing these lines means the density is locally less than about $10^7\ cm^{-3}$. In contrast, in an H II region or planetary nebula the densities are more like $10^4\ cm^{-3}$ or even lower, while in a stellar atmosphere (being optically thick you get this estimate from the absorption lines) the densities are more like $10^{14}\ cm^{-3}$ or higher.

Now for the red continuum. Calling a star type M signals the presence of molecules, especially ZrO, TiO, VO, and the like. This isn't because the star has been an industrial waste dump for heavy metals but that these species are favored at temperatures below about 4000K because of their relatively high abundance, especially strong absorption bands, and the high abundance of oxygen in stellar atmospheres. The same is true for C and N bearing molecules but they are not as strong because of their particular band structures and the carbides of the heavy metals don't form stable states at these densities and temperatures. Ca does, and it is also seen, and in the radio one sees SiC and SiO, OH, and other diatomic molecules. But that is not something you'll be detecting. You will see, instead, CN and CH in the optical, we've already discussed these for novae but they are stable, dominant absorbers in the cool giants. So the strong metallic oxide bands from 5000 Å and longward are the signature of the giant. That there is no emission seen in the >5000Å range from the companion is not a surprise, it means the companion star is both very hot and comparatively low luminosity. Were it brighter than the red giant it would be only marginally detectable since the fraction o its radiation in the relevant spectral window (optical) is only a small fraction of its continuum (for such a hot source). On the other hand, there is no emission from the continuum of the giant below 4000 Å so the only thing you see there is from the ionized region around the companion and the star itself.

Now the strong forbidden line emission is coming from a low density environment. Clearly this is not compatible with the chromosphere alone, that would give lower ionization species (since a chromospheric temperature is about 10^4 - 3.10^4 K) . But there are other lines that come from that relatively low density, warm gas: lines of Ca II , Mg II, [Fe II] and Fe II, [O I], and He I, that come from the giant chromosphere and lower wind. The heating source is a separate question, it is not photoionization since the chromosphere is largely shielded from the far UV by its optical depth. In fact, since the systems are binaries, it's possible to see the variations of the lines over time and note that there are some that vary with aspect angle to the hot source (clearly being photoionized) and other parts that are constant and ``live'' on the giant.

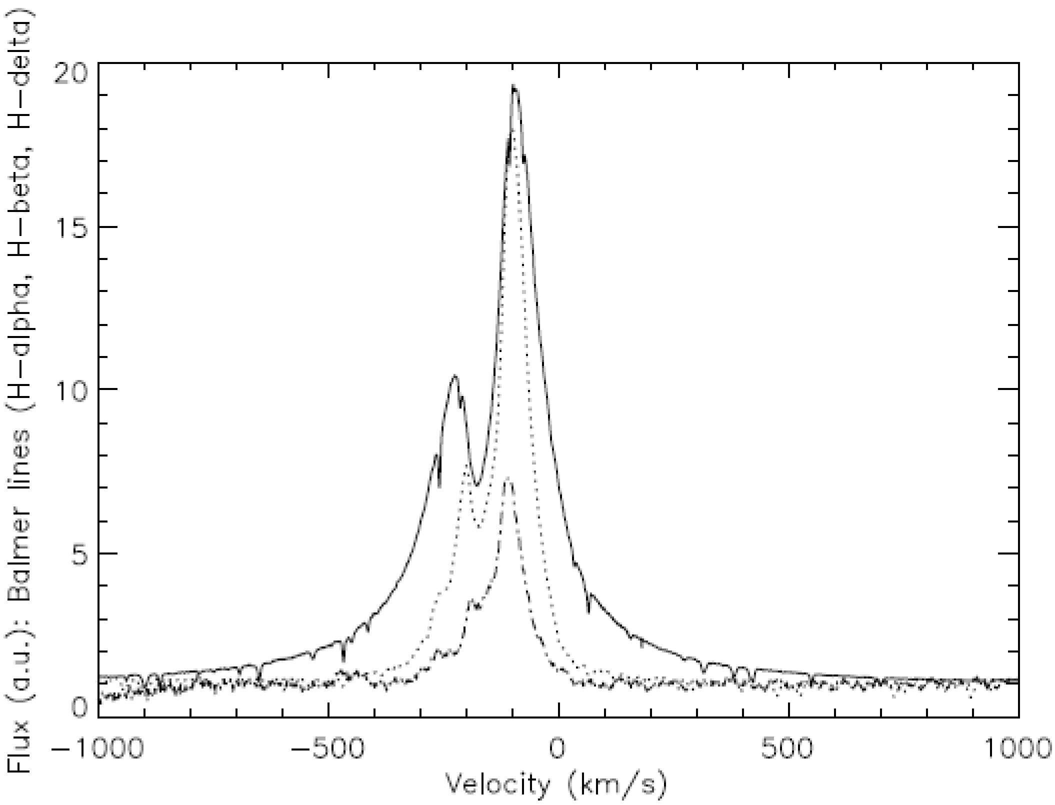


Figure 1. The Balmer lines in AG Dra

An example of the sequence of absorption and emission from a typical symbiotic star. The extraordinary width of the line wings is a combination of electron scattering and outflow, the region over which the line is formed is similar for all of the transitions but the line strength depends on the transition rates. Therefore, for the Hα the region over which the line is formed is much larger than for Hβ. The strength of the absorption, formed in the cooler red giant wind seen against the H II region around the hot component, also depends on density and is progressively weaker and lower velocity for the higher series members. This is a TNG spectrum (resolution about 60000)

The Balmer lines are recombination only. You see these from chromospheres but it's because the gas is thin in the visible and completely opaque in the UV. The same is true here. The ionization is supplied by the companion, the wind of the red giant is so optically thick that the Balmer lines can also absorb against the ionized region. This produces what you've seen in Christian Buil's spectra, for instance, the narrow displaced absorption line in Hα and Hβ seen against a much broader emission line. This is the same effect you will have whenever one source is viewed trough a rarified gas around another, true for any binary system (this could also be a Be star, for instance, if one of the stars is seen through the disk of the other). This is also expected for the massive-disk systems like β Lyr (I had to include that one, right?!).

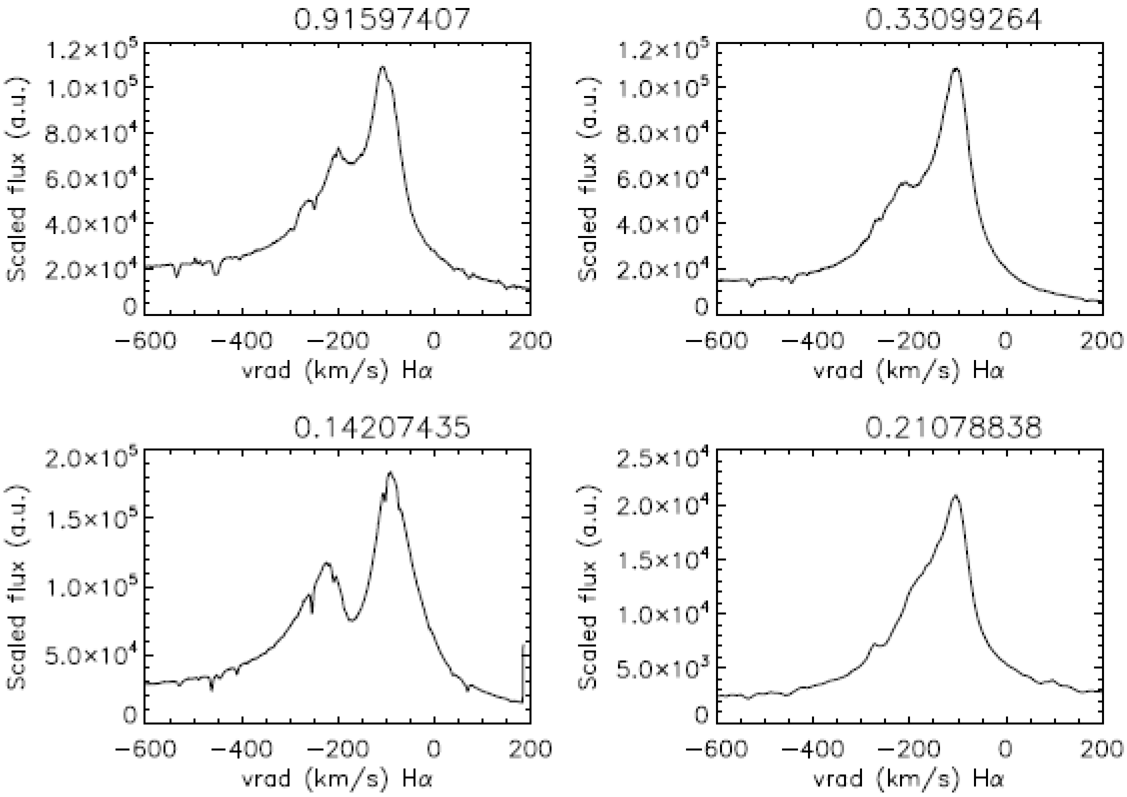


Figure 2. The Hα line in AG Dra displayed according to orbital phase

The Hα line in AG Dra displayed according to orbital phase (the binary period is long, 549.7 days). The absorption is from the intervening wind between the WD and the observer shows how the changing angle causes the absorption column to vary. This happens in any system in which a strong emission line is seen across a sufficiently optically thick line of sight. These are spectra from Asiago, resolution of about 15000. The orbital phase (to absurd accuracy, but I was in a hurry) is indicated at the top of each panel.

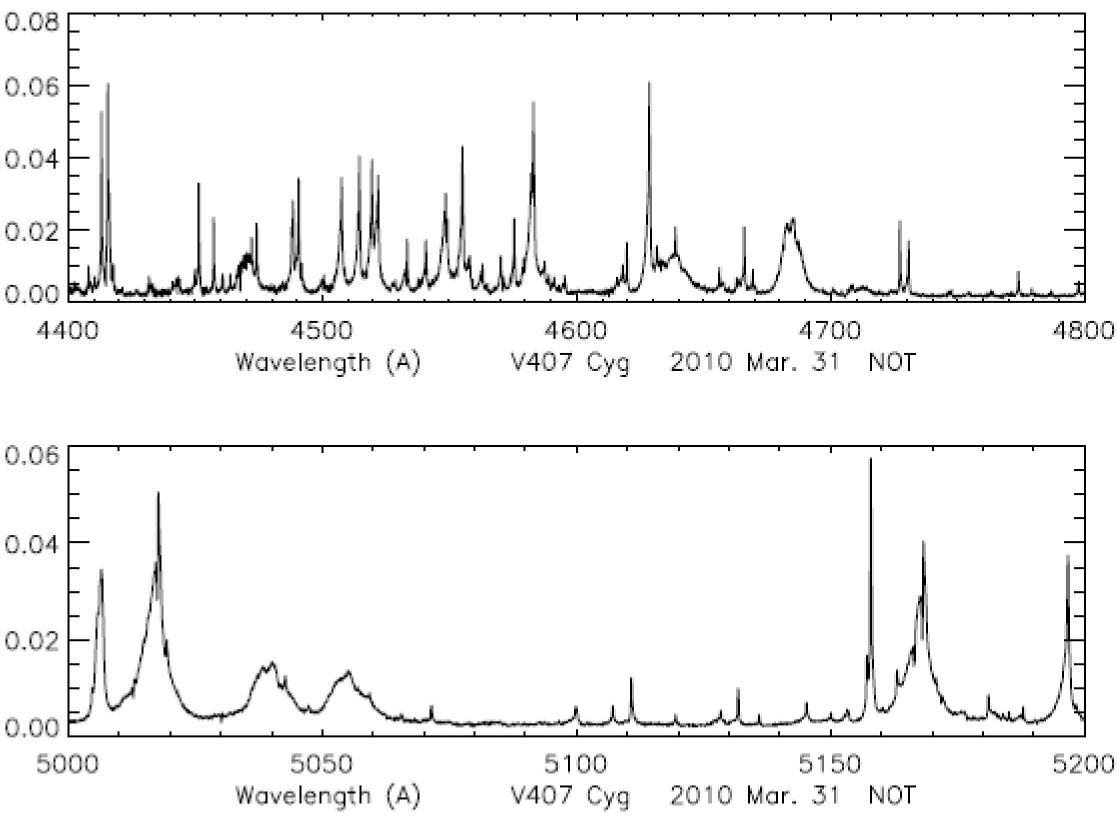


Figure 3. The optical spectrum, two weeks into outburst (2010 Mar. 31), of V407 Cyg

The optical spectrum, two weeks into outburst (2010 Mar. 31), of V407 Cyg. This is a symbiotic like recurrent nova (well, it is *likely* a recurrent, the 2010 outburst was the first recorded). The broad lines are all permitted, highly shocked gas from the giant in the post-ejecta flow. The narrow lines are from the ionized region around the WD and in the wind, ahead of the shock, and from the chromosphere of the red giant. This is a unique spectrum for such a system, obtained with the NOT at a resolution ~ 65000. Notice the narrow [O III]5007Å and the broad *and* narrow components on Fe II 5018 Å and 5169 Å. The *very* sharp features are *not* noise! These are the chromospheric lines from the giant, mainly Fe-group elements, in low ionization stages, e.g. Fe I/II, Ni II, etc).

This is a particularly complicated case to unravel, the main reason for choosing it. There are a number of separate contributors to the spectrum. Remember that V407 Cyg was a nova event. The ejecta were expelled at a velocity of >4000 km.s^{-1} into the surrounding wind and formed a shock that accelerated that environment to very high speeds. But the separation is also very large, the red giant has a radius of >300 $R_{\odot}$ so the separation is greater than 1 AU and the orbital period is likely more than 50 years. This is at the extreme end of symbiotics, just from the observational statistics but still smaller than a planetary nebula (for instance). The ejecta were slowed down by transfer of momentum to the wind through which they plowed and their emission produced an additional UV source (the temperature post-shock reached -ray levels, about 10^7 K, but ejections at lower velocities are known from many symbiotics (e.g. Z And, CH Cyg, AG Peg). The hot star, the white dwarf, also irradiated the gas. Between these, the UV produced fluorescent emission (you'll recall we discussed this before for novae) since the wind absorbs in the UV and de-excited by emission in the optical and infrared where the opacity is lower. These are mainly from the lower parts of the giant's wind, its chromosphere, so many of these lines are {\it not} normally seen in either giants or less extreme symbiotic stars. But they are, nonetheless, accessible transitions. Other symbiotic-like recurrents, V3890 Sgr, V745 Sco, RS Oph, T CrB, were not observed at such high resolution or signal to noise so early in the outburst but they should also show these features. Notice that the narrowest lines are thermal widths, that is, about 1 km.s^{-1}, while those from the shock are hundreds of km.s^{-1}. There are also some that are broader but not as broad, for instance the Fe II permitted lines, that are coming from the ionized wind from the shock precursor.

One last point of physics. A shock produces both compression and heating in the gas through which it propagated. This is sufficient, depending on the speed of the front, to produce UV and XR emission. Those photons have nowhere to go but straight ahead so they pass through the front and ionize and excite the *pre-shocked* gas. You see this in atmospheric tests of nuclear weapons, an optically thick ionized surface forms immediately (at the speed of light) from the gamma-ray emission at the explosion site, the ejecta (the actual shock front) arrives some time later and beaks out of the recombining fireball. This doesn't happen in a normal nova, that explodes in a vacuum, but will if there is an enveloping wind. That there could be a nova explosion in a symbiotic system is only a surprise in that the white dwarfs are usually much less massive than those in novae, more like 0.5 to 1 $M_{\odot}$ instead of near the Chandrasekhar limit at 1.2-1.4 $M_{\odot}$.

Otherwise, it is a very fast version of what happens when the planetary nebula stage forms after the slow wind ejection of the supergiant precursor that strips bare the core of the star and leaves the white dwarf nucleus exposed. There a fast wind slams into the slower one from the earlier stage of evolution. The region you see produces the characteristic nebular lines of the planetary because the densities are low enough and the WD hot enough, so it's the same as V407 Cyg or RS Oph in slow motion. Finally, when a hot star, of type O, illuminates the interstellar medium there is a strong enough continuum to produce the O^{2+} lines but not enough, usually, to get the high ionization states seen in some symbiotics (the coronal-type lines that require 100 eV photons or higher). That's the effect of the relatively ``cooler'' continuum; there's little emission shortward of the He II ionization limit, around 54 eV, to produce those ions since the temperatures of the stars do't exceed 40-60 kK. The motion of the O star through the surrounding gas mimics, in *very* slow motion, that of the WD through the wind of the giant but on timescales of millions of years. Th star can leave an ionization trail in its wake, and so does the WD as the wind flows past it (hence the open-shape of the ionized region). The lines in the wind will also have different widths depending on where in the wind they form. The narrowest, like the fluorescent lines, are formed near the stellar surface so there's almost no outward motion. Those formed throughout the wind, especially near its outer parts where the density is lowest, are the broadest. And anything formed in the post-shocked gas in the V407 Cyg spectrum will be the broadest of all, not the shock velocity but a fraction of it.

I'll stop at this point and let you all catch your breath, we'll pick this up in the next set of notes. For the moment, an exercise: take a look at the spectrum of V407 Cyg and, using the NIST tables for atomic spectra, and knowing that you're looking at a symbiotic star-type object, find some of the identifications of the strongest lines (yes, I know this is a figure with relatively little information, but that's deliberate. Think of those who were doing this for the first time, like Maury, Fleming, and Cannon).

Steve Shore 07-09-2014

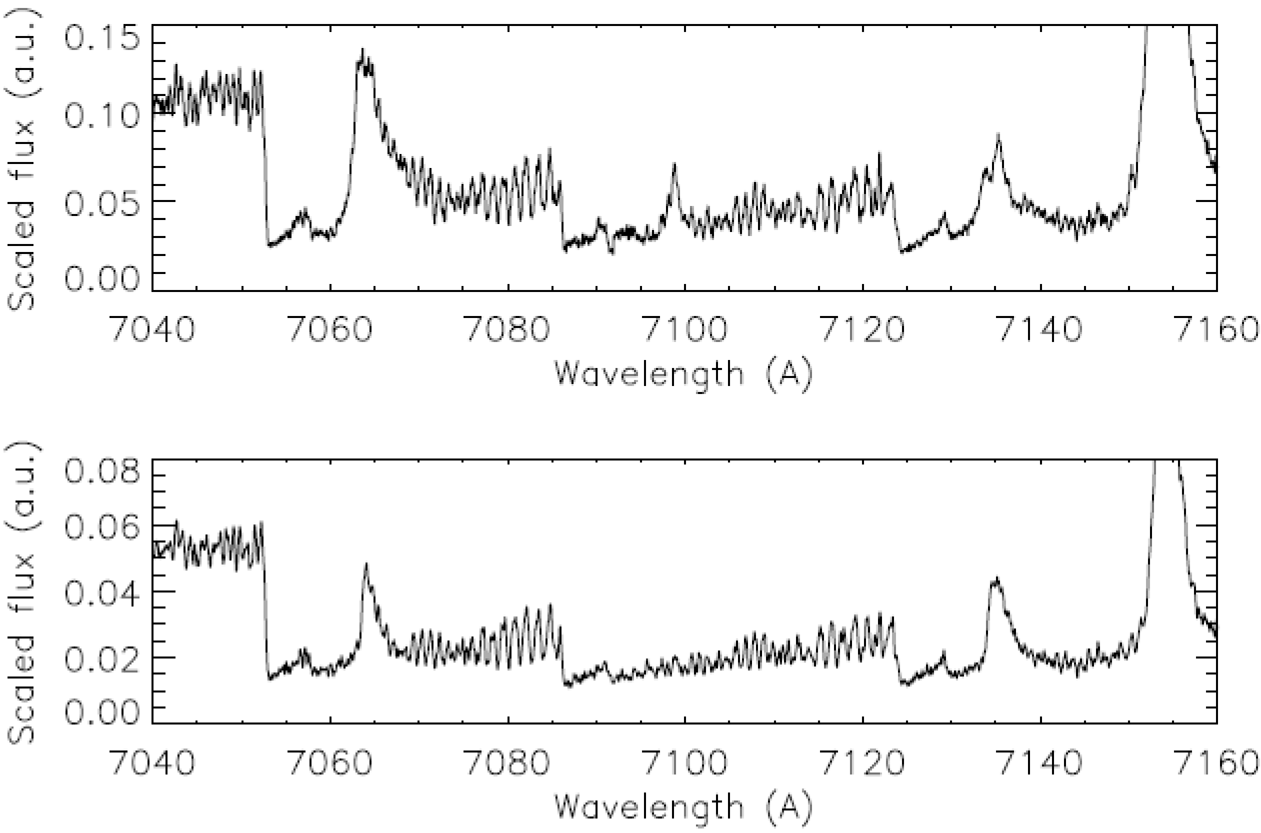
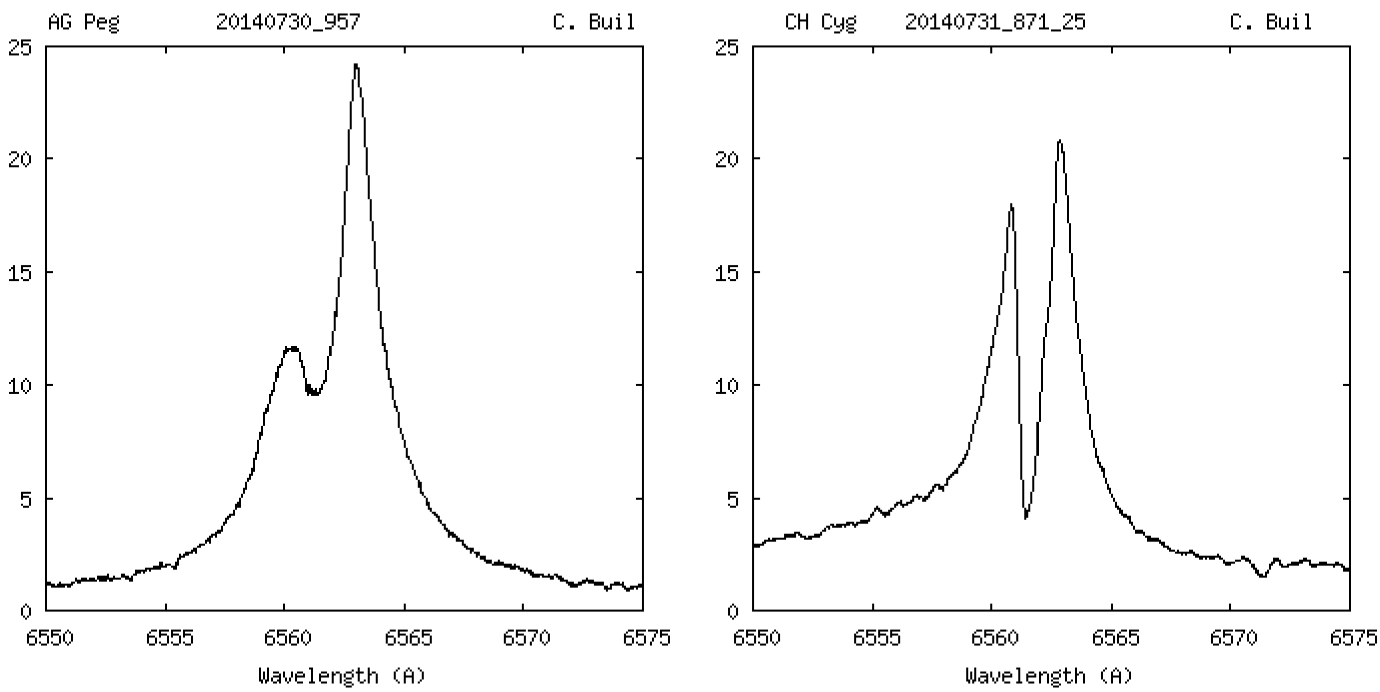


Figure 4. The red spectrum of V407 Cyg on 2010 Jul. 15 and 2011 Aug. 21.
This is the same star as the emission line object in the previous figure! Note the absorption band spectrum, this is *not* terrestrial. The emission at He I 7065 Å while difficult to separate from the underlying absorption, is still visible.



Hα profiles of AG Peg and CH Cyg at very high resolution (R = 50 000) by Christian Buil

"On August 29, 1864 I directed the telescope armed with the spectrum apparatus to this nebula. A first I suspected some derangement of the instrument had taken place …"

150 years ago
The first spectroscopic observation of a planetary nebula

150 years ago, on August 29, 1864, Williams Huggings observed for the first time the spectrum of a planetary nebula .
Following an idea of Filipe Dias, Olivier Thizy call for observation of NGC 6543 (also named "Cat's eye nebula")
http://www.spectro-aras.com/forum/viewtopic.php?f=6&t=898

Here's the first contributions in response to that nice idea from Jacques Montier, Umberto Sollecchia, Robin Leadbeater, Olivier Thizy and Torsten Hansen.

See also Sky and Telescope and
http://www.shelyak.com/dossier.php?id_dossier=77&lang=2

The relation of the spectroscopic observation of NGC 6543 by Williams Huggins

in Philosophical Transactions of the Royal Society of London
http://www.jstor.org/stable/108876?origin=JSTOR-pdf

William Huggins was born at Cornhill, Middlesex in 1824. He married Margaret Lindsay, daughter of John Murray of Dublin, who also had an interest in astronomy and scientific research.She encouraged her husband's photography and helped to put their research on a systematic footing.

Huggins built a private observatory at 90 Upper Tulse Hill, London from where he and his wife carried out extensive observations of the spectral emission lines and absorption lines of various celestial objects. On 29 August 1864, Huggins was the first to take the spectrum of a planetary nebula when he analysed NGC 6543. He was also the first to distinguish between nebulae and galaxies by showing that some (like the Orion Nebula) had pure emission spectra characteristic of gas, while others like the Andromeda Galaxy had the spectral characteristics of stars. Huggins was assisted in the analysis of spectra by his neighbour, the chemist William Allen Miller. Huggins was also the first to adopt dry plate photography in imaging astronomical objects

Wikipedia
http://en.wikipedia.org/wiki/William_Huggins

XIII. *On the Spectra of some of the Nebulæ.* By William Huggins, *F.R.A.S.* *A Supplement to the Paper "On the Spectra of some of the Fixed Stars.* By William Huggins, *F.R.A.S., and* W. A. Miller, *M.D., LL.D., Treas. and V.P.R.S." Communicated by Professor* W. A. Miller, *M.D., LL.D.*

Received September 8, 1864, and printed in continuation of the paper preceding.

[No. 4373. 37 H. IV. R.A. $17^h\ 58^m\ 20^s$. N.P.D. 23° 22′ 9″·5. A planetary nebula; very bright; pretty small; suddenly brighter in the middle, very small nucleus.] In Draco.

On August 29, 1864, I directed the telescope armed with the spectrum apparatus to this nebula. At first I suspected some derangement of the instrument had taken place; for no spectrum was seen, but only a short line of light perpendicular to the direction of dispersion. I then found that the light of this nebula, unlike any other ex-terrestrial light which had yet been subjected by me to prismatic analysis, was not composed of light of different refrangibilities, and therefore could not form a spectrum. A great part of the light from this nebula is monochromatic, and after passing through the prisms remains concentrated in a bright line occupying in the instrument the position of that part of the spectrum to which its light corresponds in refrangibility. A more careful examination with a narrower slit, however, showed that, a little more refrangible than the bright line, and separated from it by a dark interval, a narrower and much fainter line occurs. Beyond this, again, at about three times the distance of the second line, a third, exceedingly faint line was seen. The positions of these lines in the spectrum were determined by a simultaneous comparison of them in the instrument with the spectrum of the induction spark taken between electrodes of magnesium. The strongest line coincides in position with the brightest of the air lines. This line is due to nitrogen, and occurs in the spectrum about midway between *b* and F of the solar spectrum. Its position is seen in Plate XI.†

The faintest of the lines of the nebula agrees in position with the line of hydrogen corresponding to Fraunhofer's F. The other bright line was compared with the strong line of barium 2075‡: this line is a little more refrangible than that belonging to the nebula.

Besides these lines, an exceedingly faint spectrum was just perceived for a short distance on both sides of the group of bright lines. I suspect this is not uniform, but is crossed with dark spaces. Subsequent observations on other nebulæ induce me to regard this faint spectrum as due to the solid or liquid matter of the nucleus, and as quite distinct from the bright lines into which nearly the whole of the light from the nebula is concentrated.

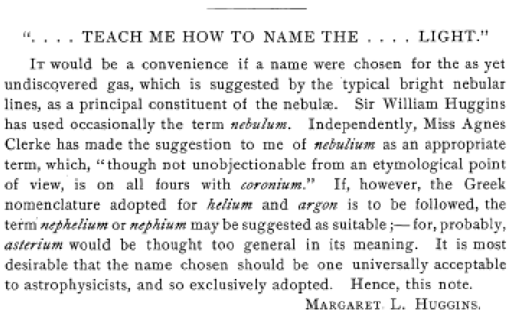
In the diagram (fig. 5, Plate X.) the three principal lines only are inserted, for it would be scarcely possible to represent the faint spectrum without greatly exaggerating its intensity.

The colour of this nebula is greenish blue.

Tribute to Williams Huggins and Margaret Lindsay Huggins

Margaret Lindsay, Lady Huggins (1848 1915), was an Irish scientific investigator and astronomer. With her husband William Huggins she was a pioneer in the field of spectroscopy and co-authored the Atlas of Representative Stellar Spectra (1899).
..., Margaret's grandfather taught her the constellations, and as a result of this she began studying the heavens with home-made instruments. She constructed a spectroscope after finding inspiration in articles on astronomy in the periodical Good Words. Her interest and abilities in spectroscopy led to her introduction to the astronomer William Huggins, whom she married in 1875

Source : Wikipedia



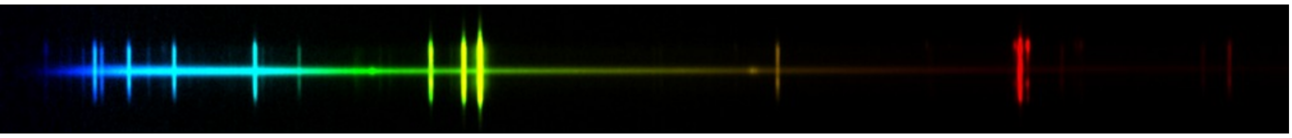
"". . . . TEACH ME HOW TO NAME THE . . . . LIGHT."

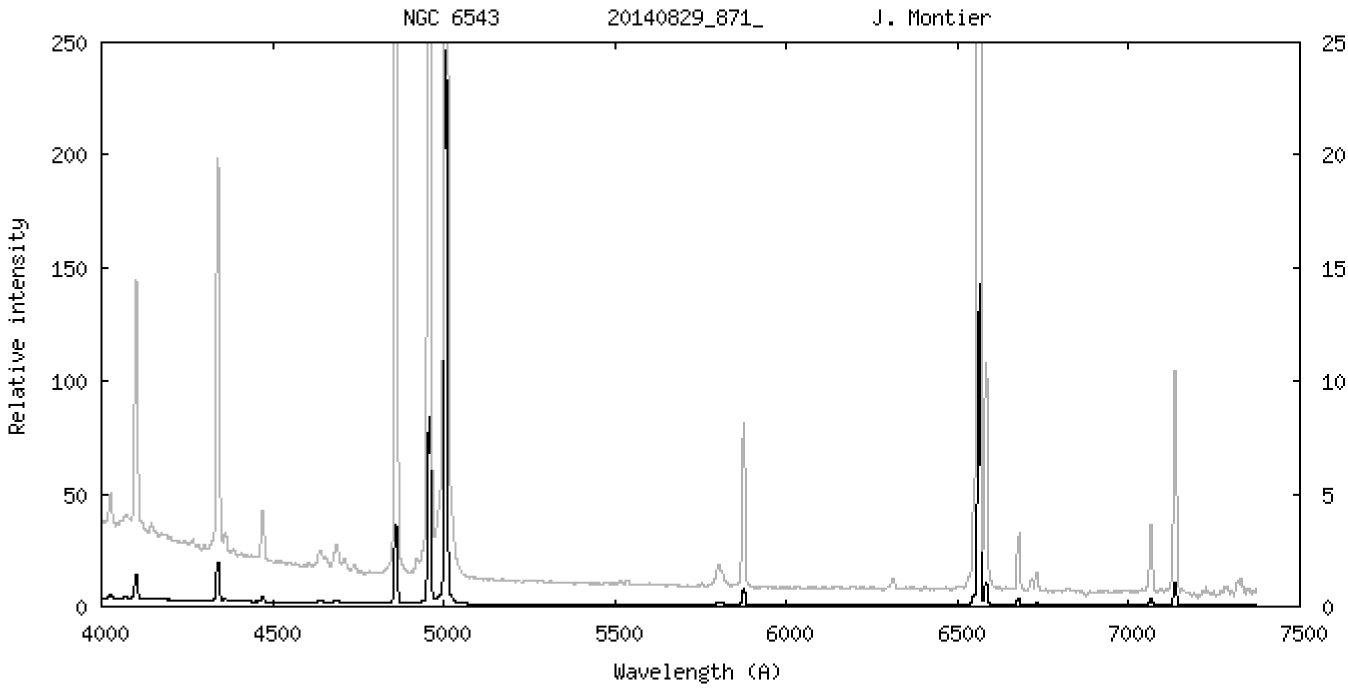
It would be a convenience if a name were chosen for the as yet undiscovered gas, which is suggested by the typical bright nebular lines, as a principal constituent of the nebulæ. Sir William Huggins has used occasionally the term *nebulum*. Independently, Miss Agnes Clerke has made the suggestion to me of *nebulium* as an appropriate term, which, "though not unobjectionable from an etymological point of view, is on all fours with *coronium*." If, however, the Greek nomenclature adopted for *helium* and *argon* is to be followed, the term *nephelium* or *nephium* may be suggested as suitable;—for, probably, *asterium* would be thought too general in its meaning. It is most desirable that the name chosen should be one universally acceptable to astrophysicists, and so exclusively adopted. Hence, this note.

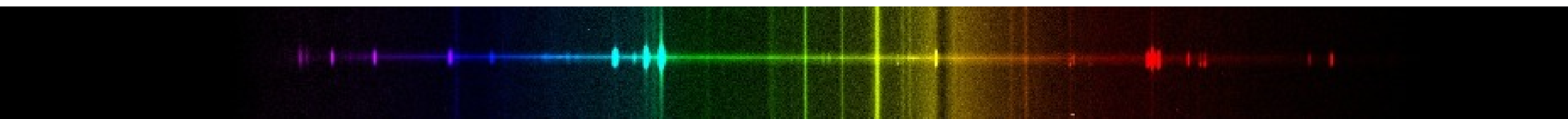
MARGARET L. HUGGINS.

Astrophysical Journal, vol. 8, p.54-54

This publication of Margaret Lindsays Huggins (with its wonderfull title) gives the opportunity to mention Agnes Clerke, whose works were the major source of inspiration for amateur spectroscopists in the late 19th century.
A "hall of fame" should include Clerke, Fleming, Maury,Huggins(s), Rutherfurd, Lockyer, Hale, Frauenhofer ...



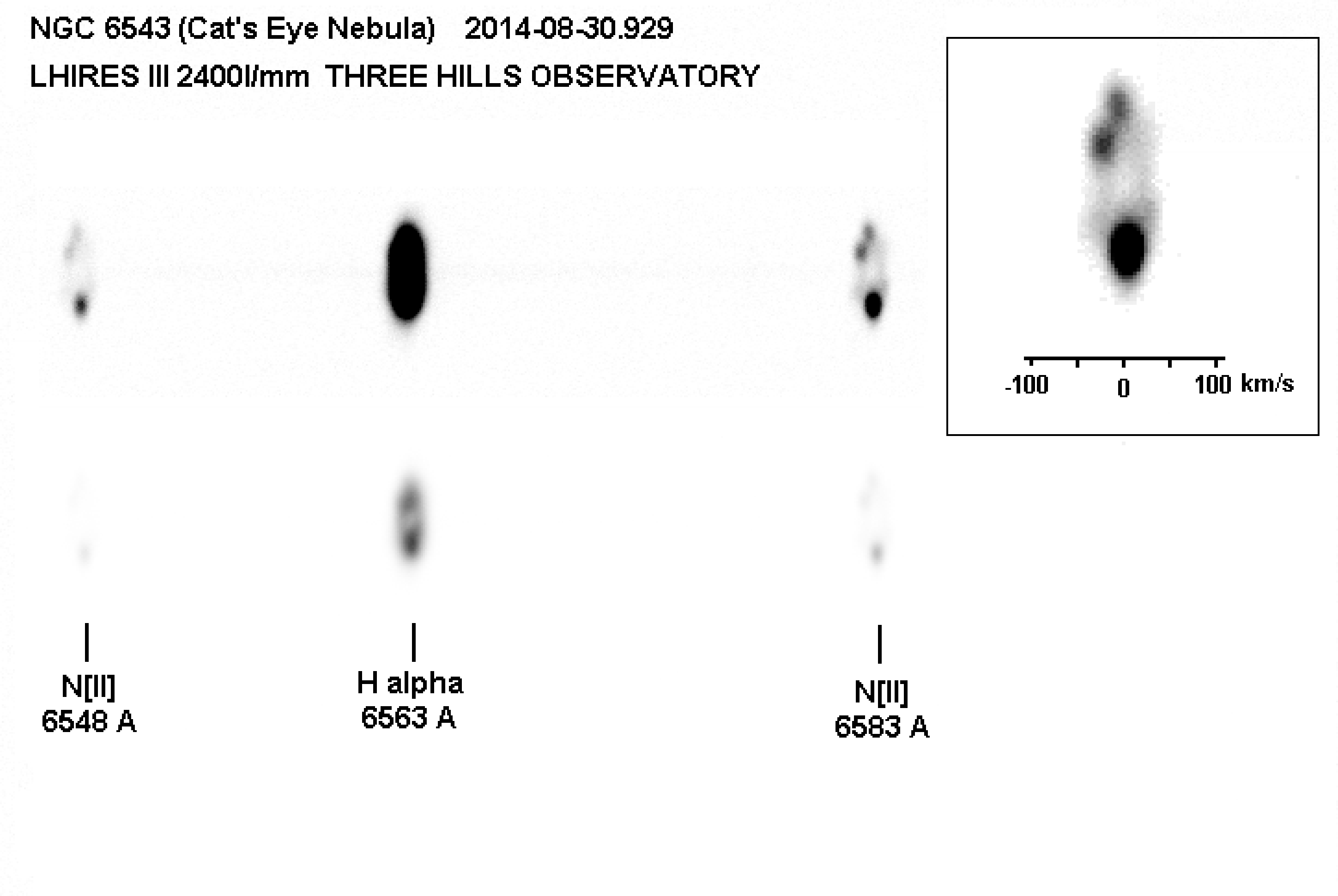




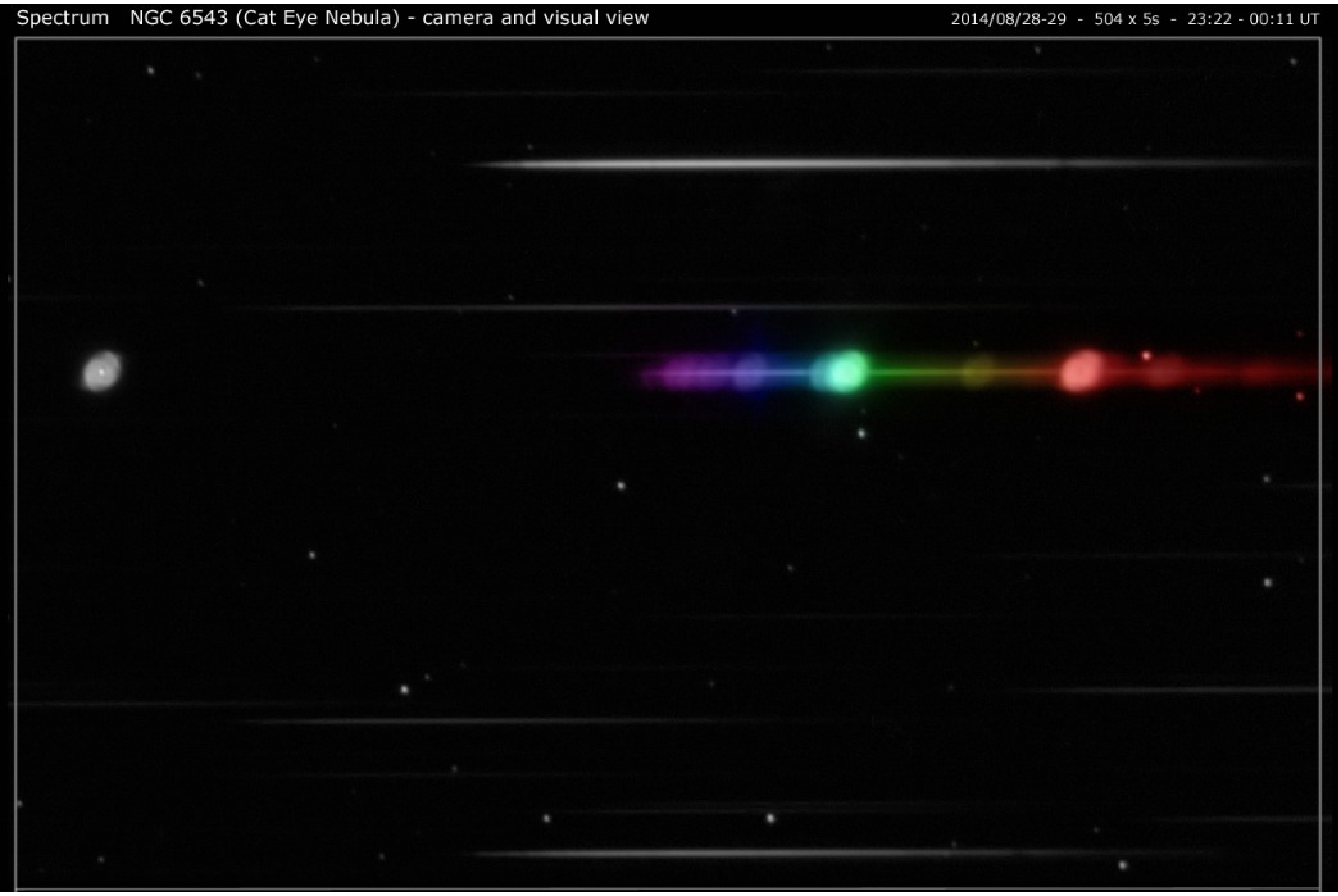
Spectrum obtained by Olivier Thizy with a LISA - Sky pollution not removed
And the setup used - 150 years after Huggings, amateur devices has evolved !

The H alpha region at high resolution by Robin Leadleabeater with a LHIRES III 2400 l/mm

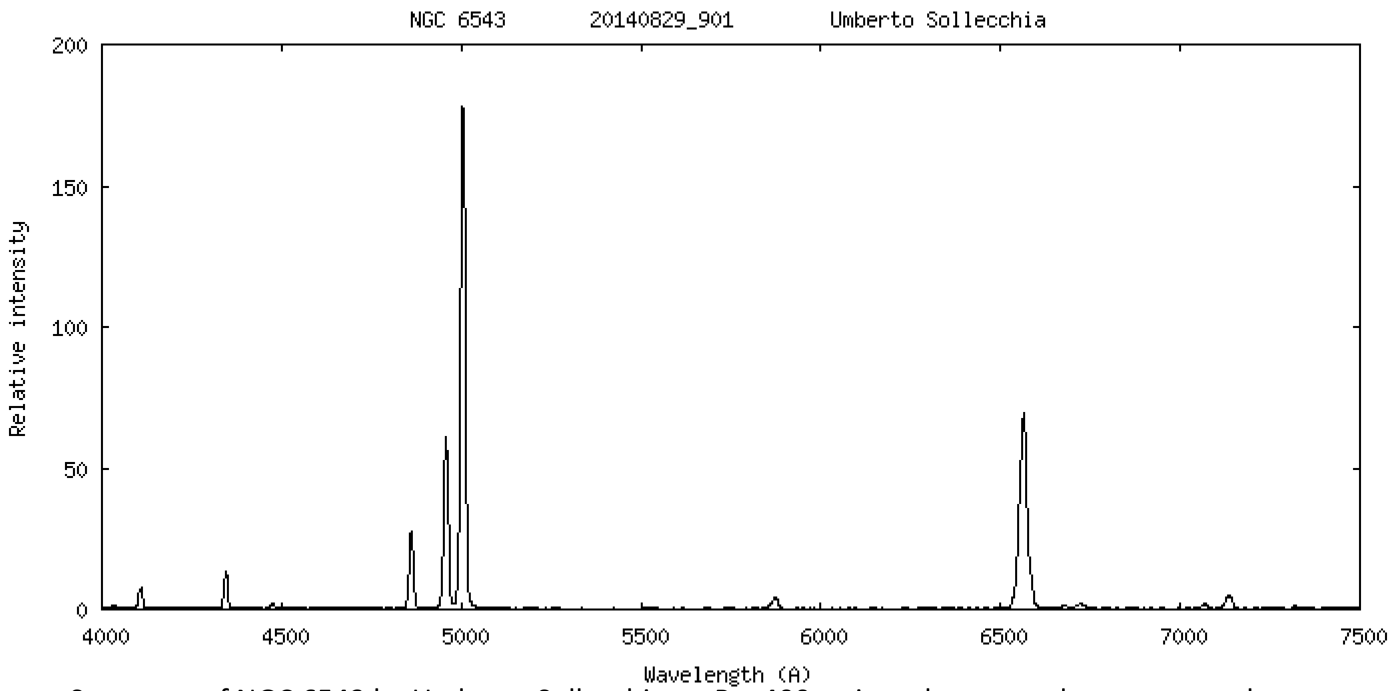
"Some interesting structure due to various regions moving at different velocities"



Comments from Steve :
The Balmer and forbidden lines are seen differently in different locations, not just at different velocities, On a composite spectrum, the lines are broadened and separate components are detected depending on the dynamics. The excitation conditions are different in different regions, there's also shielding (where the hard radiation is blocked you see the neutral phase). One last point: the region immediately around the central star is surrounded by a fast compact wind, although not realized in Huggins' time. BUT what they did notice was the similarity of many of these stars to Wolf-Rayet stars (again, we're nearly at an anniversary of those beasts) in which the lines also resemble to novae

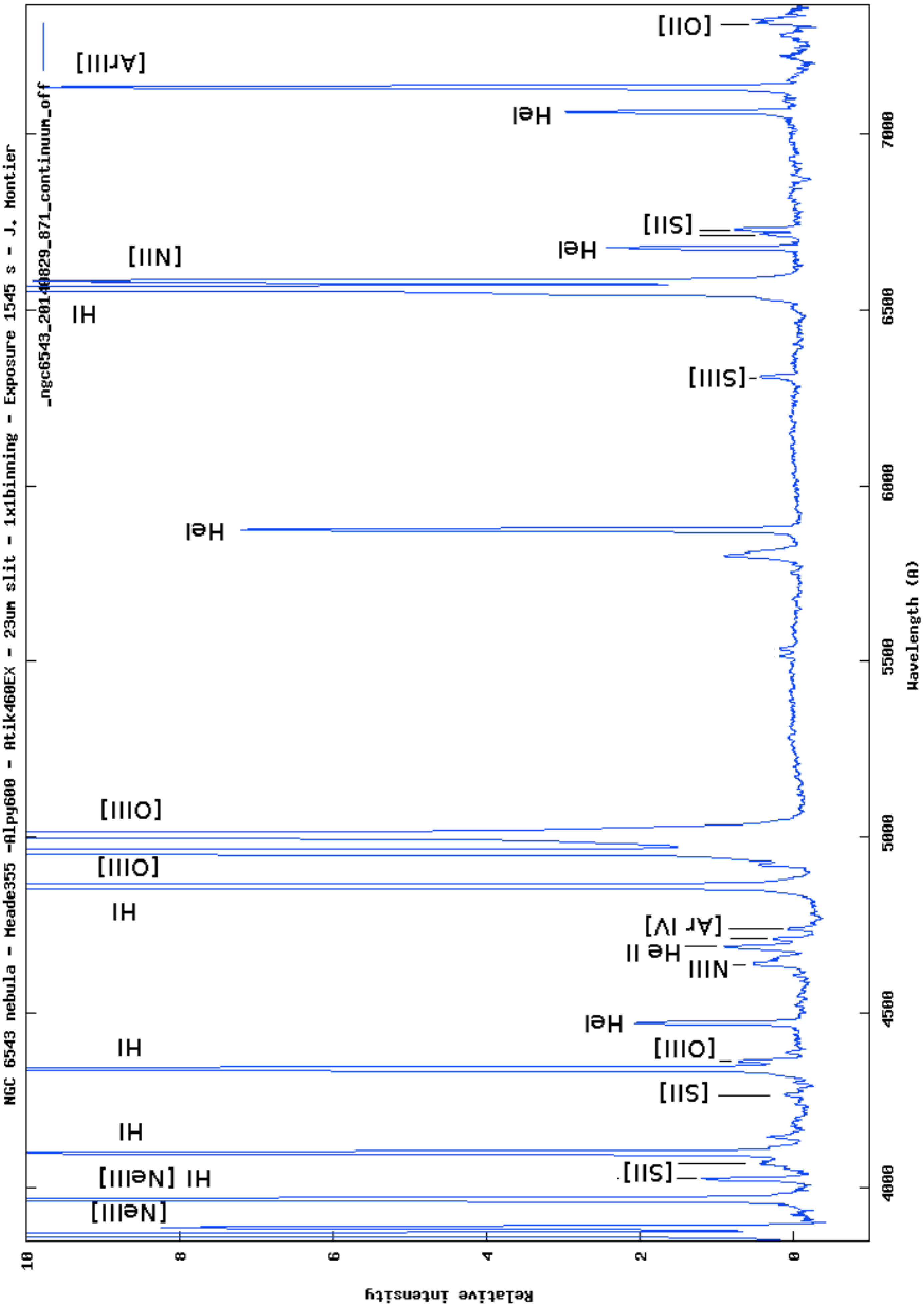


Torsten Hansen took this spectrum on August, 30th with a Star Analyser
Here is the link to the full Torsten observation:
http://www.aau.telebus.de/Ver_7/user/Torsten_Hansen/Spektren2014August/20140829NGC6543colcamvis2.jpg



Spectrum of NGC 6543 by Umberto Sollecchia, at R ~ 400, using a home-made spectrograph

NGC 6543 - Lines identification by Jacques Montier



Novae

Fermi Establishes Classical Novae as a Distinct Class of Gamma-Ray Sources
C.C. Cheung, P. Jean, S.N. Shore
Science 345: 554-558, 2014
http://arxiv.org/abs/1408.0735

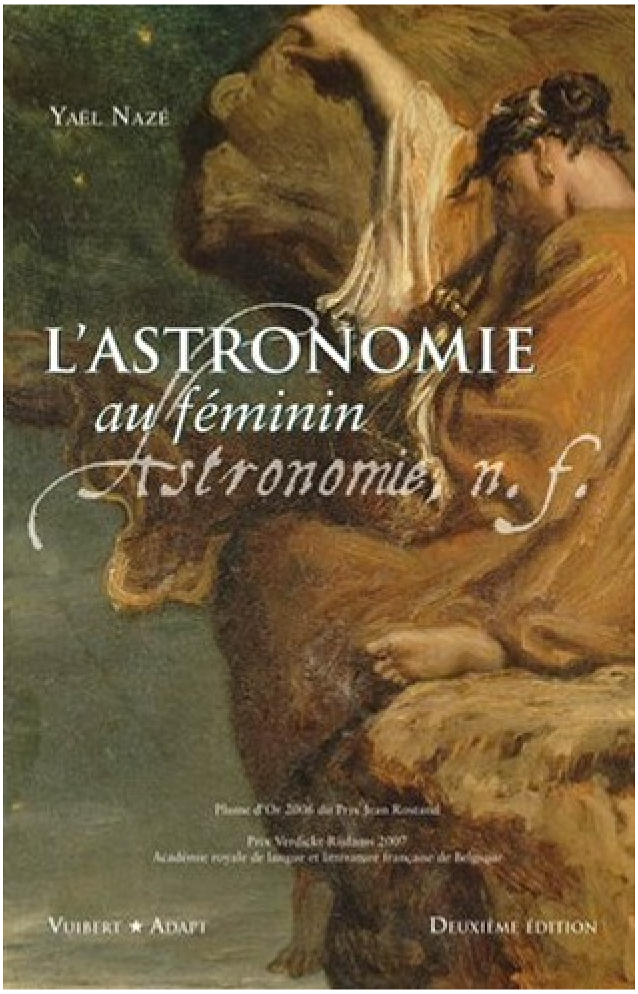
First high resolution ultraviolet (HST/STIS) and supporting optical spectroscopy (CHIRON/SMARTS, HRS/SALT) of V1369 Cen = Nova Cen 2013
S. N. Shore (Univ. of Pisa, INFN-Pisa); G. J. Schwarz (AAS); F. M. Walter (SUNY-SB); S. Crawford (SAAO); P. A. Woudt (Univ. of Cape Town); R. E. Williams (STScI); E. Mason (INAF-OA Trieste); L. Izzo (Univ. of Rome - La Sapienza); K. L. Page, J. P. Osborne (Leicester); J-U Ness (ESA); S. Starrfield (ASU); C. E. Woodward (Univ. of Minnesota) ; P. Vaisanen, F. Marang, L. Crause, L. Tyas (SAAO)
ATel#6413

On the narrow emission line components of the LMC novae 2004 (YY Dor) and 2009a
Mason, Elena; Munari, Ulisse
http://arxiv.org/abs/1408.4038

Amateur Spectroscopy in publications

Olivier Thizy built a great list of (non-exhautive) publications involving amateurs

http://thizy.free.fr/shelyak/bookcover/BiblioArticlesProAm.htm



Le rôle important joué par Margaret Lindsay Huggings, bien plus qu'une simple "assistante" de Williams Huggins est l'occasion de rappeler le remarquable " Astronomie au féminin" publié en 2008 par Yaël Nazé.

Un pdf, largement inspiré du livre :
http://www.astrosurf.com/quasar95/exposes/astronomie_au_feminin.pdf

Yaël Nazé
Vuibert, 2008

About ARAS initiative

Astronomical Ring for Access to Spectroscopy (ARAS) is an informal group of volunteers who aim to promote cooperation between professional and amateur astronomers in the field of spectroscopy.

To this end, ARAS has prepared the following roadmap:

• Identify centers of interest for spectroscopic observation which could lead to useful, effective and motivating cooperation between professional and amateur astronomers.
• Help develop the tools required to transform this cooperation into action (i.e. by publishing spectrograph building plans, organizing group purchasing to reduce costs, developing and validating observation protocols, managing a data base, identifying available resources in professional observatories (hardware, observation time), etc.
•Develop an awareness and education policy for amateur astronomers through training sessions, the organization of pro/am seminars, by publishing documents (web pages), managing a forum, etc.
• Encourage observers to use the spectrographs available in mission observatories and promote collaboration between experts, particularly variable star experts.
• Create a global observation network.

By decoding what light says to us, spectroscopy is the most productive field in astronomy. It is now entering the amateur world, enabling amateurs to open the doors of astrophysics. Why not join us and be one of the pioneers!

Contribution to ARAS data base
From 01-08 to 31-08-2014

P. Berardi
T. Bohlsen
D. Boyd
C. Buil
P. Dubreuil
M. Dubs
A. Garcia
K. Graham
J. Guarro
T. Lester
J. Montier
M. Rodriguez
P. Somogyi
F. Teyssier

And for “cat eye nebula” project
Olivier Thizy
Torsten Hansen
Umberto Sollecchia

Submit your spectra

Please :
- respect the procedure
- check your spectra BEFORE sending them
Resolution should be at least R = 500
For new transcients, supernovae and poorly observed objects,
SA spectra at R = 100 are welcomed

1/ reduce your data into BeSS file format
2/ name your file with: _novadel2013_yyyymmdd_hhh_Observer
novadel2013: name of the nova, fixed for this object

Exemple: _chcyg_20130802_886_toto.fit

3/ send you spectra to
Novae Symbiotics : François Teyssier
Supernovae : Christian Buil
to be included in the ARAS database

Further informations :
Email francoismathieu.teyssier at bbox.fr

Download previous issues :
http://www.astrosurf.com/aras/novae/InformationLetter/InformationLetter.html