Eruptive stars spectroscopy
Cataclysmics, Symbiotics, Novae, Supernovae

ARAS Eruptive Stars
Information letter n° 8 - 11-08-2014

News

Time series observations of the microquasar **SS 443** during an optical flare by S. Charbonnel, O. Garde and J. Edlin. Observations published in ATel #6355

Last minute
AX Per in outburst

The prototype Symbiotic **AX Per** has been detected in outburst by ANS collaboration
See ATel #6382
The current mag is about 10.5
Spectra of this event are welcome for ARAS data base
Data Base AX Per
Aras topic for exchanges Forum

Coordinates (2000.0)	
R.A.	**1 36 22.7**
Dec.	**+54 15 2.5**

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

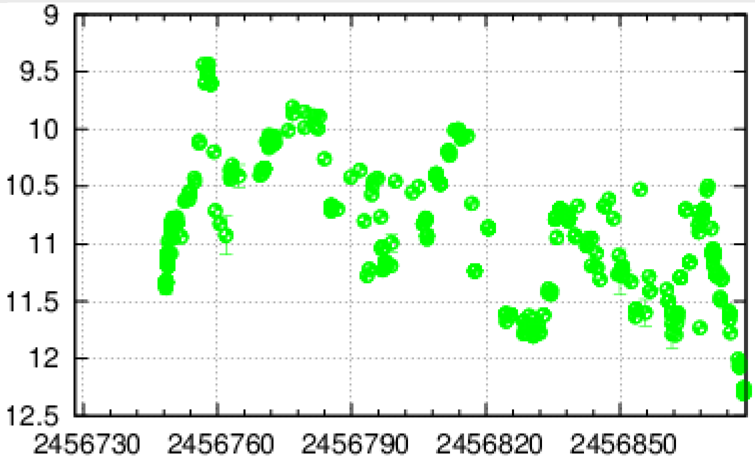
Contents

Aknowledgements : V band light curves from AAVSO photometric data base

N O V A E

Nova Cyg 2014

Luminosity
Mag V = 12.3 (08-08-2014)
Unusual light curve
After the big dip in June (mag 10.5 to 11.8), the nova recovers and oscillates in july between 10.5 and 11.8. At the begining of August, the lumisity declines of 1.8 magnitude in 8 day



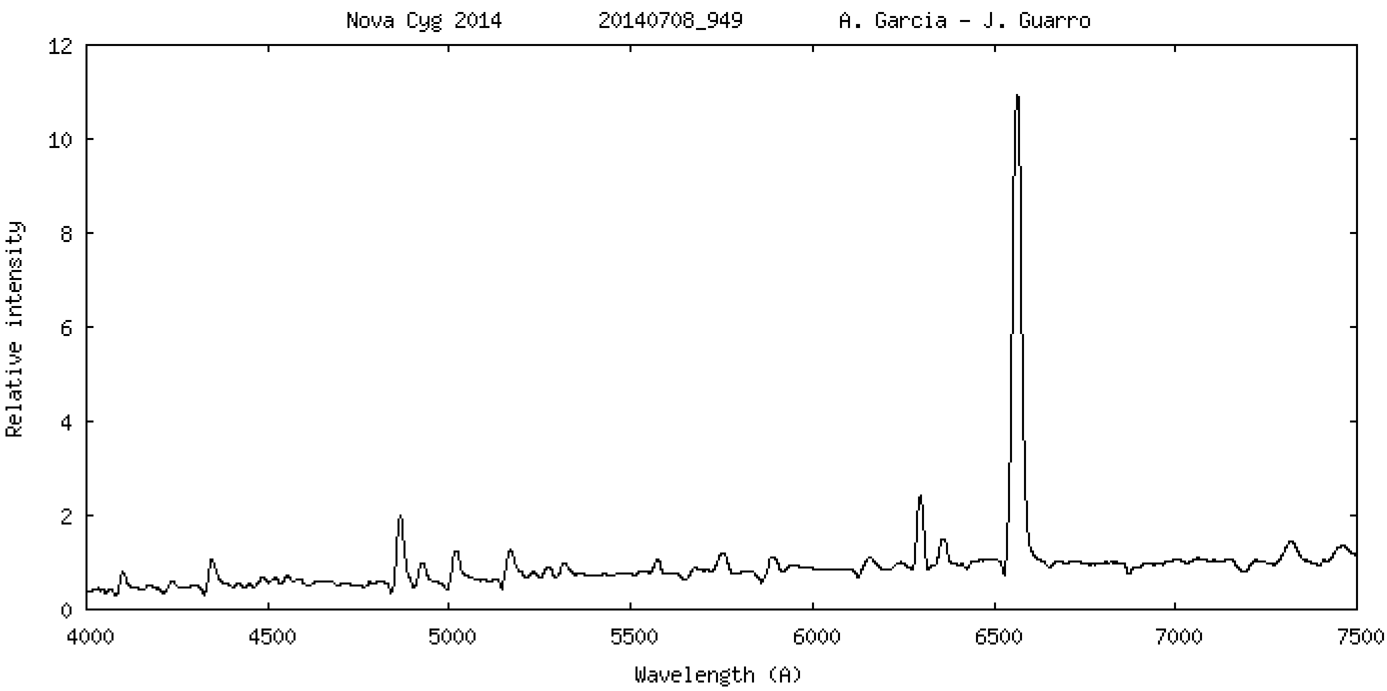
Observing : spectra required for this peculiar nova - One a day

Request for observations from Steve Shore

The photometric behavior currently being recorded for N Cyg 2014 is starting to look **bizarre**. Transitions in the B magnitude of order a factor of 50% to 2 are occuring on intervals as short as two days.
Regardless of the mechanism (and of course I have conjectures galore), there is a clear connection between the spectroscopic phenomenology and the photometry. During the B (or V) maxima, the absorption component strengths for the P Cyg lines on the principal Fe II transitions (4923, 5018, 5169) and also the Balmer lines -- the multiplets with which you're so familiar from the V339 Del spectra -- are varying by factorsn of two in equivalent widths.

At the moment, **the transitions in strength are unpredictable and, not having seen anything quite like this before in previous novae, are a NEW THING**. It's entirely possible that this is actually almost normal an not previously seen because of cadence of observations, but we don't know. There is very clearly a differential change between the [O I] 6300,6364 lines and the Fe II (and there may also be variations at He I 7065, 6678, and 5876).

One important thing -- this time S/N ratio is really important, the lines are very weak relative to Halpha (about 10-20%) so if possible try to obtain a set in which one of the spectra is very overexposed on Halpha.



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

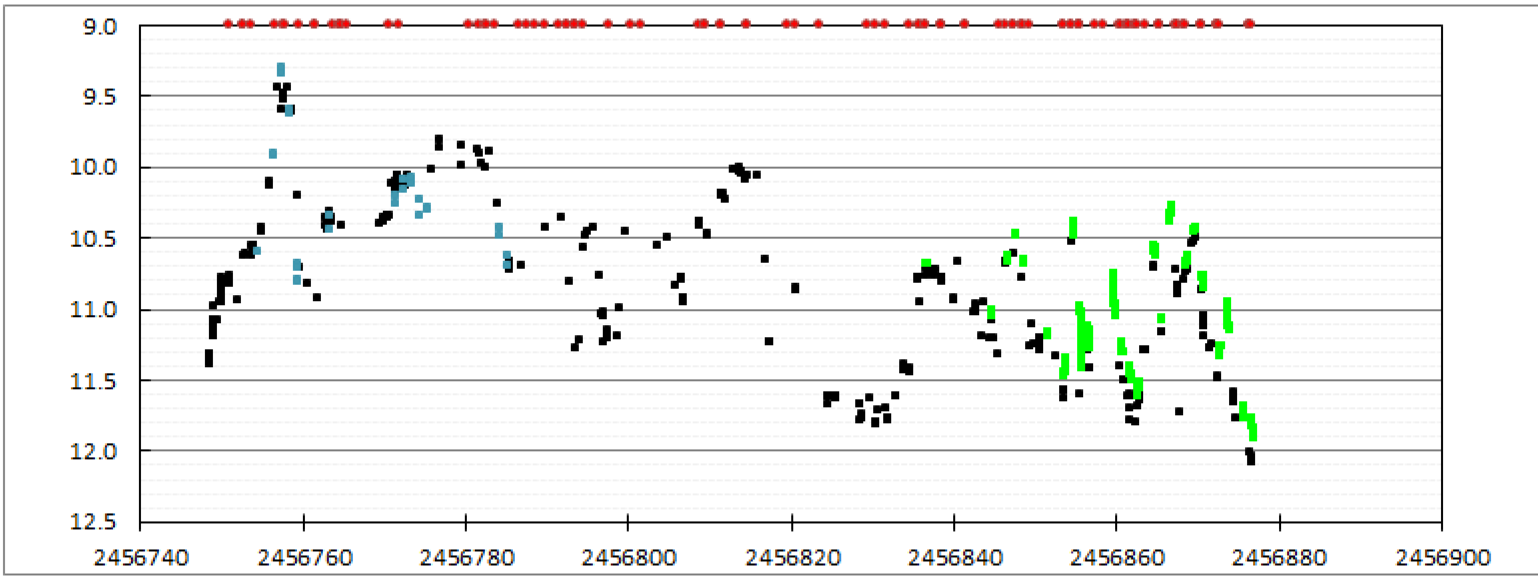
ARAS DATA BASE : 104 spectra http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cyg-2014.htm
Web Page : http://www.astrosurf.com/aras/novae/NovaCyg2014.html

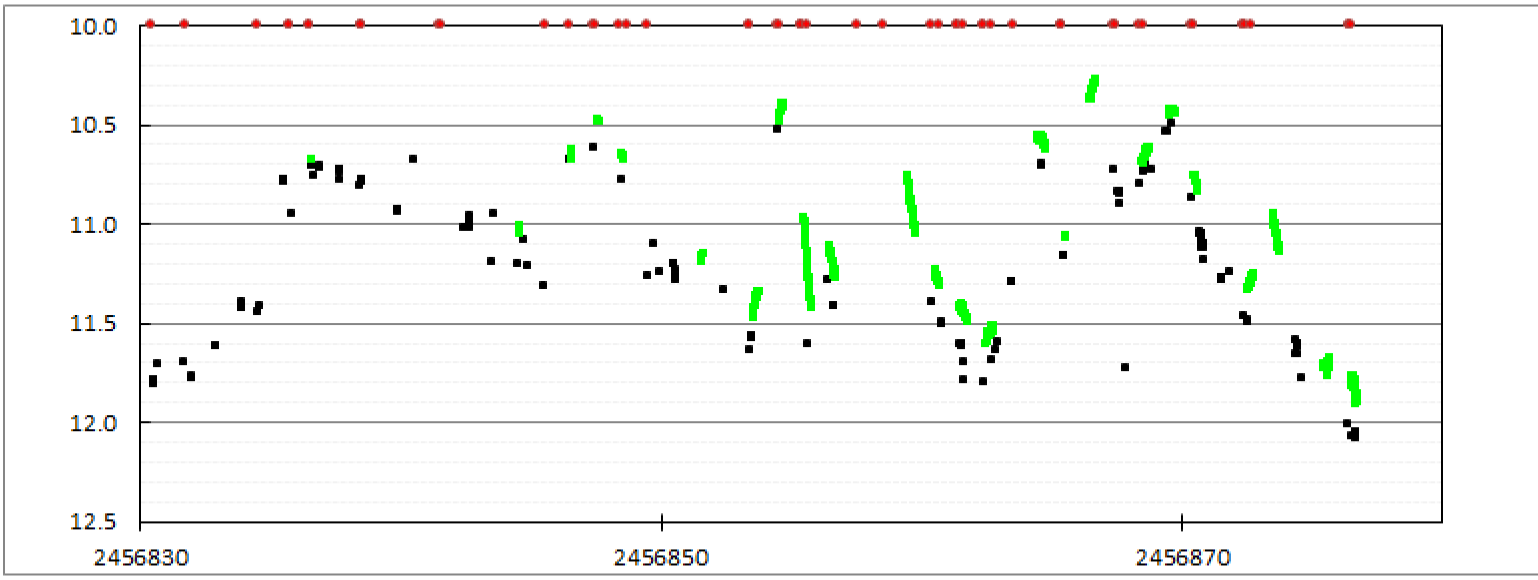
NOVAE

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

Antonio Garcia and Joan Guarro performed V band photometry time series from their remote observatory of Santa Maria (SP)
The quality and the density of their observations provide useful information on the evolution of this nova (870 data collected at date)

Black squares : AAVSO V Band
Blue squares : K. Imamura & al., ATel #6128
Green squares : A Garcia & J Guarro
Red dots : ARAS Spectra

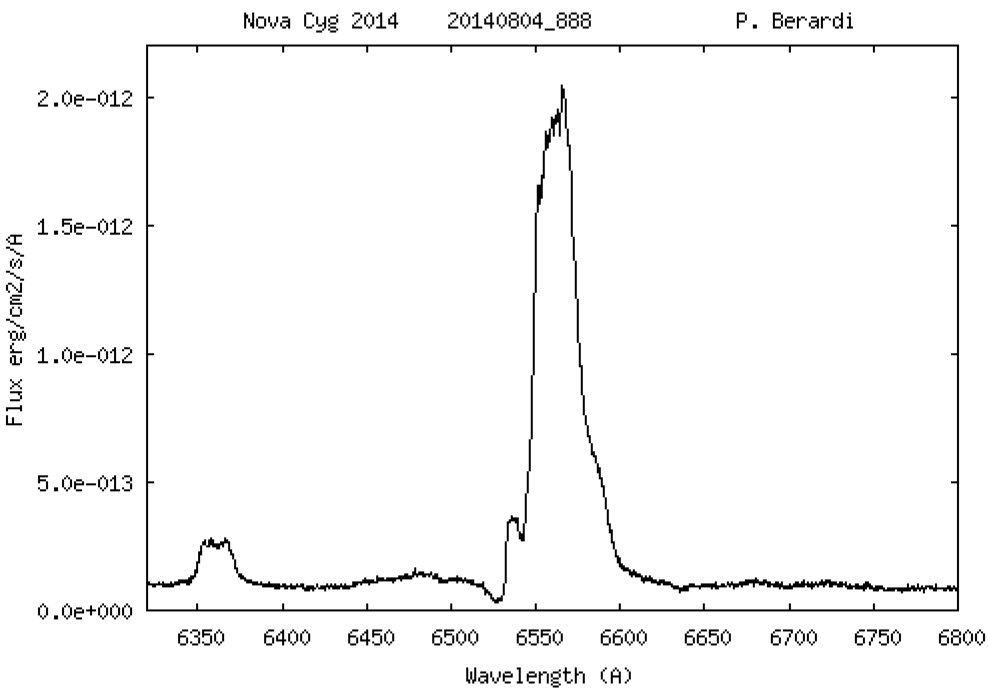




Crop on 02-06 to 08-08-2014 period showing the complex behaviour of luminosity
Very fast changes are highlighted by Antonio and Joan's photometry
See for example :

JD	Mag V	Δ V	Δ V / day
2456853.496	11.463		
2456854.627	10.384	-1.08	-0.95
2456855.733	11.414	1.03	0.93

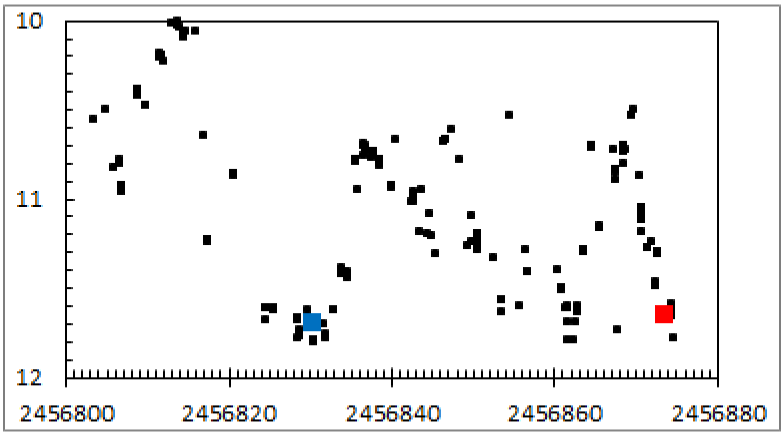
Nova Cyg 2014 evolution at medium resolution from late June to beginning of August, 2014

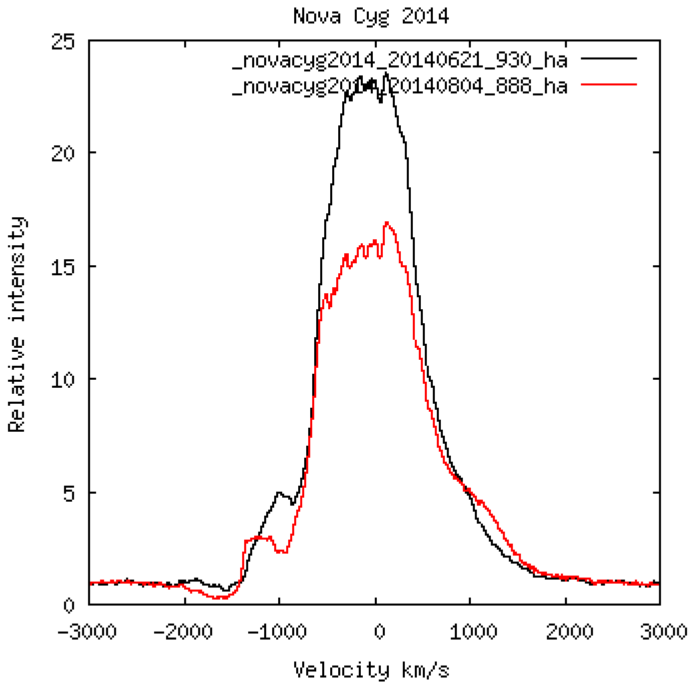


2014-08-04.888

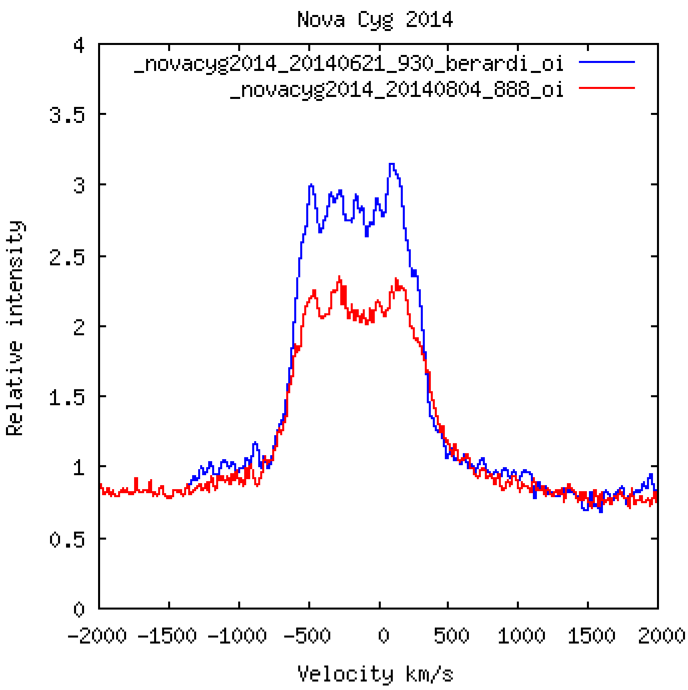
Hα and [OI] 6363 by Paolo Berardi with a Lhires III 1200 l/mm (R = 5000)

Two absorption systems clearly visible. Maximum velocity = 2000 km.s^{-1}





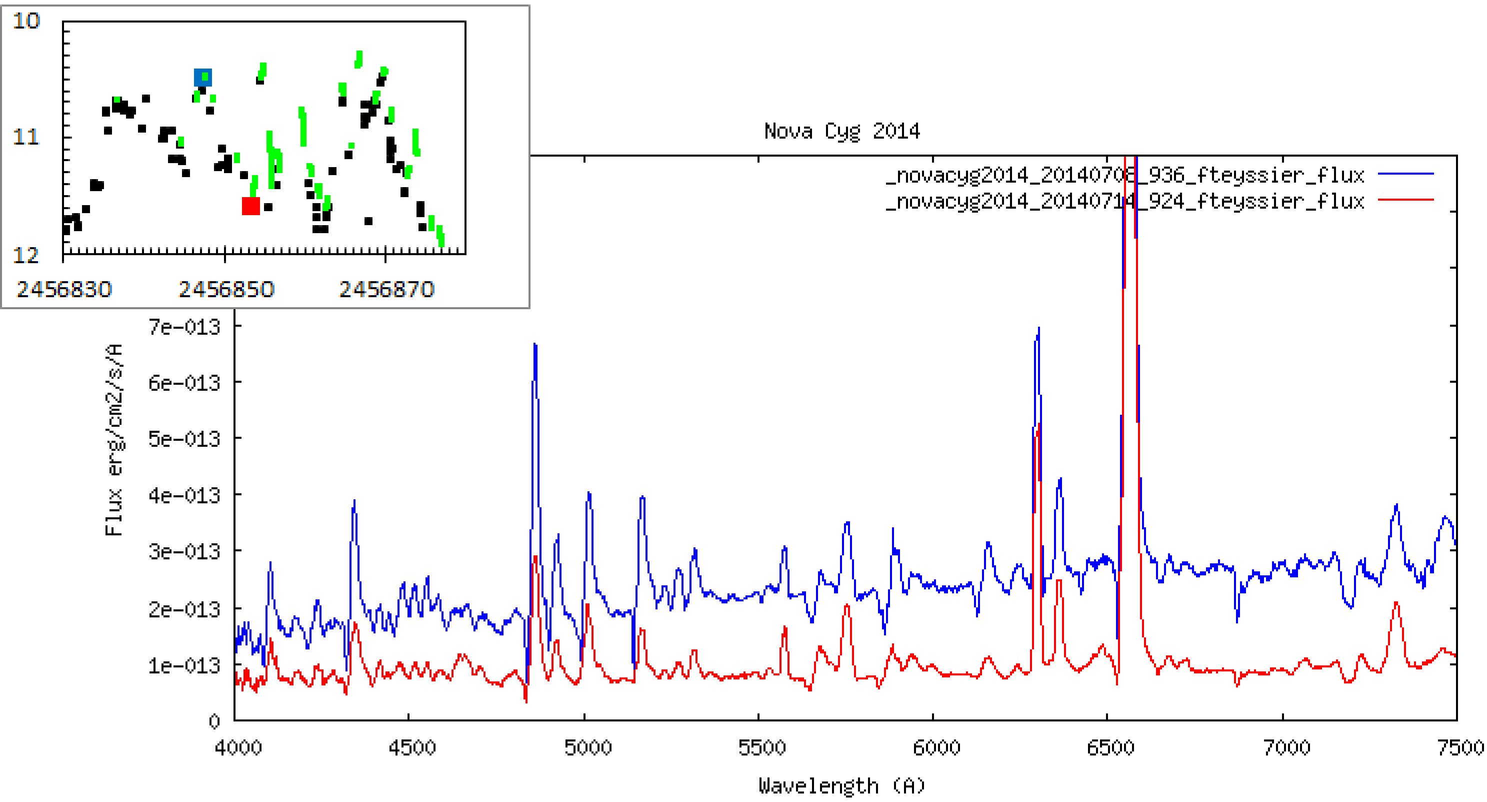
Comparison of two spectra obtained at about the same luminosity (~ 11.7) on June, 21.9 and August 04.9 - Obvious changes in absorption profiles

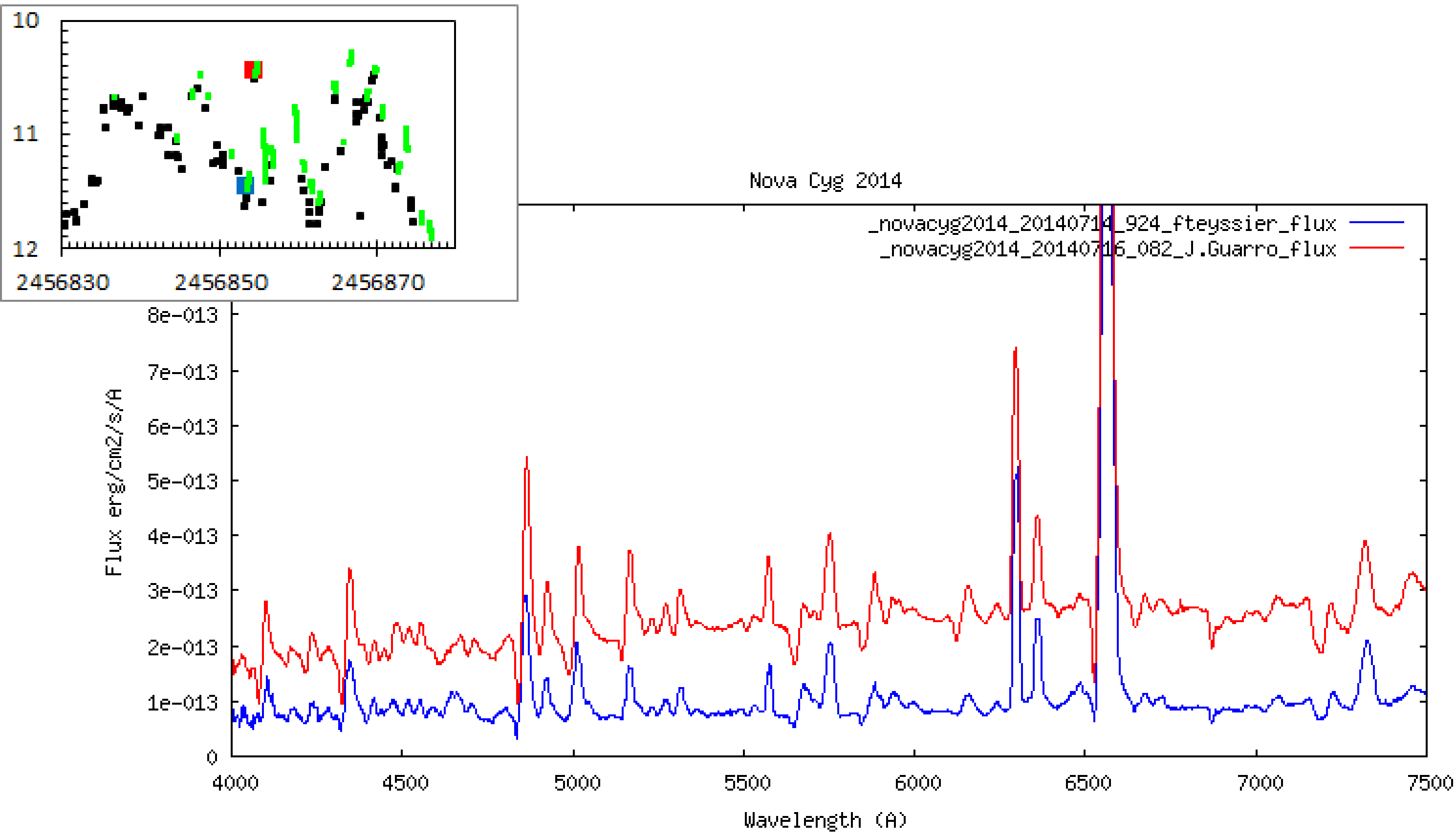


The same with [O I] 6363

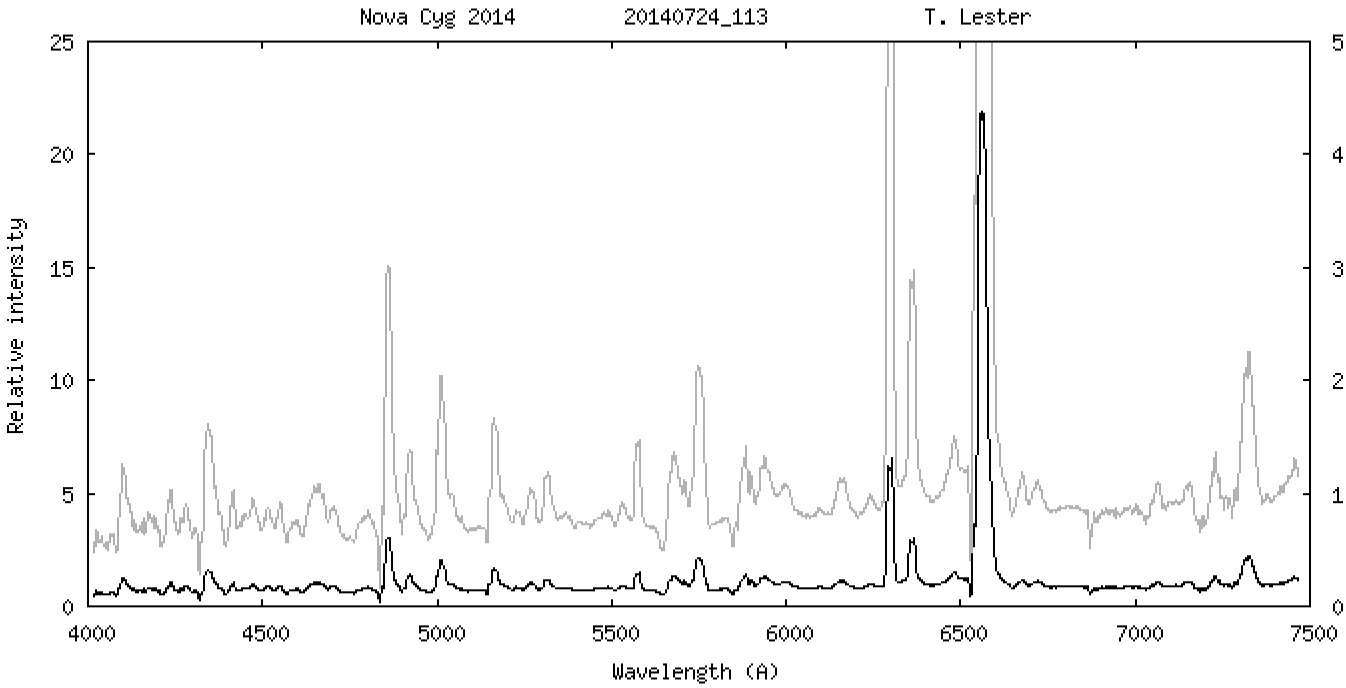
NOVAE

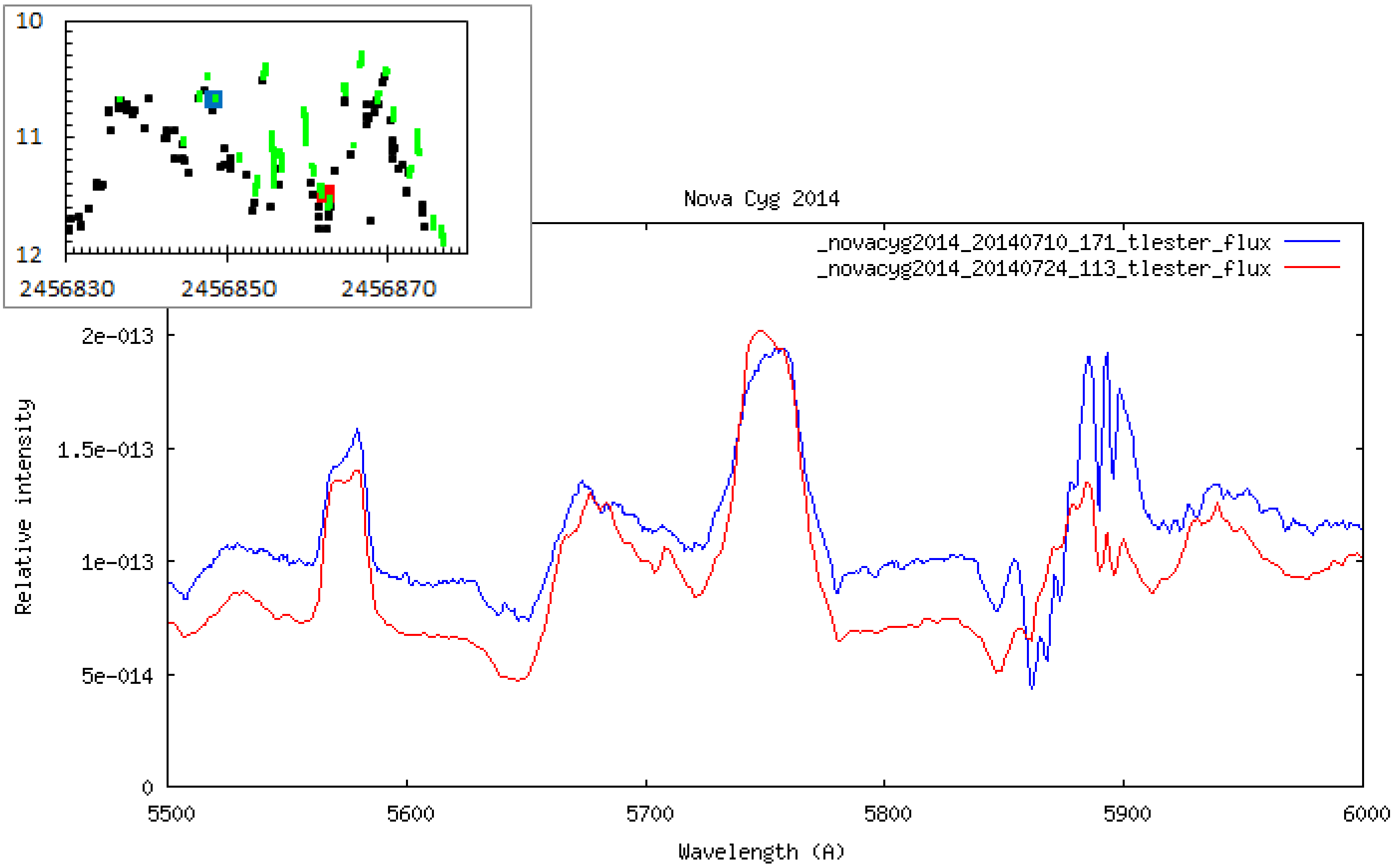
Nova Cyg 2014 evolution





Nova Cyg 2014 evolution



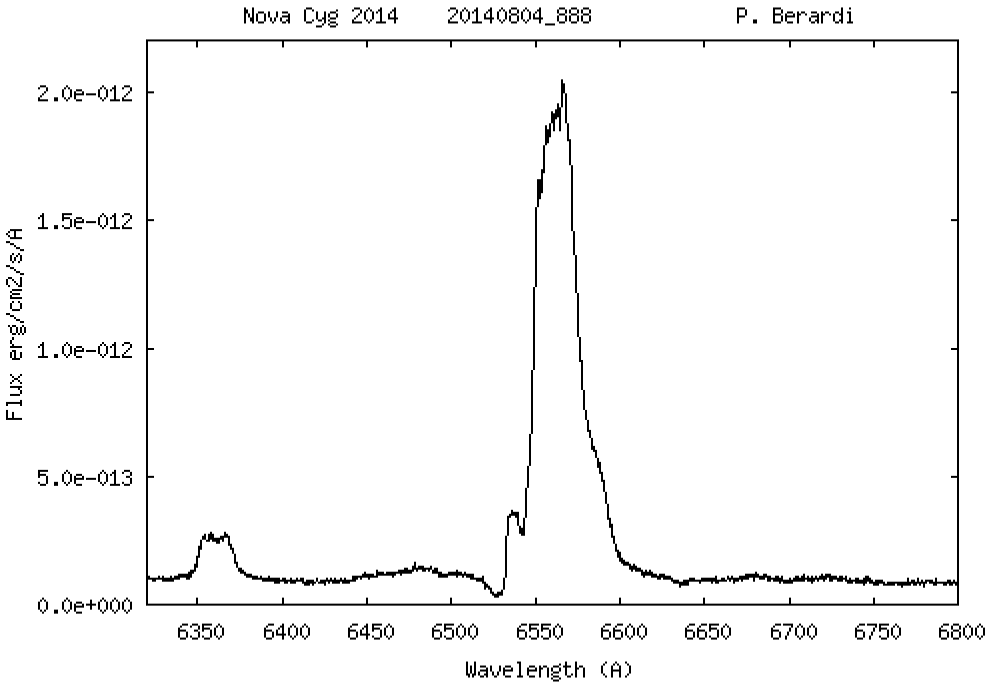


Evolution in NaI D region with [O I] 5577, [N II] 5755, blend He I 5876 and Na I D

V mag ~ 10.8 (10-07) V mag ~ 11.5 (24-07)

Note changes in absorption features of He I/Na I D blend

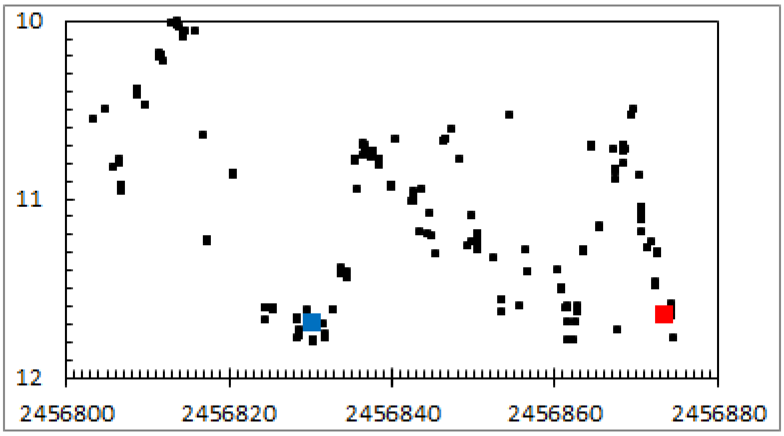
Nova Cyg 2014 evolution at medium resolution from late June to beginning of August, 2014

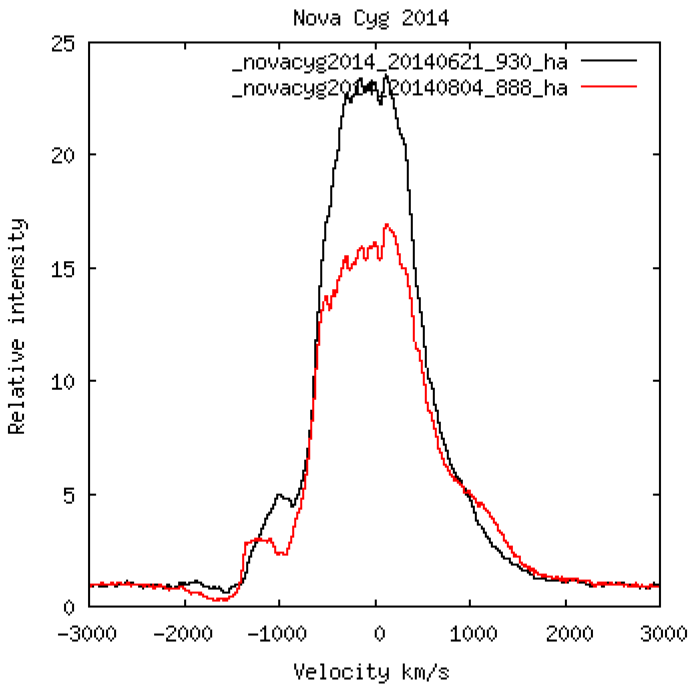


2014-08-04.888

Hα and [OI] 6363 by Paolo Berardi with a Lhires III 1200 l/mm (R = 5000)

Two absorption systems clearly visible. Maximum velocity = 2000 $km.s^{-1}$





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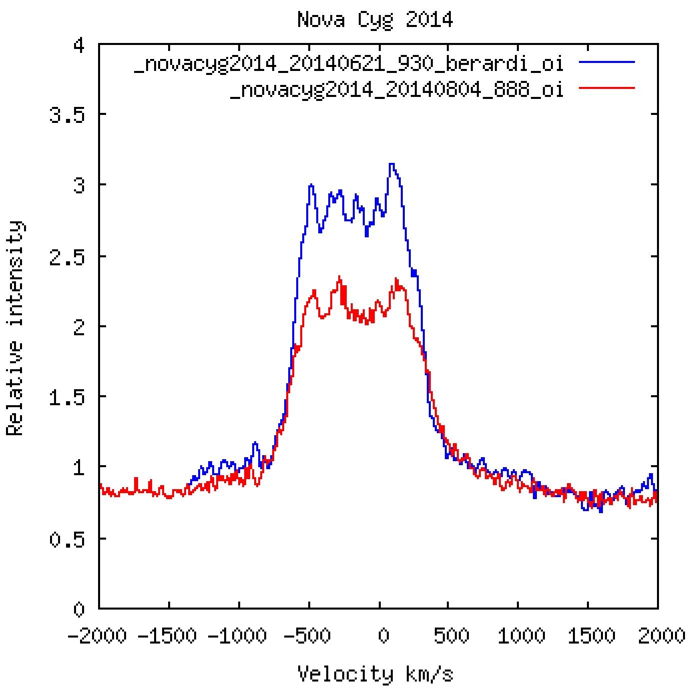
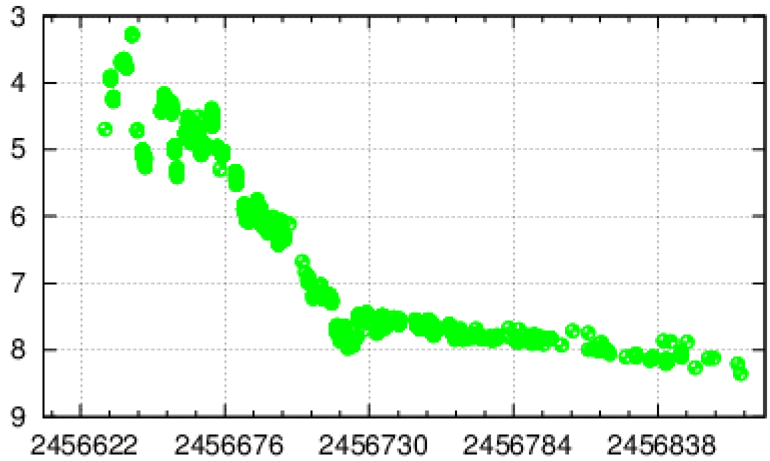


The same with [O I] 6363

NOVAE

Nova Cen 2013 = V1369 Cen

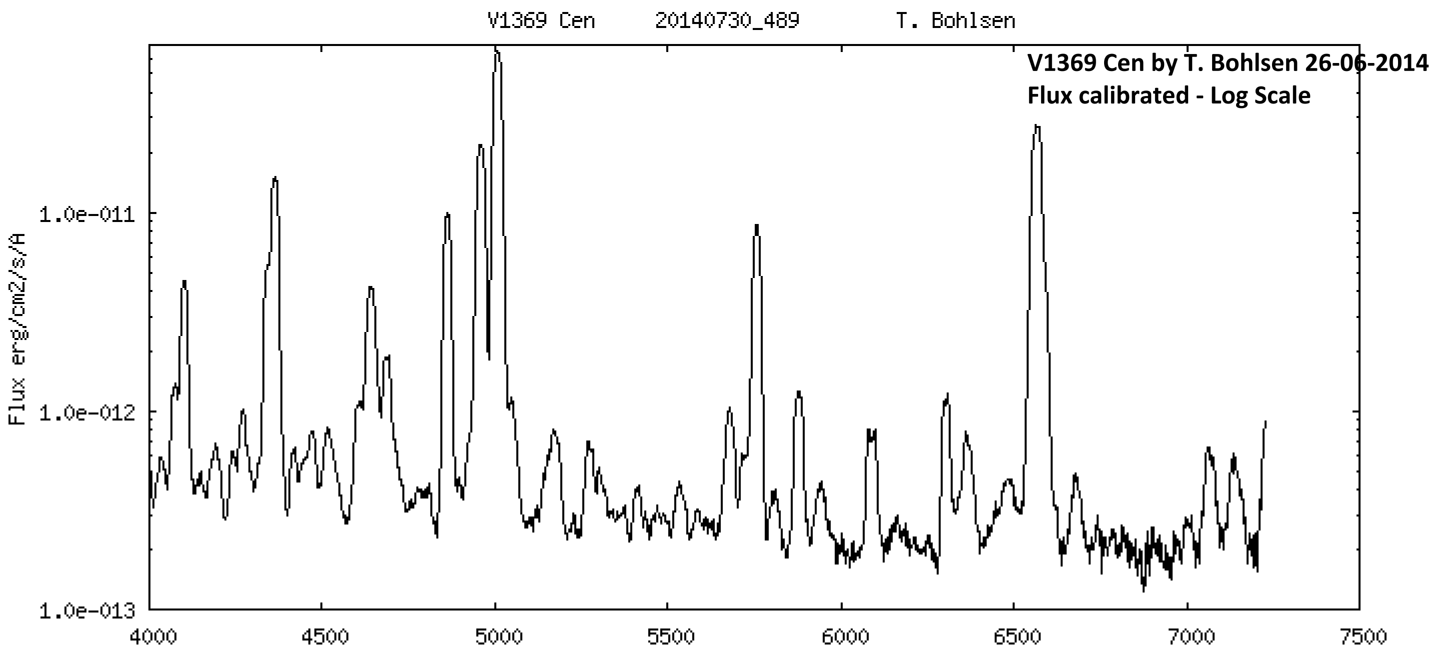
Luminosity
Mag V = 8.2 (28-07-2014)
Slowly declining, about 4.6 mag under maximum luminosity

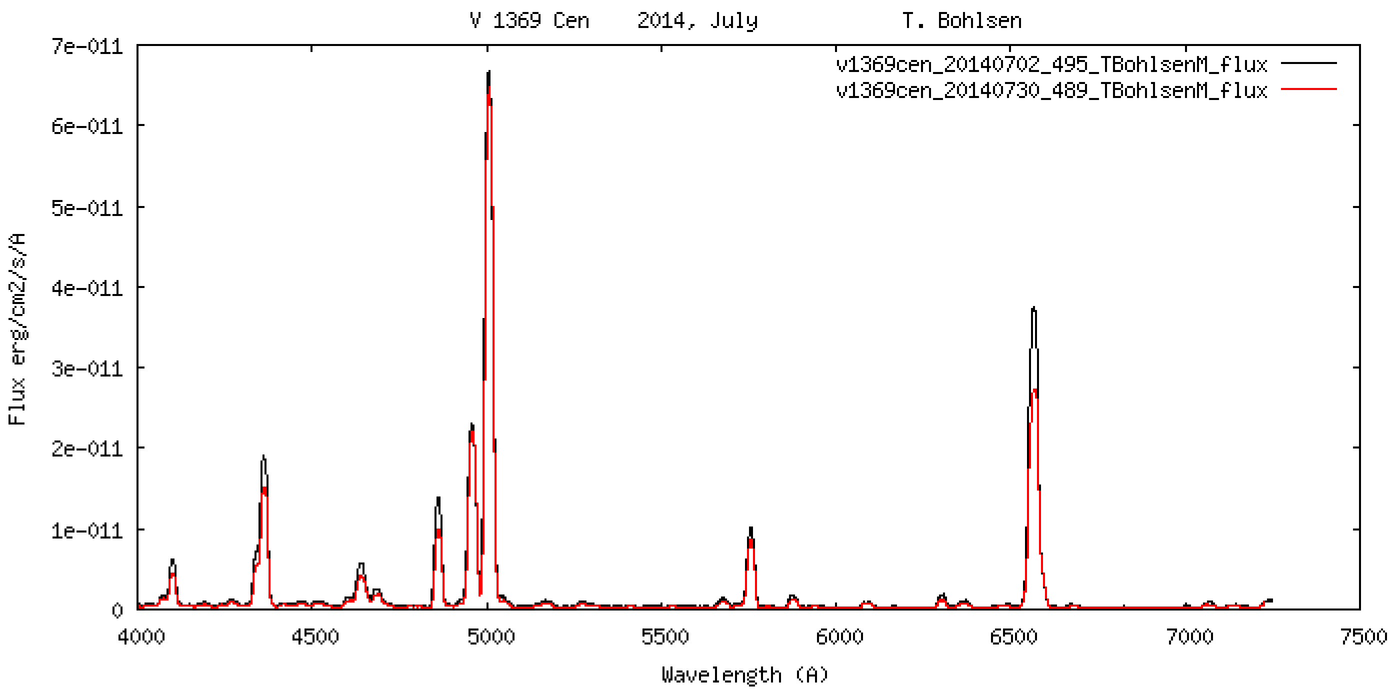


Observing

New spectra from Terry Bohlsen

[O III] 5007, 4959 remain constant from 2d to 30th of july





V1369 Cen evolution from 02-07 to 30-07-2014

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

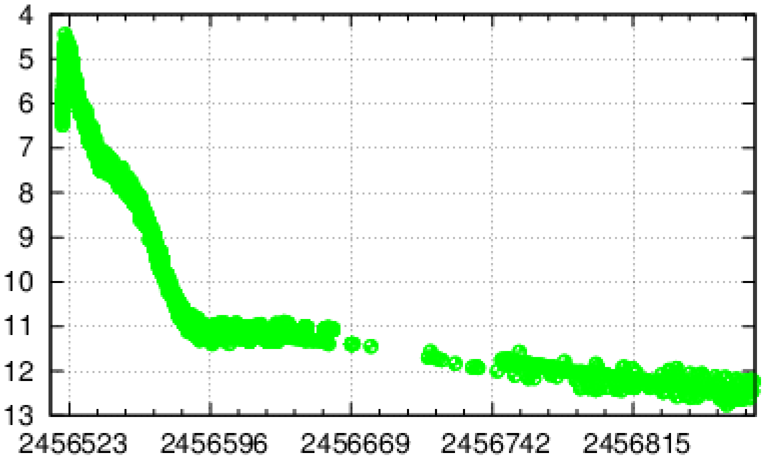
ARAS DATA BASE : 158 spectra http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cen-2013.htm

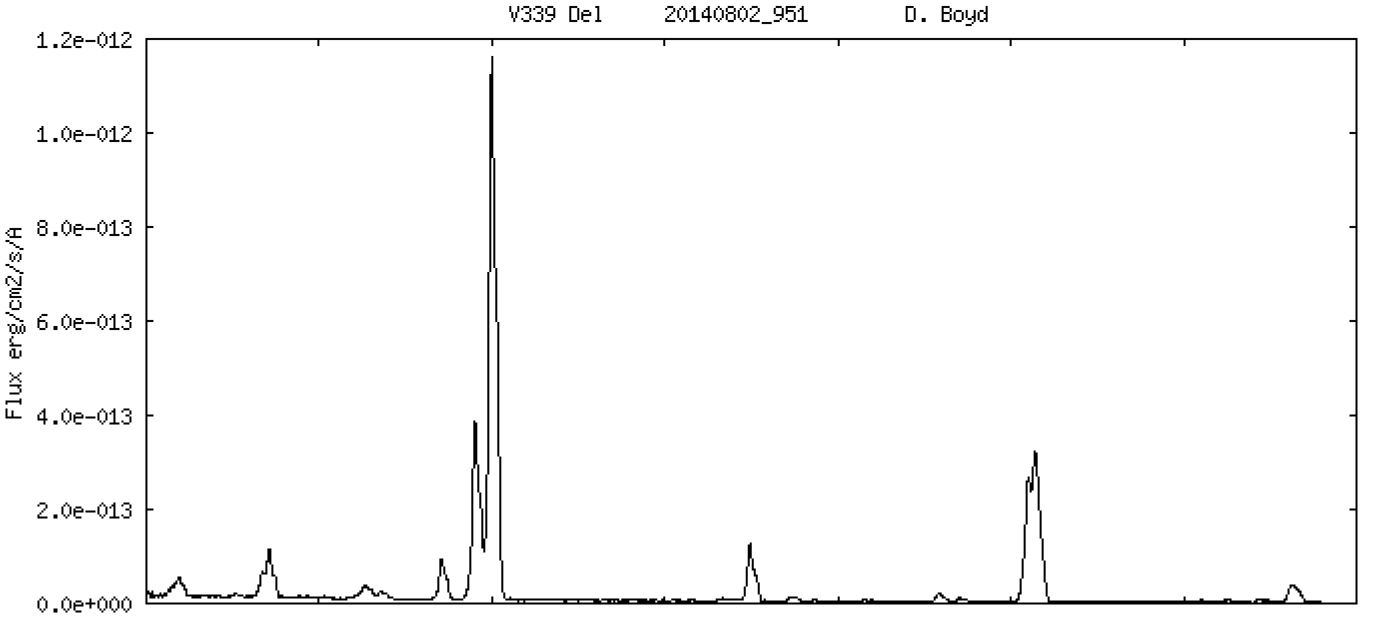
N O V A E

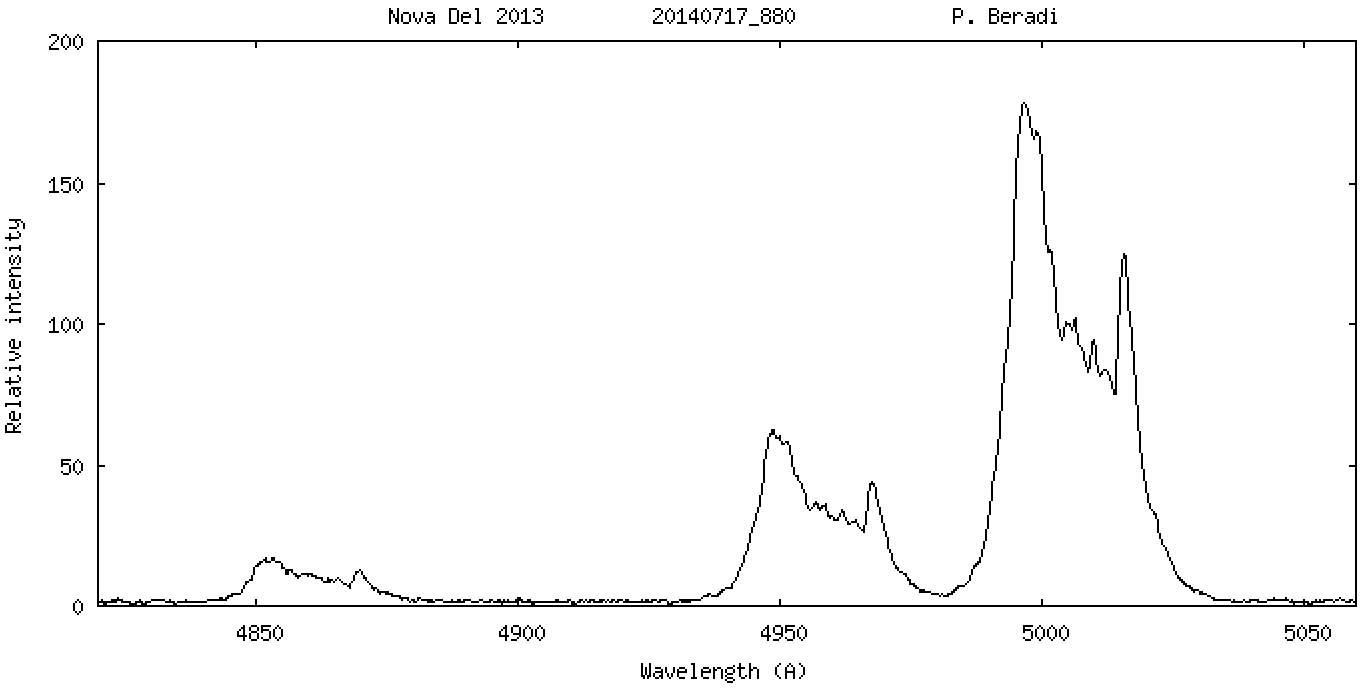
Nova Del 2013 = V339 Del

Luminosity
Mag V ~ 12.4 (07-08-2014)
Slowly declining

Observing
Spectra required (one a week)





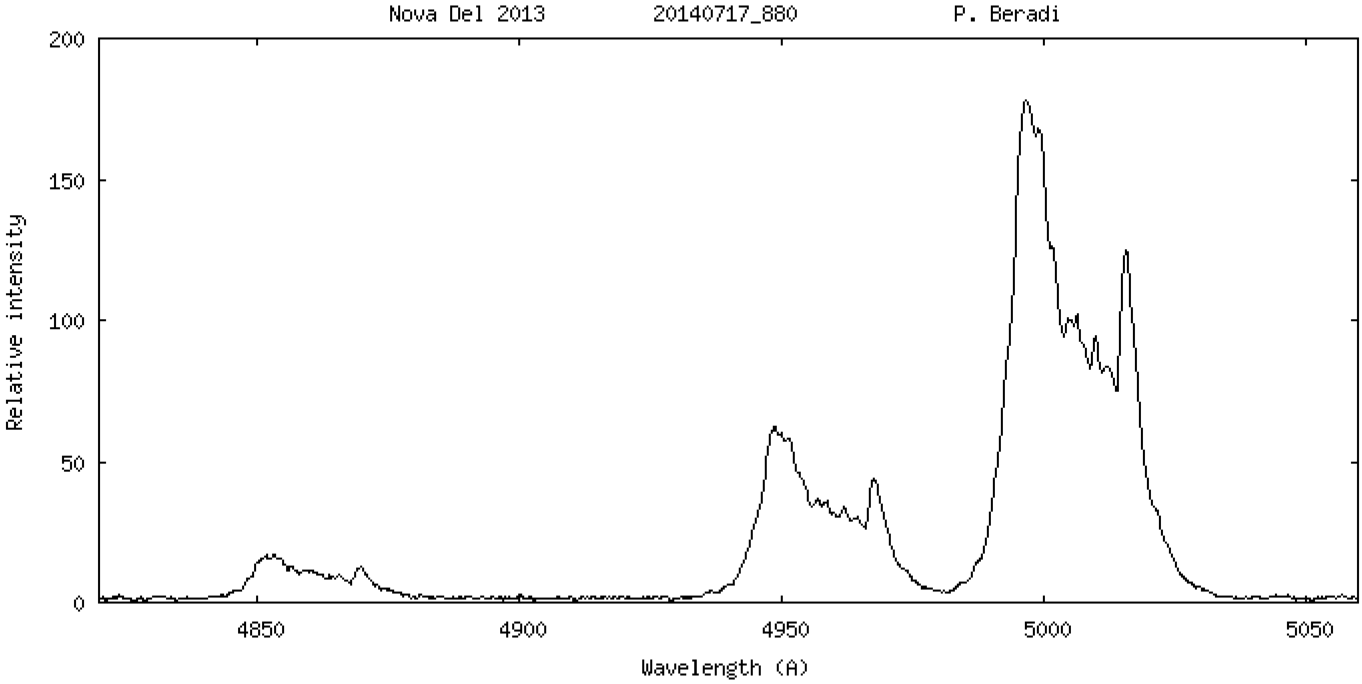


Hβ, [OIII] 4959, 5007 ÅÅ by Paolo Berardi with Lhires III 1200 l/mm R = 5000 and SC 235 mm

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

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

Nova Del 2013 = V339 Del



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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

Symbiotics

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

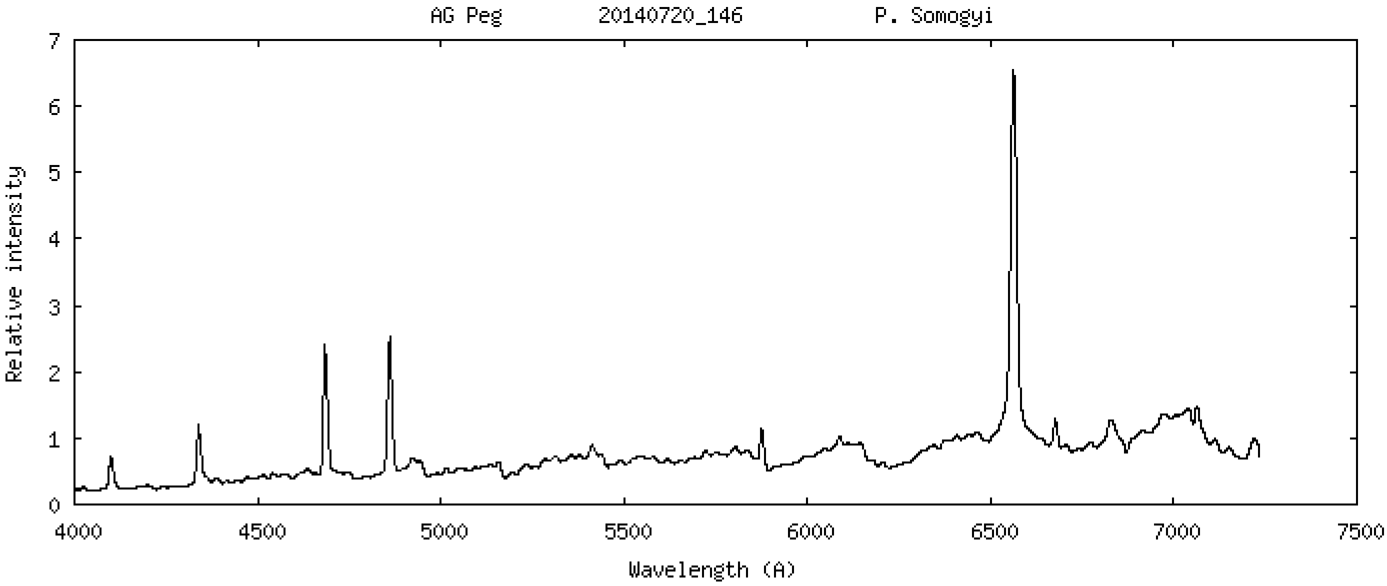
Mag V * : 01-04-2014

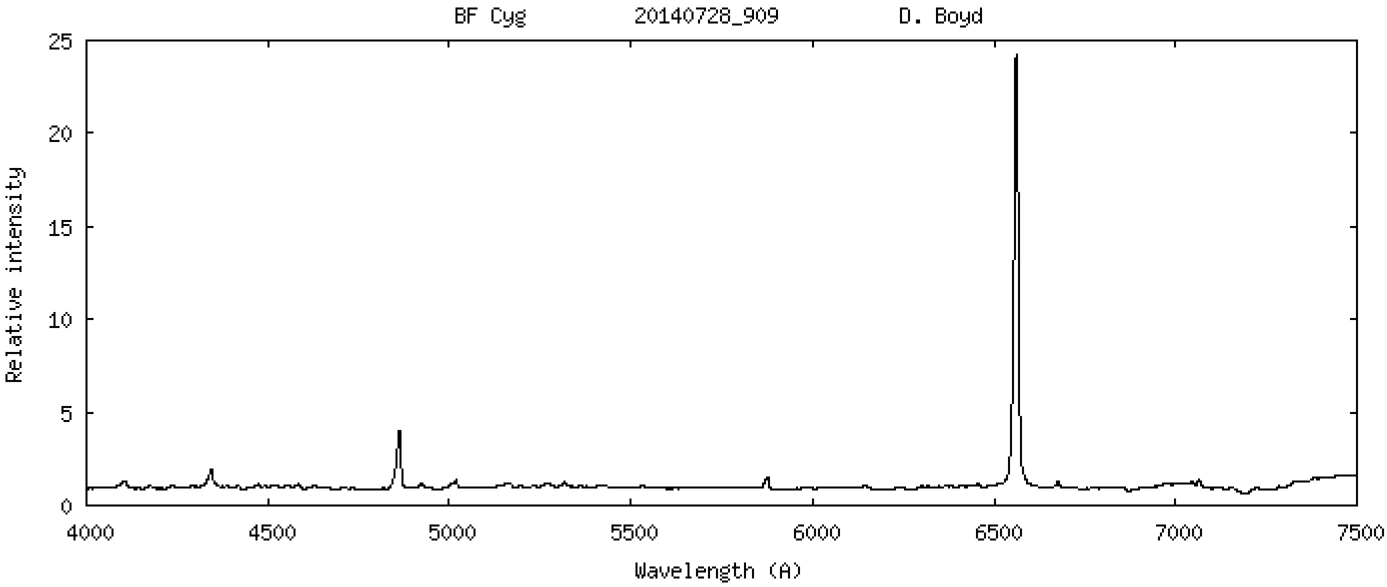
Observations
from 01-07 to 08-08-2014

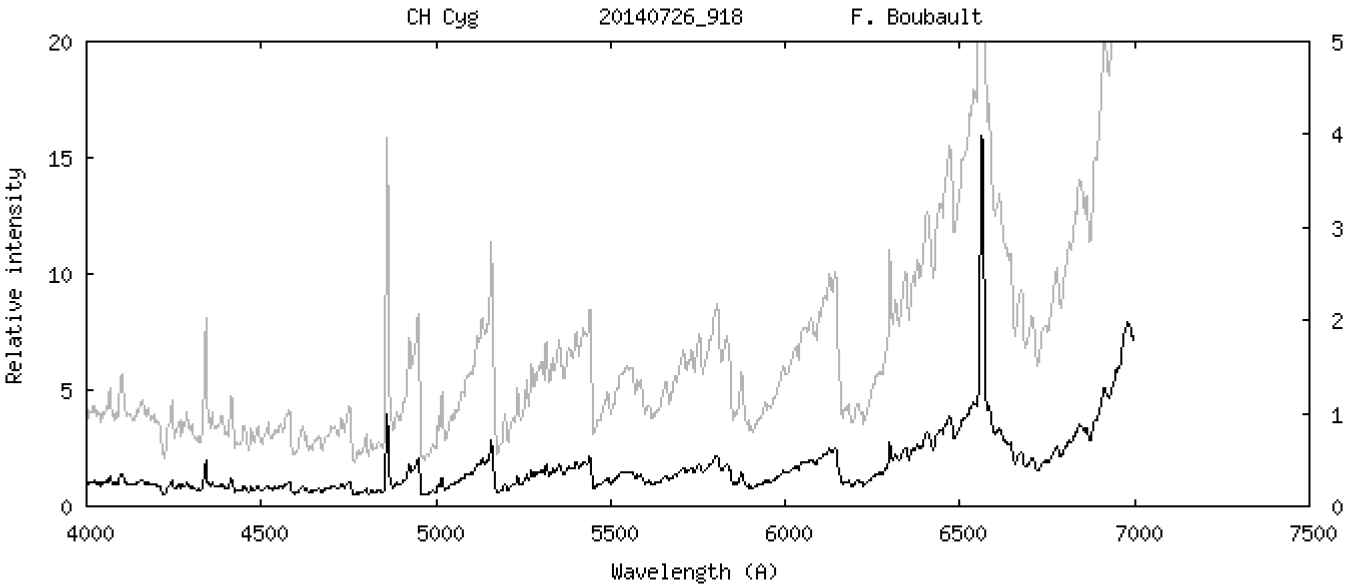
New spectra	
T CrB	1
BF Cyg	2
CH Cyg	4
CI Cyg	3
YY Her	1
RS Oph	1
AG Peg	1
FG Ser	1
FN Sgr	2

ARAS DATA BASE | http://www.astrosurf.com/aras/Aras_DataBase/Symbiotics.htm

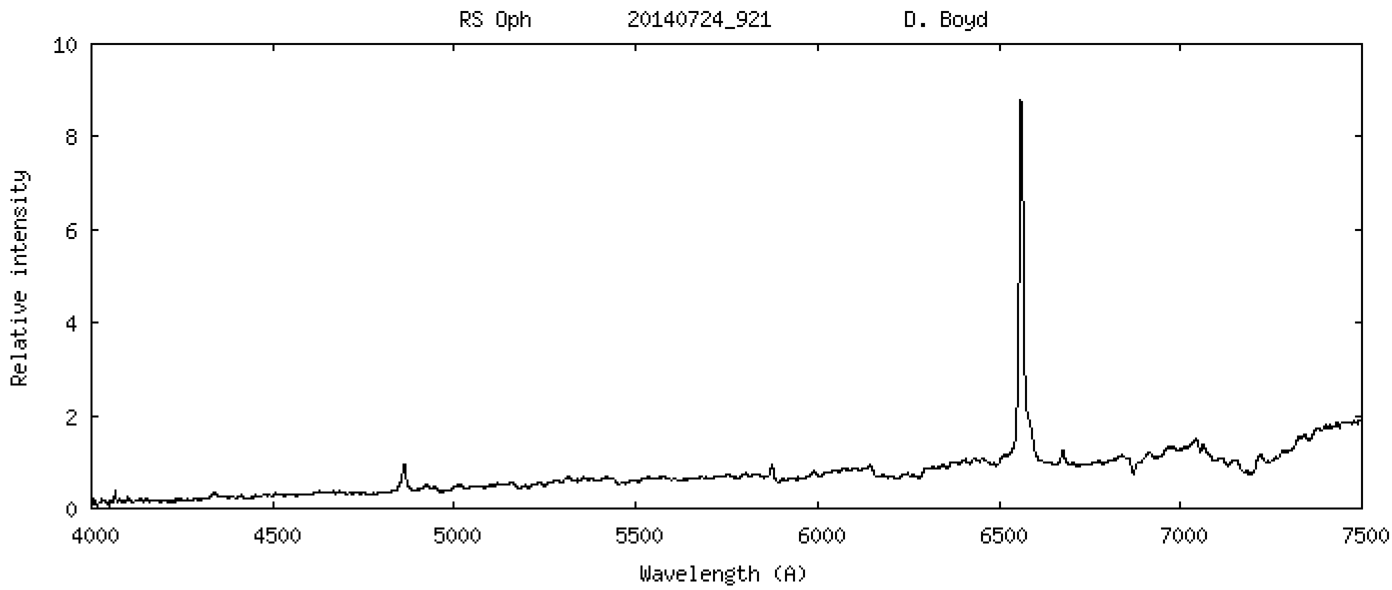
AG Peg | BF Cyg | CH Cyg

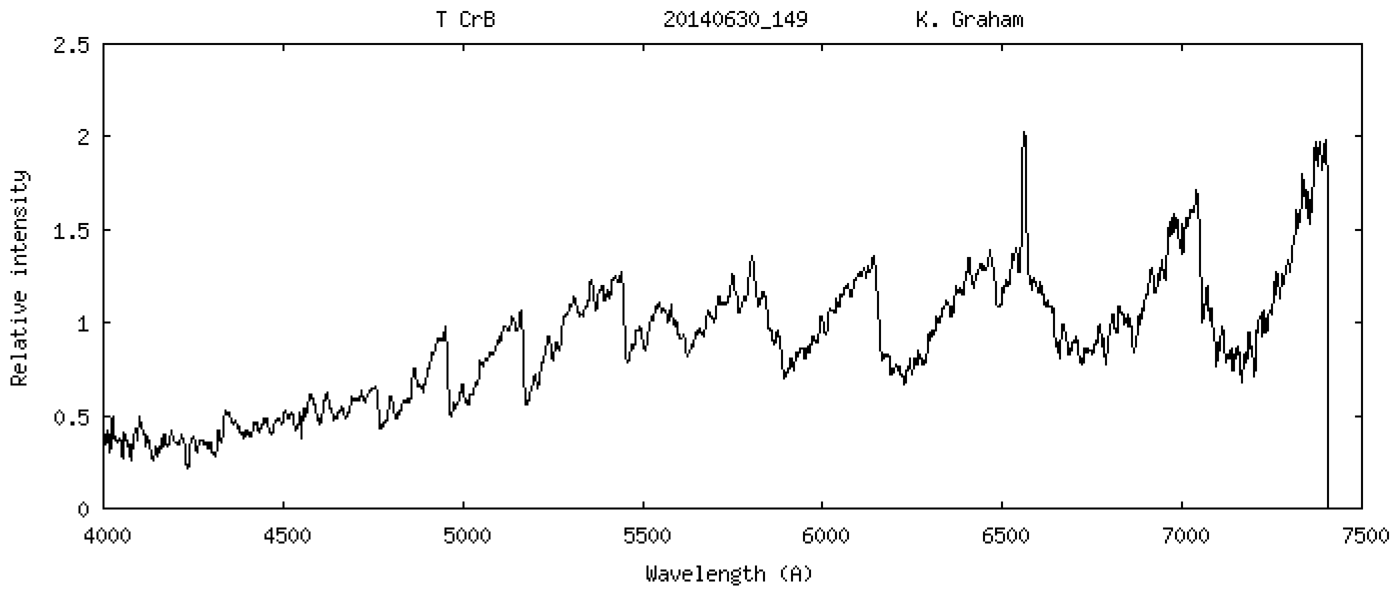


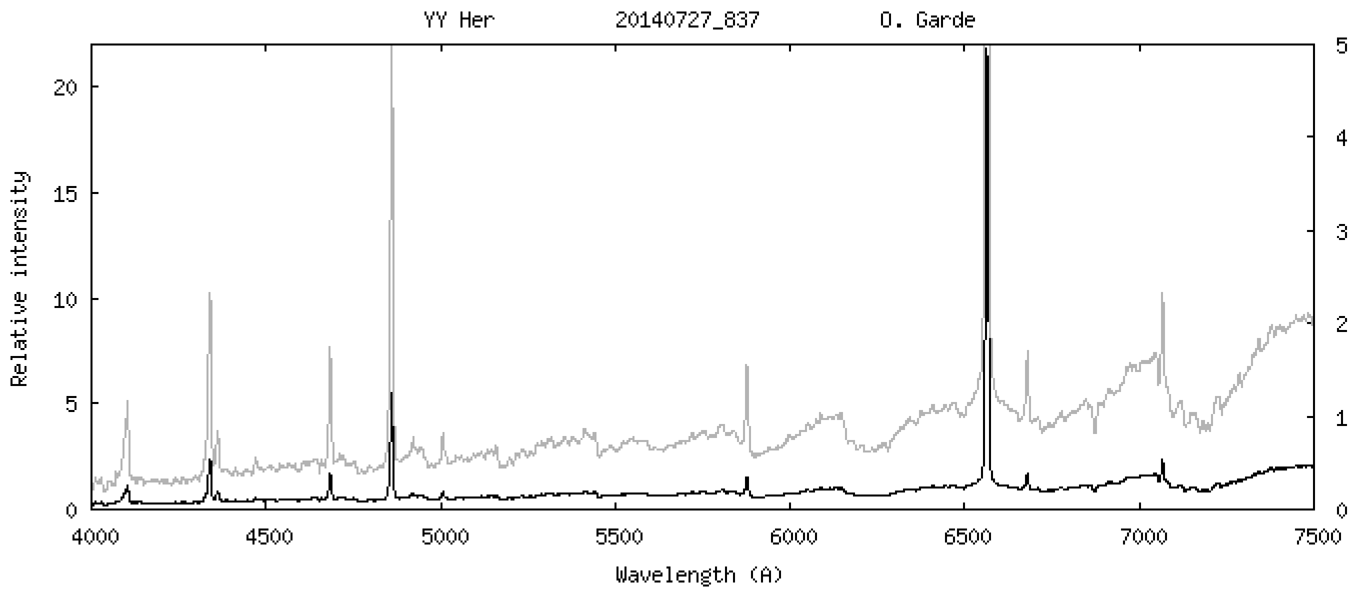




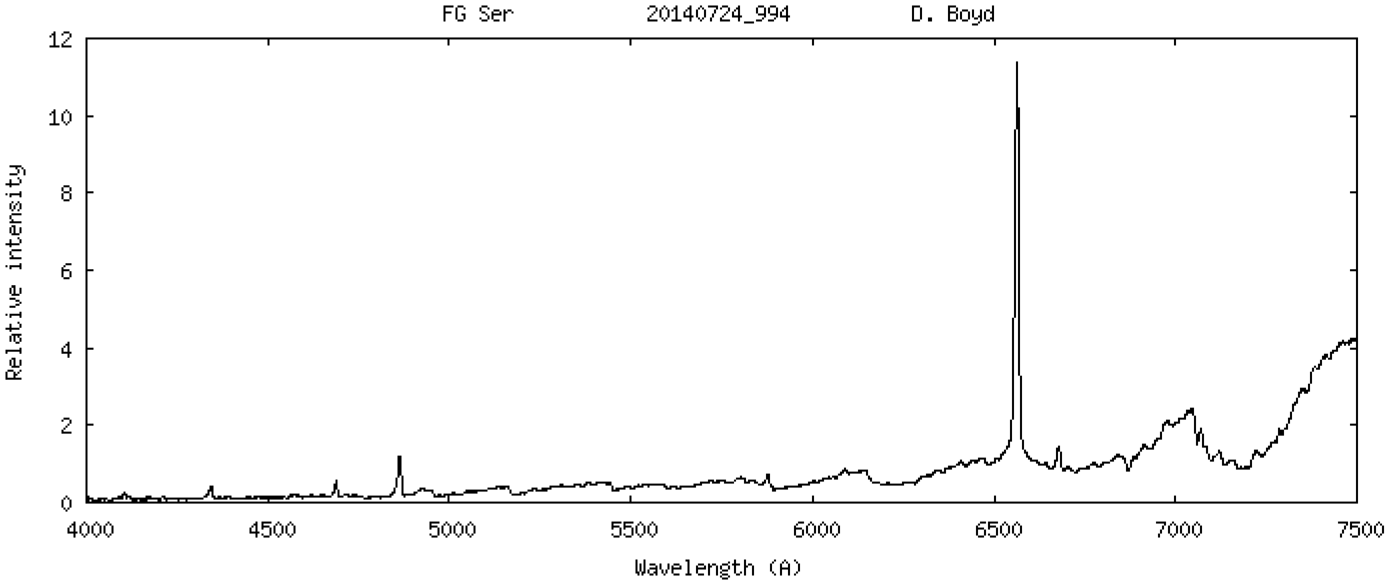
RS Oph | T CrB | YY Her

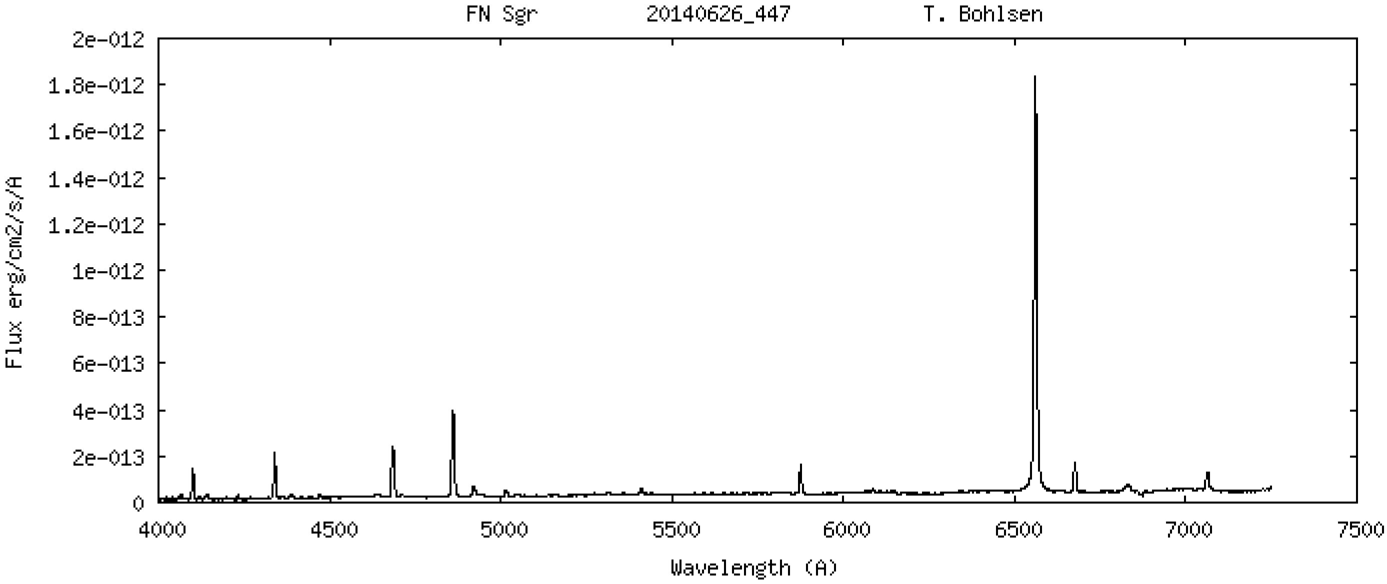


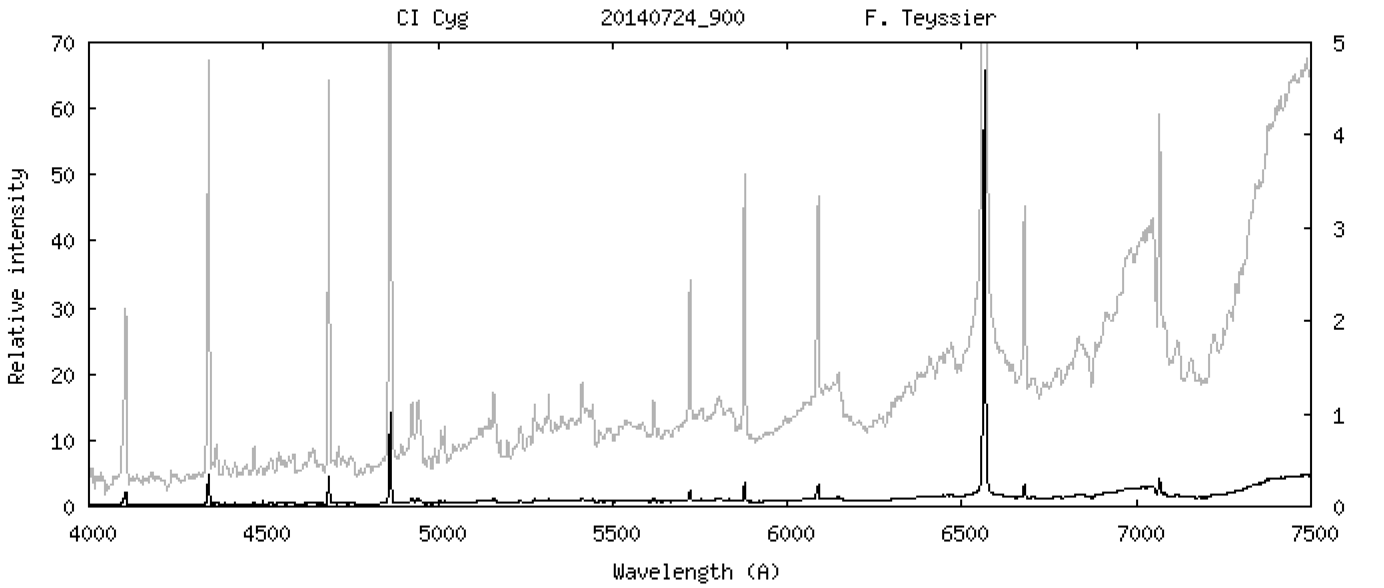




FG Ser | FN Sgr | CI Cyg





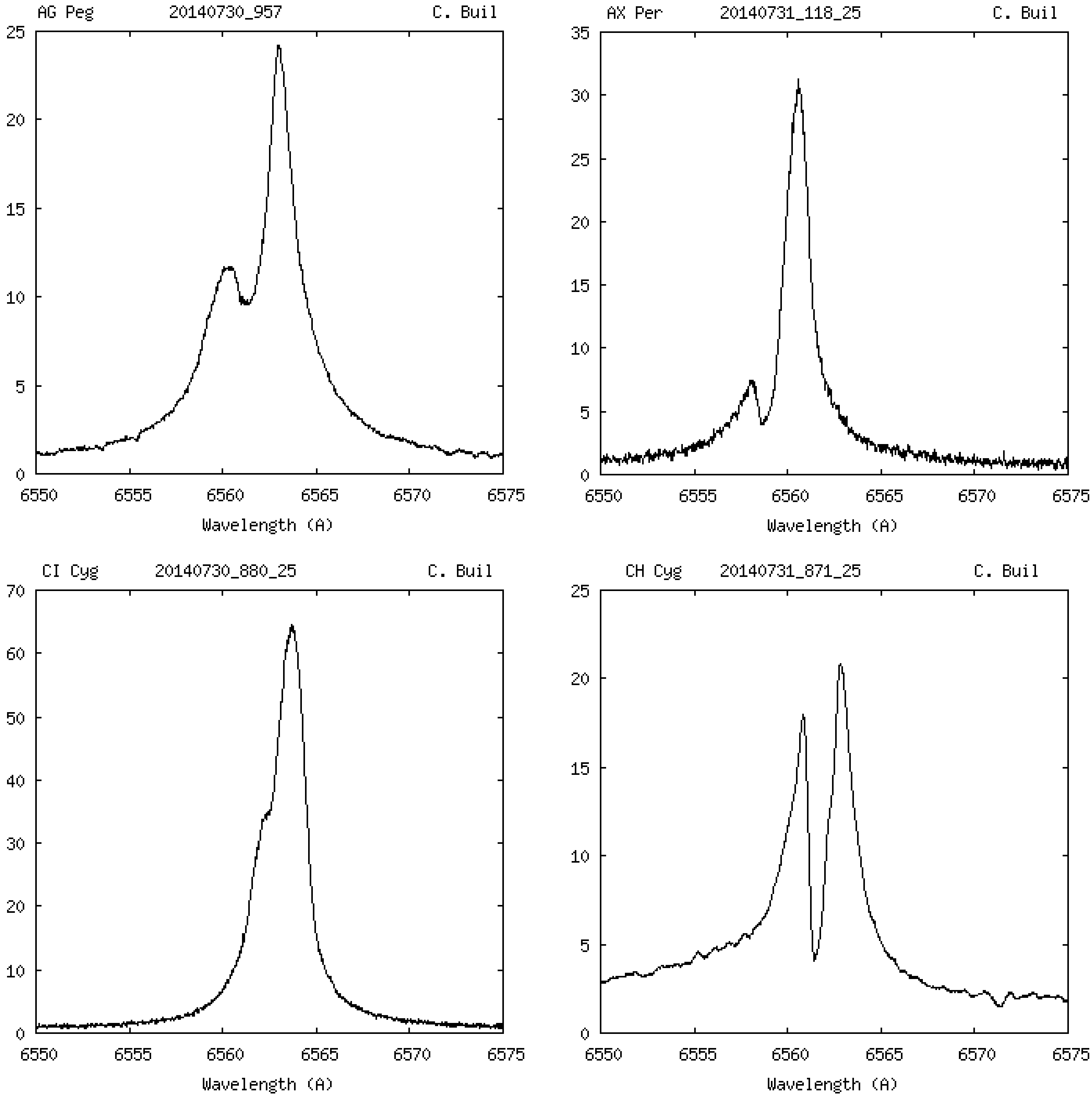


ARAS DATA BASE | http://www.astrosurf.com/aras/Aras_DataBase/Symbiotics.htm

Symbiotics at very high resolution (R = 50 000) by Christian Buil 1/2

A part of the impressive work done by Christian Buil with a prototype spectroscope at very high resolution (50 000) with a telescope of diameter = 235 mm

H alpha profiles (heliocentric velocity not corrected, telluric lines removed



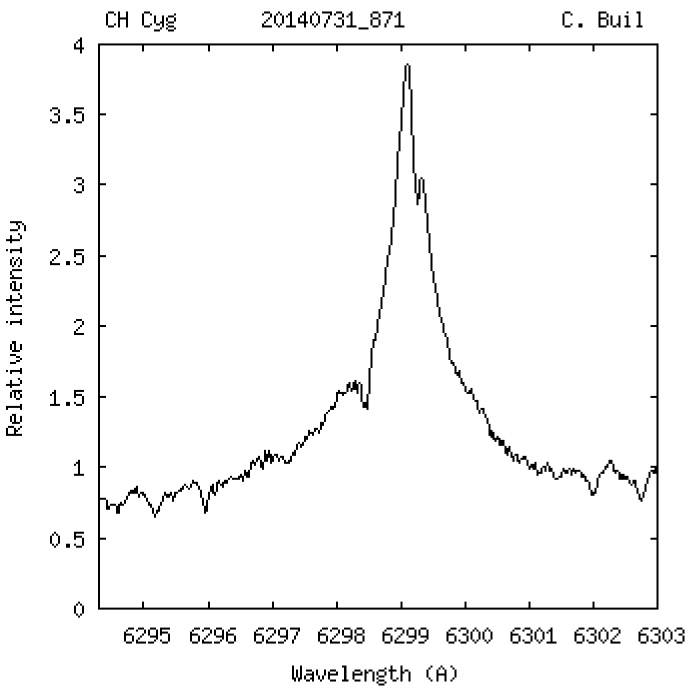
Selected publications on Emission lines profiles in Symbiotic Stars

Spectroscopic Diagnostics of Symbiotic Stars. II. Statistical Analyses of Highly Resolved Emission-Line Profiles
Ikeda, Y., Tamura, S., Publications of the Astronomical Society of Japan, Vol.56, No.2, pp. 353-379
http://adsabs.harvard.edu/abs/2004PASJ...56..353I

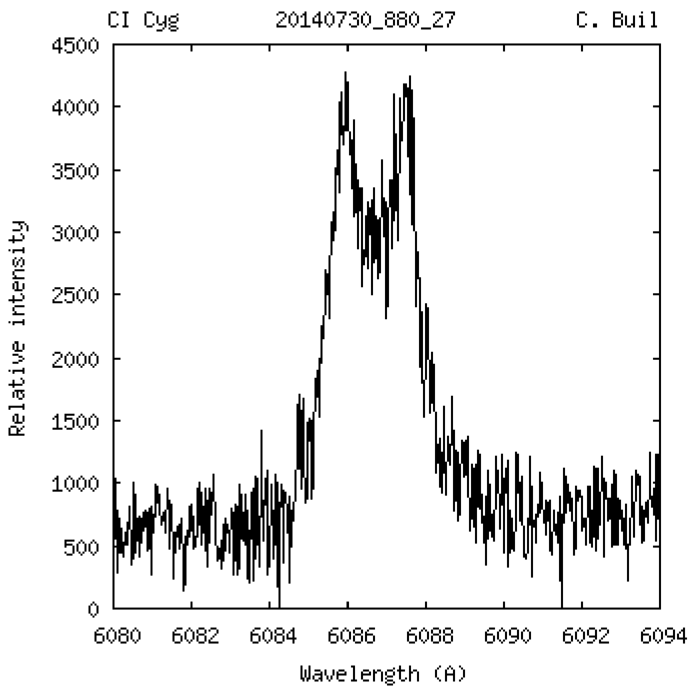
An atlas of high resolution line profiles of symbiotic stars. II. Echelle spectroscopy of northern sky objects
Ivison, R. J.v Bode, M. F.; Meaburn, J., Astronomy and Astrophysics Suppl. 103, 201-233 (1994)
http://adsabs.harvard.edu/abs/1994A%26AS..103..201I

Symbiotics at very high resolution (R = 50 000) by Christian Buil 1/2

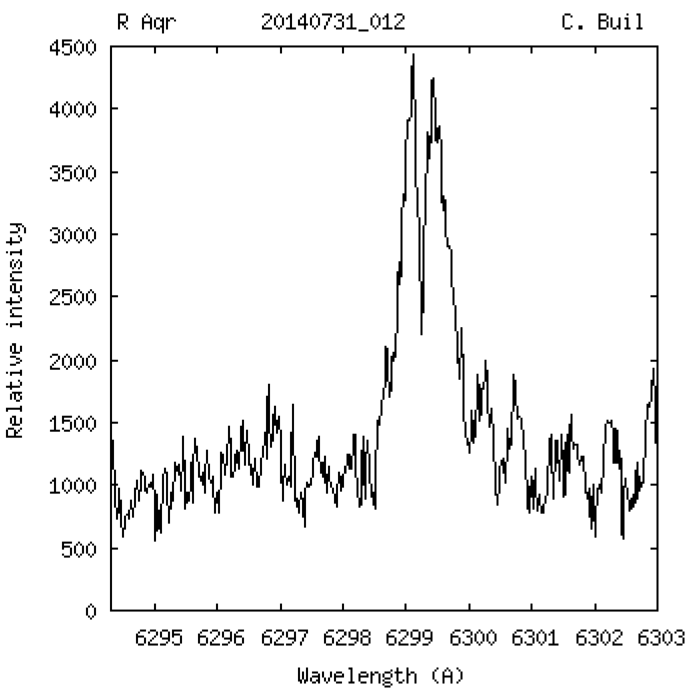
Various lines profiles (heliocentric velocity not corrected, telluric lines not removed)



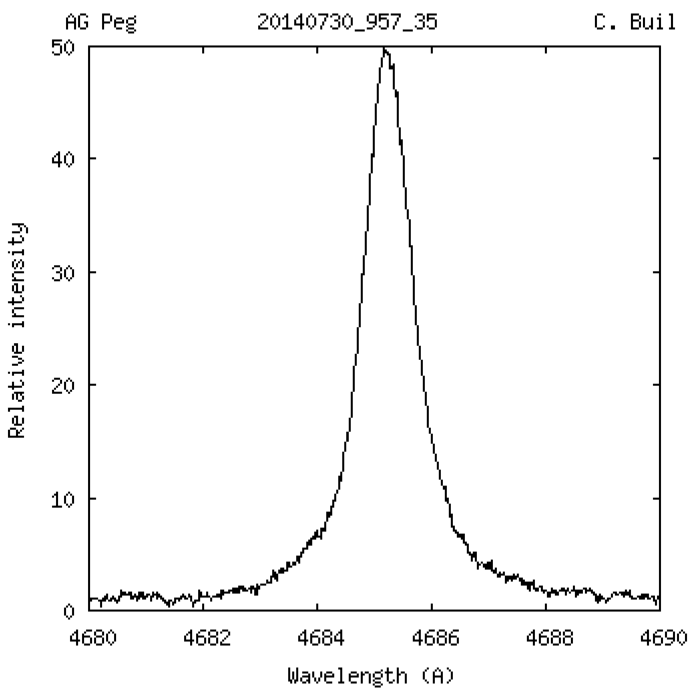
[O I] 6300 in CH Cygni



[Fe VII] 6087 in CI Cygni
The profile can be approximated by two gaussians of FWHM = 65 km/s separated of 70 km/s



[O I] 6300 in the symbiotic mira R Aqr



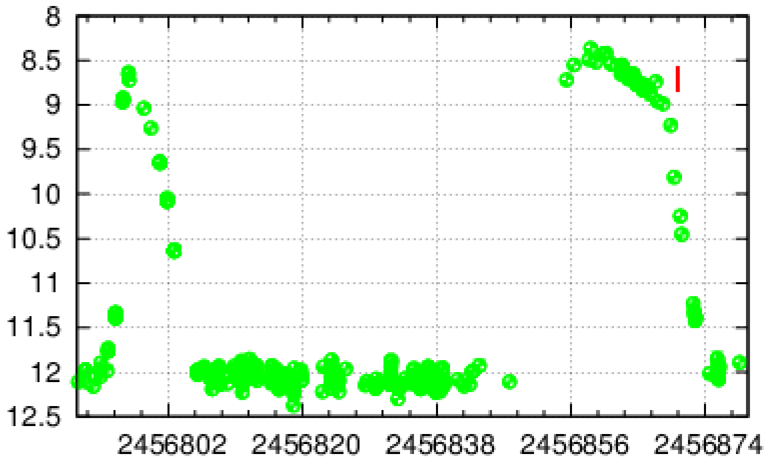
He II 4686 in AG Peg

http://www.astrosurf.com/buil/vhires/test.htm

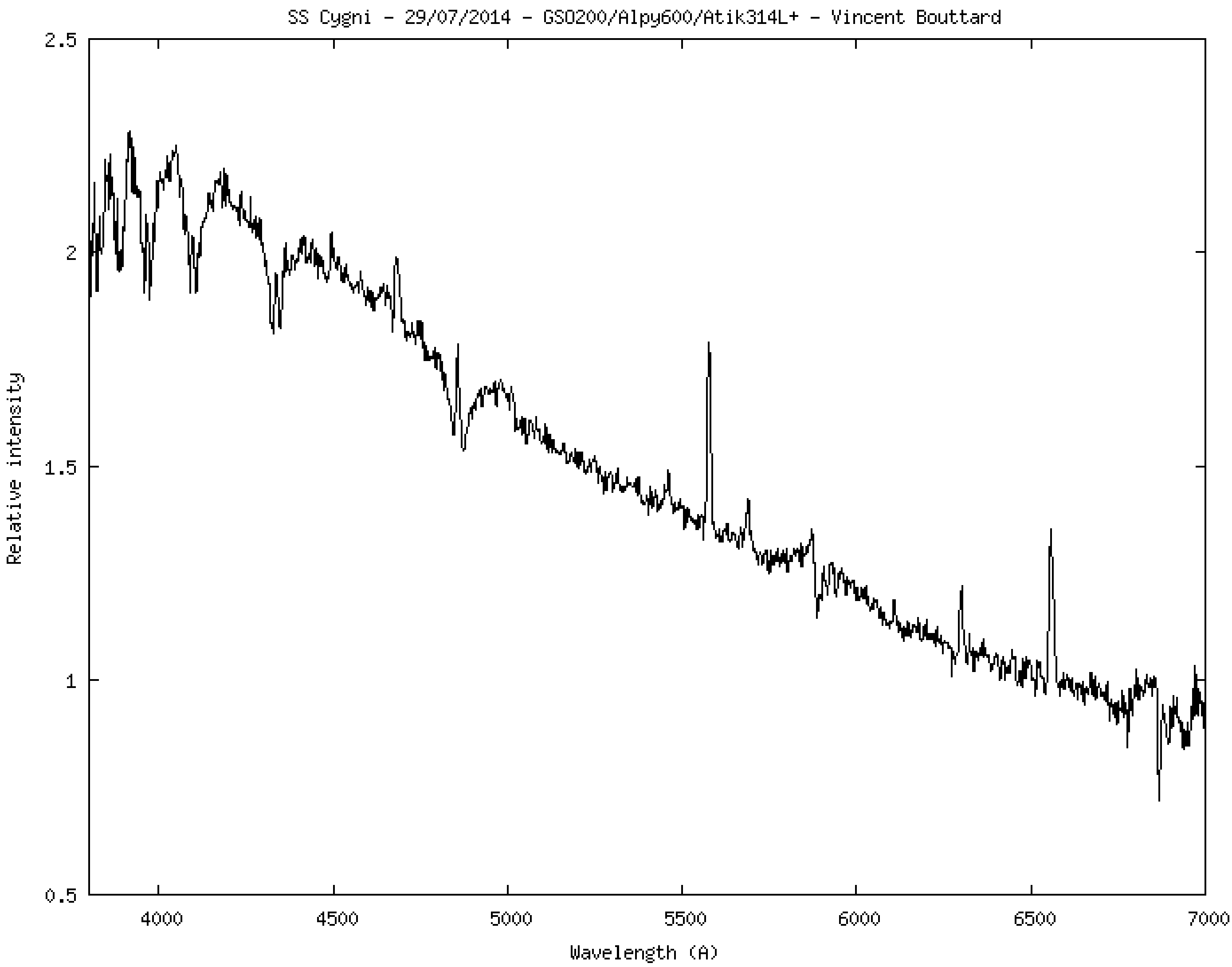
SS Cygni during its last outburst

Coordinates (2000.0)	
R.A.	19 58 21.68
Dec.	+35 12 05.8

Spectrum obtained by V. Bouttard during at the transition between low and fast decline of the long outburst of SS Cygni at mag ~9.2



The broad absorption of Balmer lines indicates an optically thin disk. Narrow emission components in the center of the emission. He I and He II in emission. [OI] 5577, 6300 are impressive

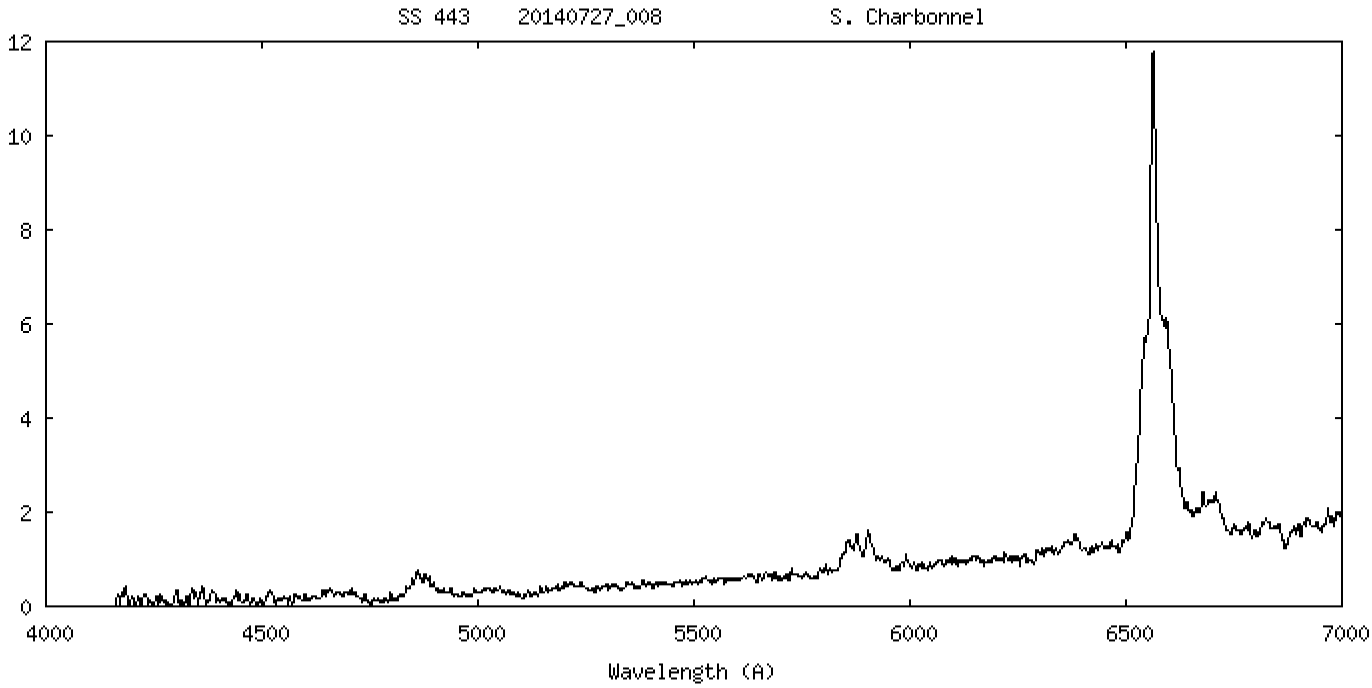


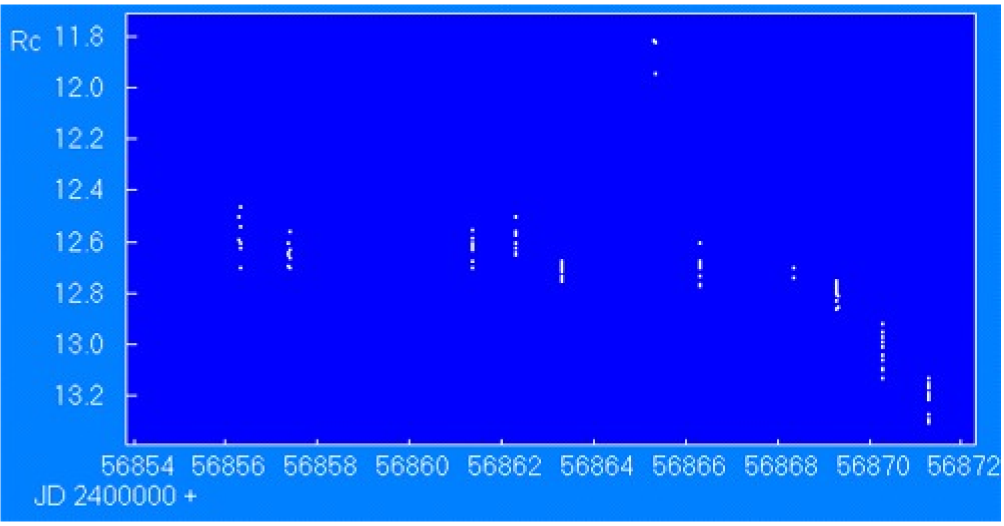
SS Cygni - GSO+Alpy600 - 2014-07-29.934 - V. Bouttard

SS 443 Optical flare

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

A bright flare of microquasar has been detected on July 26.778 (ATel #6347) just before Stephane Charbonnel acquired a spectrum during OHP meeting.
During the following night, S. Charbonnel, Olivier Garde and J. Edlin performed high cadency time-series (300 sec.) of the event and produced their results in Atel #6355, with the support of Steve Shore
Shortly after, SS443 returned to "low" state (see Pierre Dubreuil's spectrum page 17)





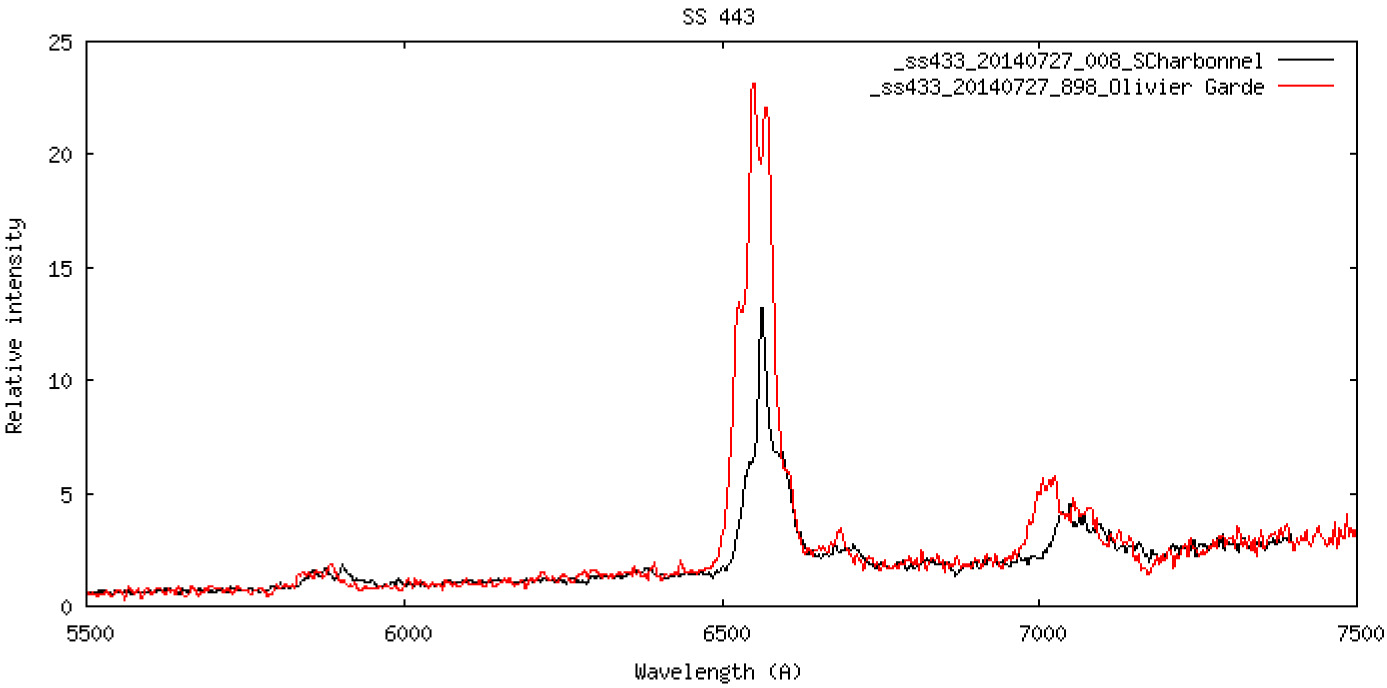
The optical flare has been detected on 2014 July 26.778 UT, at mag R = 11.8 (V. P. Goranskij , O. I. Spiridonova, ATel #6347).
SS 443 returned to quiescent level on August 1 (Sokolovsky K. V. & Al., ATel #6364)

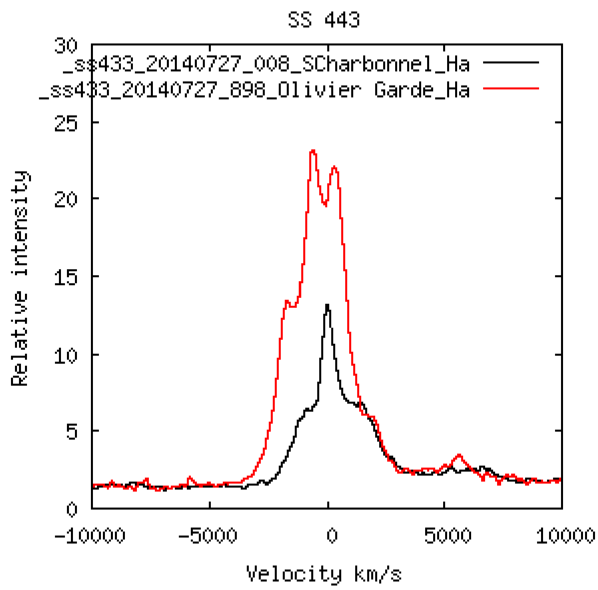
Rc light curve

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
See also
http://www.astrosurf.com/buil/microquasars/obs.htm

References for the flare
ATel #6347
ATel #6355
ATel # 6364

SS 443 Optical flare





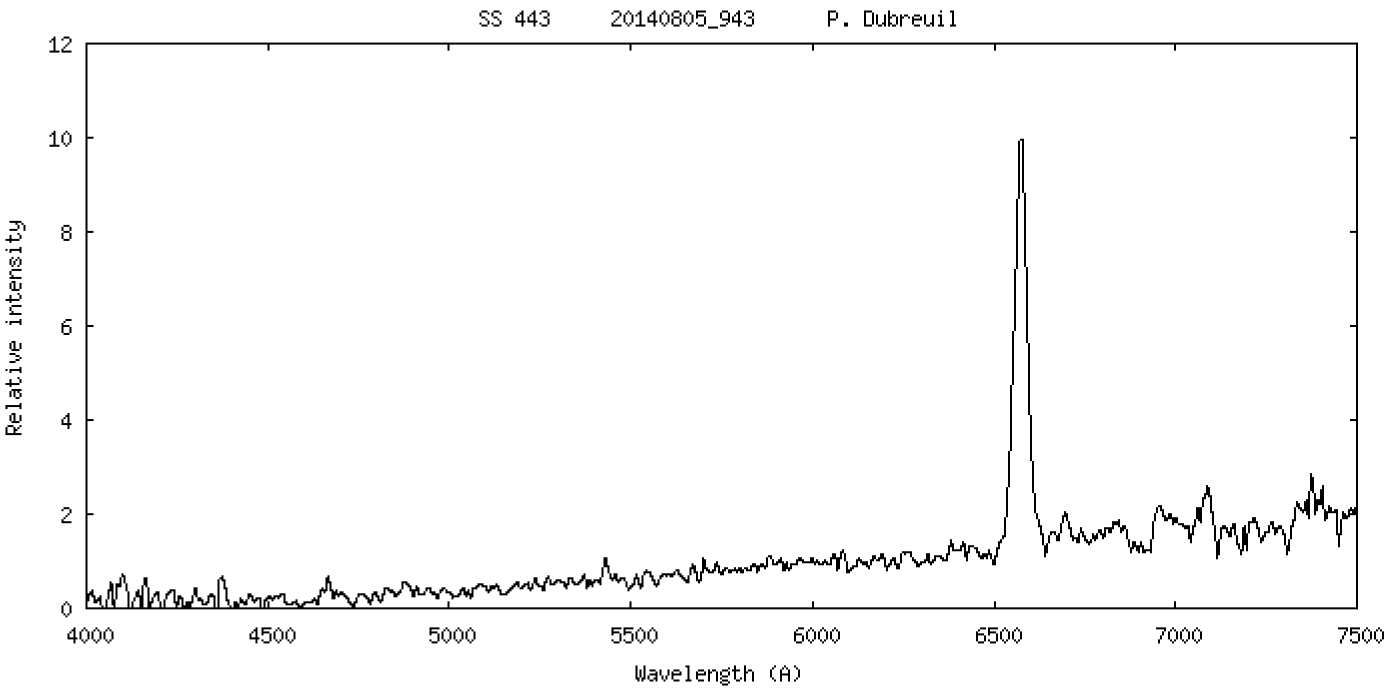
The Astronomer's Telegram

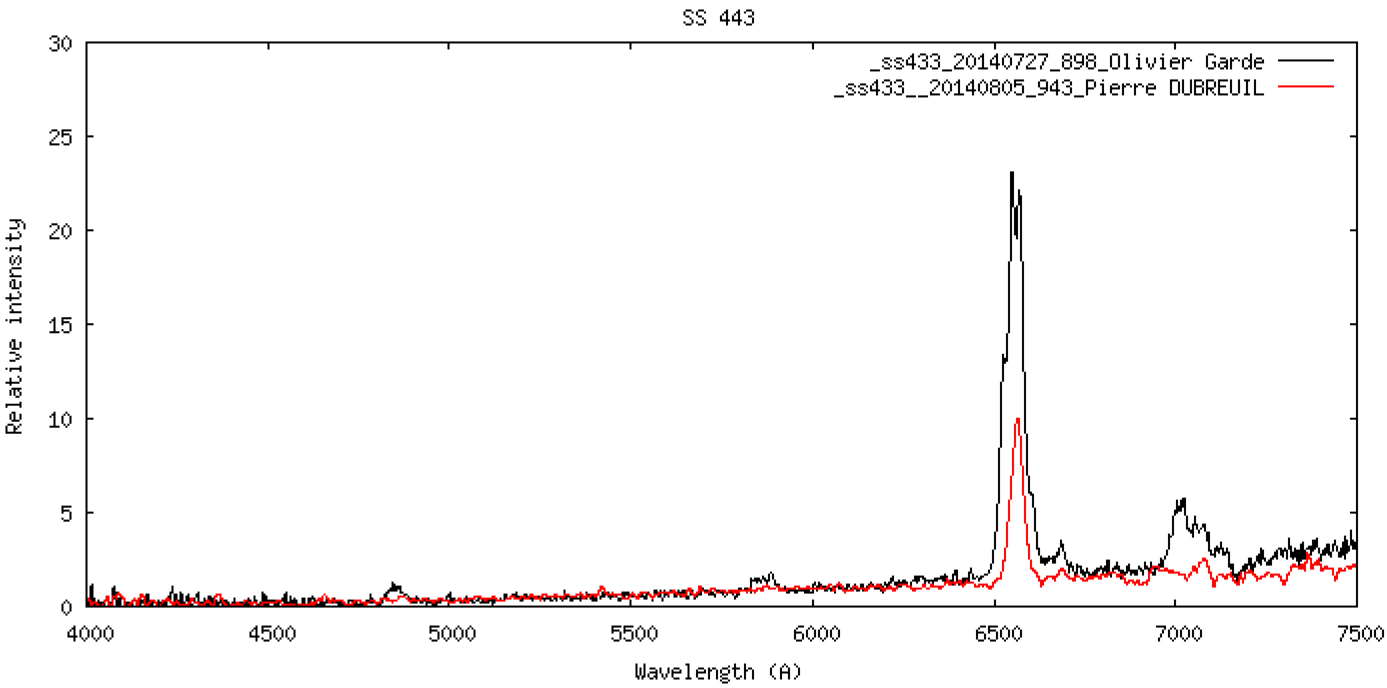
Observations of rapid line variations of the Halpha line of SS 433 following a large optical flare

ATel #6355
S. Charbonnel, O. Garde, and J. Edlin (for the ARAS Group)
on 31 Jul 2014; 14:21 UT
Credential Certification: S. N. Shore (shore@df.unipi.it)
Referred to by ATel #: 6364

Following the announcement of an extreme outburst of SS 433 (#ATel 6347) we observed the source between 3800 - 7500A at a resolution of ~600. All observations reported here were obtained on consecutive nights, 2014 Jul. 27 - 29UT. Coverage was continuous throughout the night and the observations were reduced independently. The orbital phases covered were calculated using (Goranskii et al. 1998, Astr. Rep. 41, 656; Goranskij 2011, PZ, 31, 5), JD 2450023.62+13.08211E (phase 0.0 is mid-eclipse. The first spectrum (56865.508) was obtained at orbital phase 0.00 and the last (56866.45) at phase 0.08 with a cadence of about 10 minutes and exposure times of 600 sec with a SNR ~ 10 in the continuum (e.g. 4900-5500A). In X-rays (Ginga), first contact is at about phase 0.9 and last contact at 0.1. The stationary Halpha profile displayed three strong peaks and displayed rapid variations of their ratio. Comparison with orbit-resolved observations in the literature (see Gies et al. 2002, ApJ,566,1069; Blundell et al. 2011, MNRAS, 417, 2401) shows that the profiles during these days did not match well the historical triple peaked line at the orbital phases sampled by our spectra. The central peak remained invariant to within the noise but the red peak, at around +1500 km/s, varied by a factor of two (from about 0.5 the intensity of the central peak to equality) between Jul 27.0 and Jul. 27.9. The weak emission peak at approx +3000 km/s varied by a similar fraction (at a level of 0.25 of the central peak at maximum strength). The blue peak remained constant at about 0.5 the intensity of the central peak. The FWZI remained ~8000 km/s throughout the sequence. No significant variations were seen on either the jet lines or He I 6678. The Hbeta line also shows only low amplitude, possibly statistically insignificant, variability. It is not clear whether the line profile variations are due to the outburst, they may be related to the eclipse rather than to the outburst. But if so, they are far faster than most reported in the literature. Monitoring is continuing.

SS 443 Optical flare





MicroQuasars

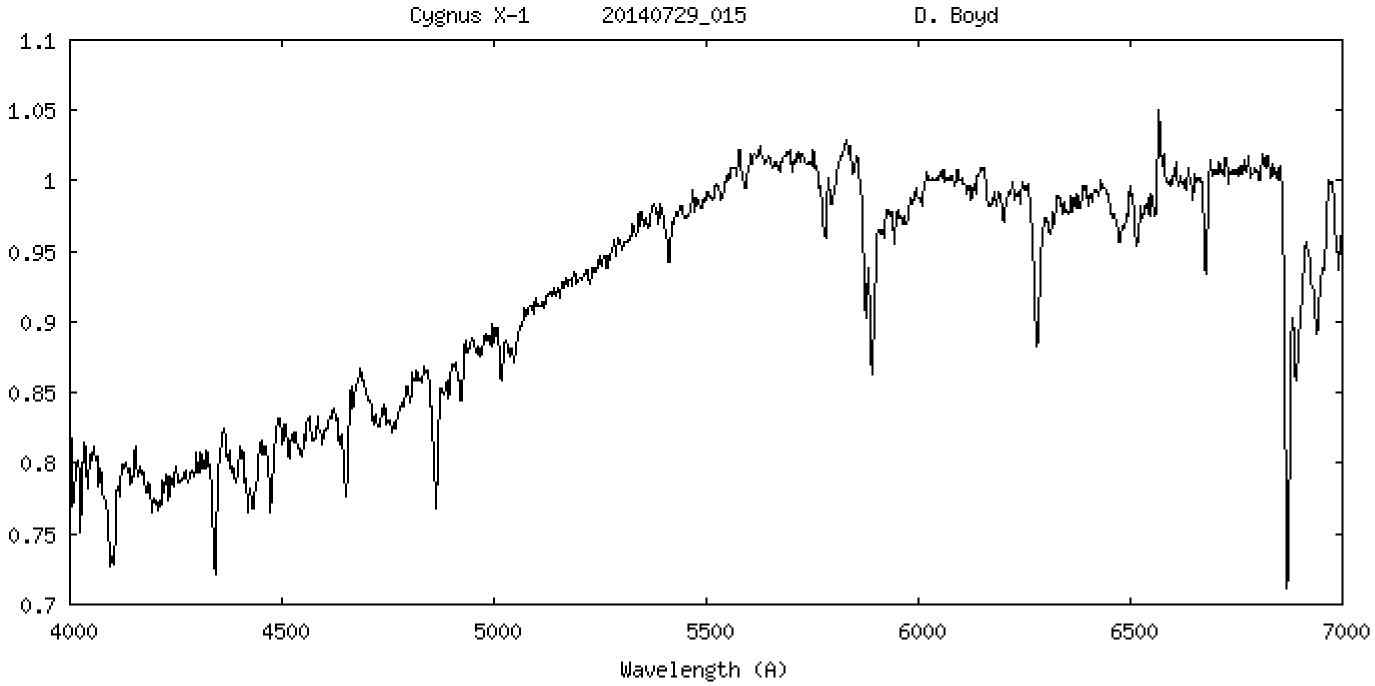
Cygnus X-1

Coordinates (2000.0)	
R.A.	19 58 21.68
Dec.	+35 12 05.8

Following Steve Shore's suggestion (ARAS Information Letter # 7, 2014 June), David Boyd imaged microquasar Cygnus X-1
At mag ~ 9, Cygnus X-1 is an excellent target for amateur spectroscopic survey

Cyg X-1, also known (by Interpol) with the alias HD 226868, is an O supergiant - black hole system, the first discovered. TAt V=8.9, it's a bright source and not a difficult observation. **The orbital period is 5.6 days making it an ideal candidate for monitoring.** This was the first high mass XR binary to be discovered with a BH companion (Bolton 1972), with an inferred mass well above the upper limit for a neutron star (it's about 10 $M_\odot$ depending on the mass of the O supergiant). The system is highly variable over decades, going into outbursts that depend on the mass accretion rate and the optical thickness of the disk. And since it has a black hole at its center, the phenomena under what is called ``strong gravity'' dominate the inner disk structure. This includes dragging of the inner boundary by the rotation rate of the central BH.
The disk in its outer parts should behave much like any other cataclysmic, except that it is likely more massive, but since it is unstable and there is also a wind (at least in part) from he companion it is important to monitor the changes in the system through outbursts. These are noted, for instance, in ATels and surveyed by XR satellites. If you need something to do in the next months, while you're being voyeurs of its neighbour in Cygnus, you might give a look at this wonder.
Remember, it's a close encounter with general relativity in the cosmos.

Steve Shore, ARAS Information Letter # 7, 2014 June



In the discussions at OHP, I didn't have a chance to explain one of the most useful diagnostic features of line spectra. Let's start with a simple case, hydrogen. In the neutral state, H has only one electron and this has three labels: *n*, principal quantum number that gives the mean distance of the electron from the nucleus; *l* that describes the angular distribution (symmetry) of the electron cloud; and *s*, the spin. For HI , the H^0 atom has states labeled *s, p, d, f*, etc. according to whether l = 0,1,2, … . The value of *l* and *n* are *always* integers. In contrast, the spin *s* is a multiple of 1/2. I hesitate to use the word but, like angular momentum, it's frozen in the vocabulary of quantum mechanics but you can think of *s* as the intrinsic magnetic dipole moment of the electron (it's alignment or anti-alignment in an external magnetic field and relative to the other electrons in the atom). You know the distribution of the energy levels for H I, they're the upper states of the Lyman (or Balmer) series and very simple. But this is also the case for He II (He^+), also a one-electron system. Only the nuclear charge is different (so the energy of each state (*n,l,s*) is shifted by a factor of Z^2 where *Z* is the atomic number (the number of positive charges in the nucleus). This displacement in energy is because the ionization energy (that is, the electrostatic binding energy) of the atom is increased and all of the states scale accordingly. So with an ionization energy of about 13.6 eV for H I, for He II it's about 54.4 eV. OK, the exact equivalence of all strictly one electron atoms can be extended throughout the periodic table, to Li III and Be IV and so on. But that would be of little use unless we were dealing with a plasma that is so hot that it can achieve C VI or N VII (or Fe XXVI, which actually happens in accretion disks around neutron stars!).

Instead, think now of Na I. With an atomic number Z=11, there is one electron outside of a closed set of shells. The ground state is $1s^2 2s^2 2p^6 3s$. In other words, since no two electrons can have precisely the same state (meaning they can only com at most in pairs at the same energy, anti-aligned in *s*) the Na^0 atom ``looks'' sort of hydrogenic. But the difference with H I is that there are inner electrons that *screen* the nuclear charge. Thus, the ionization energy for Na I is *not* 11^2 times that of hydrogen. In fact, it's far lower, 5.14 eV. So what has happened is that the inner 10 electrons, which are the ground state of Ne I, reduce the nuclear charge so far that the Na^0 atom is actually more easily ionized than hydrogen. But Na II, which is the same configuration as Ne I, has a much *higher* ionization energy (47.3 eV compared to 21.6 eV) because the nuclear charge is 11 instead of 10. No the systematics come into play. The ground state of Na II has the same form as Ne I. So the excited states are the same as well. The electrons are indistinguishable (they don't ``know'' that they're part of a different element!) so you expect the same distribution of lines but at different energies since the energy levels are all shifted by the different nuclear charge. That is, Na II and Ne I are *isoelectronic*.

For your spectroscopic experience, a much more familiar and more important, example is the sequence [C I, N II, O III]. Again, the number of electrons is identical and so is the *set* of available states. But the energies are shifted. For example, take N II and O III. The bright nebular lines of [O III] are at 4363, 4959, 5007 ÅÅ. These are the principal diagnostic forbidden lines in hot ionized low density plasmas; think the nebular stage of nova ejecta, the ionized circum-white dwarf environment of a symbiotic star wind, or an H II region around a massive, main sequence star, or a planetary nebula around a hot central white dwarf. The 4959, 5007 Å pair come from a common upper state, feeding two fine structure levels that are slightly different in energy. Both are fed by radiative (or collisional) decays of the 4363 Å transition. So the ratio of *F(4363)/[F(4959)+F(5007)]* depends on density and temperature because of the collisional de-excitation of the 4363 line and the upper state of the pair. The details, for now, are less important than the fact that the ``nebular'' lines, the pair, don't appear in the spectrum if the density is above about 10^6 cm^{-3} because they are forbidden transitions and collisions at higher density are more frequent than radiative transitions. Now look at the N II lines. There's an *identical* set of three: 5755, 6548, 6583 Å. They have *precisely* the same behavior with density as [O III] *but* they have different density sensitivity because the N II atom has different energies for the same states. They are a complementary density/temperature diagnostic and also appear at different temperature because of the different ionization energy of N^0 and O^+, the ions that feed the N II and O III spectrum. Another example, a bit more complicated, for another important pair of ions: Ca II and K I. Both have resonance lines in the visible region. For Ca II this is a doublet at 3933, 3968 ÅÅ, for K I they are at 7664, 7699 Å. To extend this, the S II spectrum also has a pair of resonance lines at 4077, 4215 Å and the Ba II shows up at 4554, 4934 Å. The latter are important in carbon stars and red giants (the Ba lines are especially important for nucleosynthesis studies, the Sr II lines are indicators of gravity because they are so strong and sharp). The important point here is that these are *all isoelectronic* so knowing that you have one set and not another is an indication of ionization state of the gas. And you can use these systematics in identifying lines. You recall (those who were at OHP) that one of the persistent questions was about how you know which lines you're seeing. This is a vitally important clue, the real basis of the fingerprint that is a spectral sequence *and this is why spectral classification makes any sense!*.

This is also the basis of the diagnostics of the solar corona when only filter imaging is used. Look at the SDO or SOHO images of the corona. These are taken in the X-rays, at specific transitions (e.g. 1600 Å is dominated by C IV, 303 Å is mainly from He II) so you're using the same isoelectronic sequences *in the form of narrow band images* that are just like integrating over the line profile. Since these images are flux calibrated, the ratios of bands becomes a temperature/density diagnostic. So you can actually do what for the Sun using spatially resolved narrow band images what we are struggling with using line profiles of point sources. The advantage of being close, however, is mitigated by the lack of spectral resolution: the images confound structure and dynamics because you don't have narrow enough bands or enough of them. But the combination of spatially resolved high cadence spectra and images helps.

In nova spectra, during the optically thick stage, the couplings insure that if an ion is present in the UV its accessible energy levels will produce optical and infrared lines. The complication of velocity shifting notwithstanding, the identification must be based on the systematics of the sequences. For instance, in the Balmer sequence, since the higher lines in any of the hydrogen sequences are intrinsically weaker, they absorb less so you see through the medium to a greater depth (hence to lower velocity). The absorption -- during the P Cyg profile stage -- will reach to progressively lower maximum velocities and the emission will be biased toward higher densities for progressively higher series members (e.g. Hα vs. Hβ vs. Hγ). This is well seen in Be star spectra, where the absorption edge (also for strong wind stars like P Cyg itself) are progressively lower in what is called the *Balmer progression*. This actually maps out the structure of the absorbing medium: the lower density in the outer region means only the strongest lines will have emission at the terminal (redshifted) velocity while the absorption will be coming from the inner parts of the medium (be it a wind or ejecta). The weaker the line, the higher the absorption to emission ratio in ejecta, for instance. This is one reason why Hα is useful but, simultaneously, why it is misleading if used alone. This is especially true for novae where there is no terminal velocity; i.e. in a wind, the material at large distance reaches a finite speed above the escape velocity and coasts at constant speed,. In contrast, novae and ballistic ejecta there is no such leveling off of the velocity. So for novae, as they develop, the line profile never has a sharp blue edge unless there is a finite radius very opaque pseudo-photosphere.

I don't mean to be getting too messy here. The use of these sequences is the same as use of multiplets: the individual electron states produce specific combinations of allowed sub-states. These have nearly the same energies and behave similarly. If you see one line of a multiplet, you will see the others unless there is a very weirdly non-equilibrium situation (like shocks).

Multiplets, just a mention

In more complex atoms than hydrogen or exactly hydrogenic, many electrons can be excited in different sequences. For instance, even in the simplest two-electron atom (He^0) you can have a 1s2s or 1s2p as the first excited state but excitations like 2s3d are also possible. In other words, analogous o any probabilistic process, if something *can* happen i *will* (only, perhaps, very rarely as for forbidden transitions). The only energy level with an infinite lifetime is the ground state. The more complex the atom, the more complicated the resultant spectrum (think of Fe II, for instance, with millions of possible lines). The aid in sorting this out is that for any electron state, the coupling of the electrons produces specific *multiplets* or combinations of the different possible interactions. As an example, the 1s2 state of He I, the ground state, is unique -- a singlet state (anti-aligned *s*) with spherical symmetry (the $^1S_0$ state). There is no $^3S_1$ state because of the exclusion principle (this would require all quantum numbers to be identical, precisely the same state, instead of anti-aligned moments). So, for example, although the first excited state of Na I is $1s^2 2s^2 2p^6 4p$, there is also a state in which a core electron is also excited, e.g. $1s^2 2s^2 2p^5 3s3d$ and so on. The clue comes from the closeness of the combined states. For He I, these form singlets and triplets (single lines and groups of three close together, spaced by perhaps 100 Å). For more complex systems the ways in which the electrons couple can be approximated differently but these are only ways to estimate the structure, the precise assignments of states and lines depends on the experimental study in the laboratory. But since the multiplet states arise from the same set of electrons, in different combinations, they should have nearly the same populations. So if one line of a multiplet is present, it's likely all will be (see the Multiplet Tables by C. Moore, or the tool at NIST that gives the diagrams, called *Grotrian diagrams* of these states).

A last comment: why winds and ejecta (and sort of disks) are not the same as atmospheres (or, sort of, disks)

A great advantage of stellar atmospheres (or planetary, for that matter) is that they are hydrostatic structures for which the pressure and temperature variations in the layers is whatever are required to maintain -- everywhere -- mechanical and radiative/thermal balance. There are no mean velocities, the layer is neither in secular expansion or collapse, so the optical depth is uniquely -- and directly -- related to the geometric depth in the layer. The conditions are close to locally determined, on the large scale the medium is stationary in time and static in space. This is also a good approximation for an accretion disk, at least vertically. The heating is both local an from the central star but the vertical structure is determined at each annulus (radial distance) by the local gravity (or the projection of the central gravity vertically in the disk). As I discussed in the last set of notes, the vertical structure of an accretion disk in equilibrium is a lot like an atmosphere, with the exception of possible long-distance illumination from the central source and the surrounding boundary layer. This affects the ionization and excitation state of the gas, but for the most part you can use the same reasoning as a star: the requirement of ionization balance is essential. If you have n atmosphere, it sees only the radiation emerging from the central regions of the star. Locally, the state of the gas is determined only by the temperature and density and those must, at least for a static structure, be what comes from the requirement that the pressure deceases outward monotonically (no pressure inversions even if there are temperature inversions). So there are only a limited set of ions of any element that ca appear together. You *cannot* have, say, Ne IV and O I in the same spectrum in absorption. But this isn't true for a wind, or ejecta, or the *integrated* spectrum of a disk. Since each annulus of the disk is in orbital motion, the radial structure is determined only by that requirement. So the surface of the disk does *not* have a unique temperature, unlike an atmosphere for a star. Then in the same spectrum you might have C IV or N V and He I or Na I, depending on how far that line forming region is from the center. Novae and symbiotics are the most extreme example of how this breaks down. In winds and ejecta, being supersonic (escaping) there is no such hydrostatic requirement and the density and velocity are the link. So you can have very weird combinations of ionization states, in the same ejecta you can see O IV, C IV, and N V -- and He I and even Na I, as in V339 Del and V1369 Cen -- because they're coming from different parts of the ejecta and uncoupled to each other. They are, in fact, completely dominated by the dynamical structure of the ejecta and the conditions of the central star.

This last point is why the taxonomy of Fe-novae and He/N novae -- makes no sense, or at least doesn't have the same physical meaning as spectral types. The regularity of absorption line spectra in stellar atmospheres results from their mechanical structure. When you see regular behavior of the ion ratios it is because there is a regular variation of the pressure at the photosphere and in the overlying atmosphere. So whereas an A star is dominated by ionized Fe-group lines and the Balmer lines, and B stars show weaker H I and strong He I, and M stars show Ca I and K I and molecules and weak Balmer lines and no He I, this is because they are hydrostatic and thermally balanced and no motions are faster than the sound speed. All parts of the atmosphere are coupled. In nova ejecta, at the same time, you can have [O I], [Fe VII], He II, and the Balmer lines. This is the ionization and excitation response of the medium to the central source, its luminosity and spectral flux distribution, and the *local* density (with the kinetic temperature being determined by the requirements of overall ionization and radiative balance in an expanding medium).

Remember, when you see a nova ``surface ' it is a *pseudo*-photosphere, it isn't stationary and only optically thick. Above that layer (which moved through the ejecta over time because of the expansion) there are lower density, more optically thin layers (which may, at the recombination event, be optically thick for a while). For example, what you see now in Nova Cyg 2014 is an example. The outer parts of the ejecta are producing emission, the denser inner parts are still contributing absorption against the non-stationary surface.

And one last point for now: Don't mistake opacity for temperature, especially in novae and winds. Absorption is seen because, locally, the medium is less excited than the surface against which they are projected (remember, this is like clouds seen against the Sun). So when you have a very extended dense wind, it can have a huge emission line (say, of Hα) and also strong absorption but as the ejecta expand and the medium becomes less opaque the absorption disappears and moves inward in radial velocity (only the innermost parts will absorb). The same is true for He I, for example. In such cases as ejecta or winds, where the thermal state of the medium is *not only* locally set, you can have both absorption and emission that depends even on geometry, as we've already discussed for non-spherical ejecta. It's no temperature, it's emissivity.

So as usual, in the hope that this is helping, I'll stop. But not without adding how wonderful it was to see so many of you at the workshop in July and to add the hope that though these notes more of us can be meeting. There will be a few more things to cover, related especially with your experience with absorption spectra (we have not spent time yet on the photospheres, especially of white dwarf stars) but I truly hope this isn't getting too heavy and now it's time to stop until the next installment.

Steve Shore, 11-08-2014

Steve Shore with Participants to ARAS meeting at OHP - 2014, July (Crédit photo : François Cochard)

Recent publications

Novae

Early evolution of the extraordinary Nova Del 2013 (V339 Del)
A. Skopal, H. Drechsel, T. N. Tarasova, T. Kato, M. Fujii, F. Teyssier, O. Garde, J. Guarro, J. Edlin, C. Buil, D. Antao, J. N. Terry, T. Lemoult, S. Charbonnel, T. Bohlsen, A. Favaro, K. Graham
http://arxiv.org/pdf/1407.8212.pdf

On the 2011 outburst of the Recurrent Nova T Pyxidis
L. Izzo, M. Della Valle, A. Ederoclite, M. Henze
http://arxiv.org/pdf/1407.8212.pdf

Recurrent Novae - A Review
Koji Mukai
http://arxiv.org/pdf/1407.4526.pdf

Supernovae

Exploring the spectral diversity of low-redshift Type Ia supernovae using the Palomar Transient Factory
Kate Maguire
http://arxiv.org/pdf/1408.1430.pdf

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!

Other ARAS subjects :

Be Stars

2014 May monthly report :
http://www.astrosurf.com/aras/surveys/beactu/report2014/BeSS%20report_mai2014.pdf
And previous issues :
http://www.astrosurf.com/aras/surveys/beactu/index.htm

Transition of the H-alpha line from absorption to a double-peaked emission in the Be star HD 224544
ATel #6362
V. Desnoux (for the ARAS group) on 2 Aug 2014; 16:46 UT
Credential Certification: S. N. Shore (shore@df.unipi.it)

Outburst of the Be Star V 442 And detected by Valérie Desnoux during OHP meeting

Contribution to ARAS data base
From 01-07 to 31-07-2014

P. Berardi
T. Bohlsen
F. Boubault
D. Boyd
C. Buil
S. Charbonnel
P. Dubreuil
A. Garcia
O. Garde
K. Graham
J. Guarro
T. Lester
P. Somogyi
F. Teyssier

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