Eruptive stars spectroscopy
Cataclysmics, Symbiotics, Novae, Supernovae

ARAS Eruptive Stars
Information letter n° 6 - 30-05-2014

News

PNV J17292916+0054043

Discovered by H. Nishimura, Shizuoka-ken, Japan (2014 05 22.778)
Mag V = 12.7 (2014-05-23.490)
Identified as a dwarf nova outburst by K. Ayani, Bisei Astronomical Observatory (BAO), Ibara, Okayama, Japan (2014 05 23.6)

http://www.cbat.eps.harvard.edu/unconf/followups/J17292916+0054043.html

Contents

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

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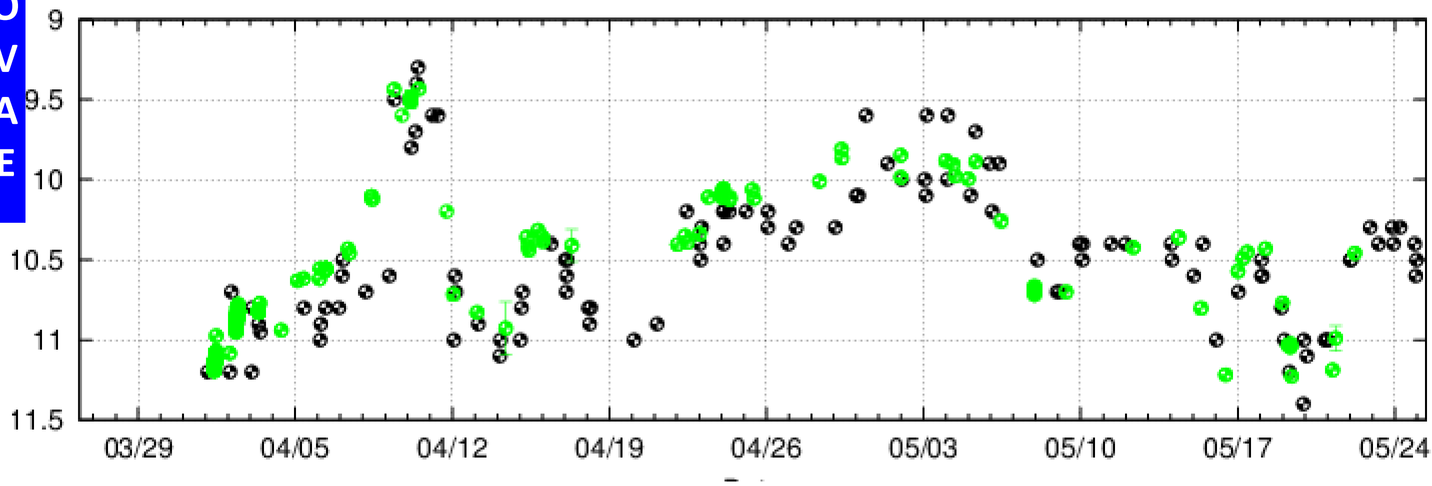
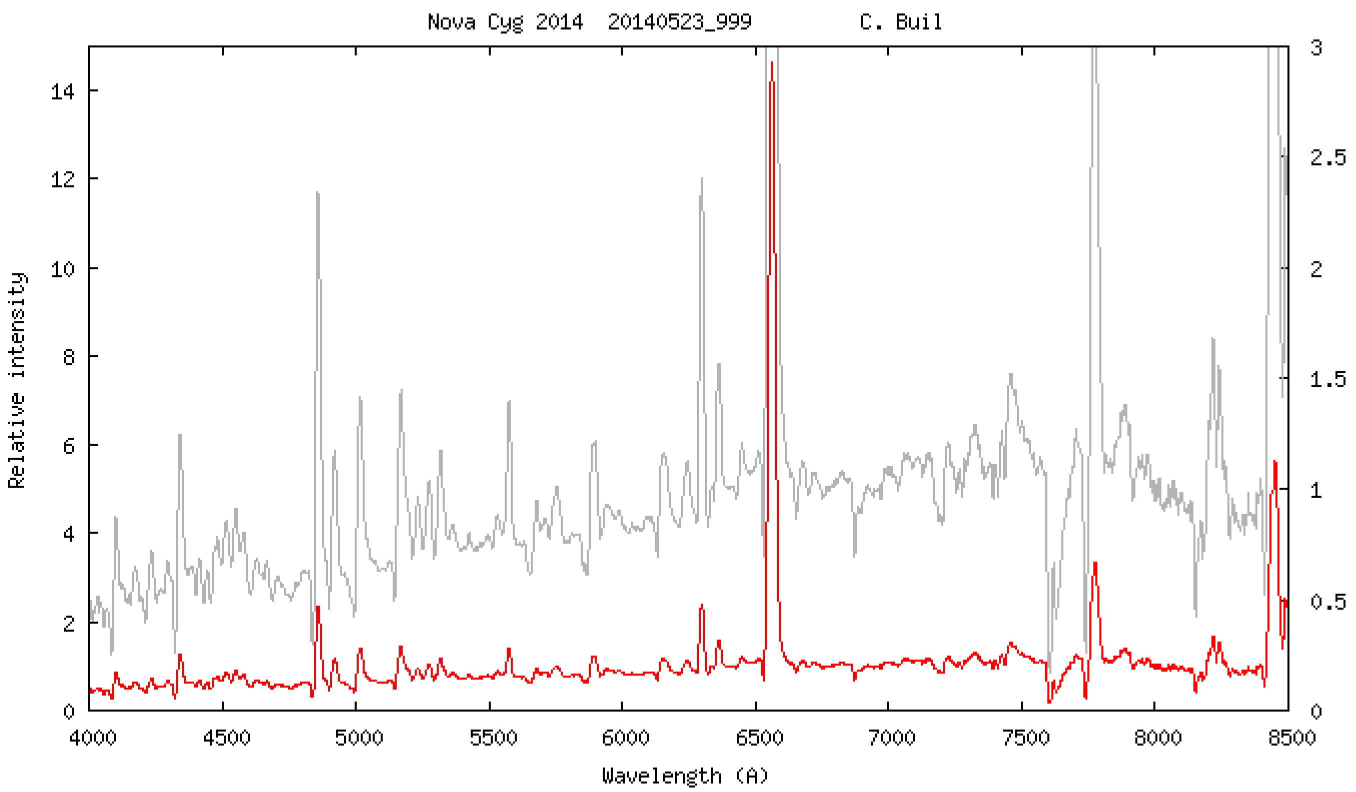
Nova Cyg 2014



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

Luminosity
Mag V = 10.2 (24-04-2014)
Unusual light curve ,
The luminosity remains at a high level, with irregular oscillations. For the last period, oscillation amplitude of about 1 mag

ARAS Web Page :
http://www.astrosurf.com/aras/novae/NovaCyg2014.html



Observers : Tim Lester | Christian Buil | Paul Gerlach | Olivier Garde | François Teyssier | Jacques Montier | A. Garcia

ARAS DATA BASE : 35 spectra http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cyg-2014.htm
Web Page : http://www.astrosurf.com/aras/novae/NovaCyg2014.html

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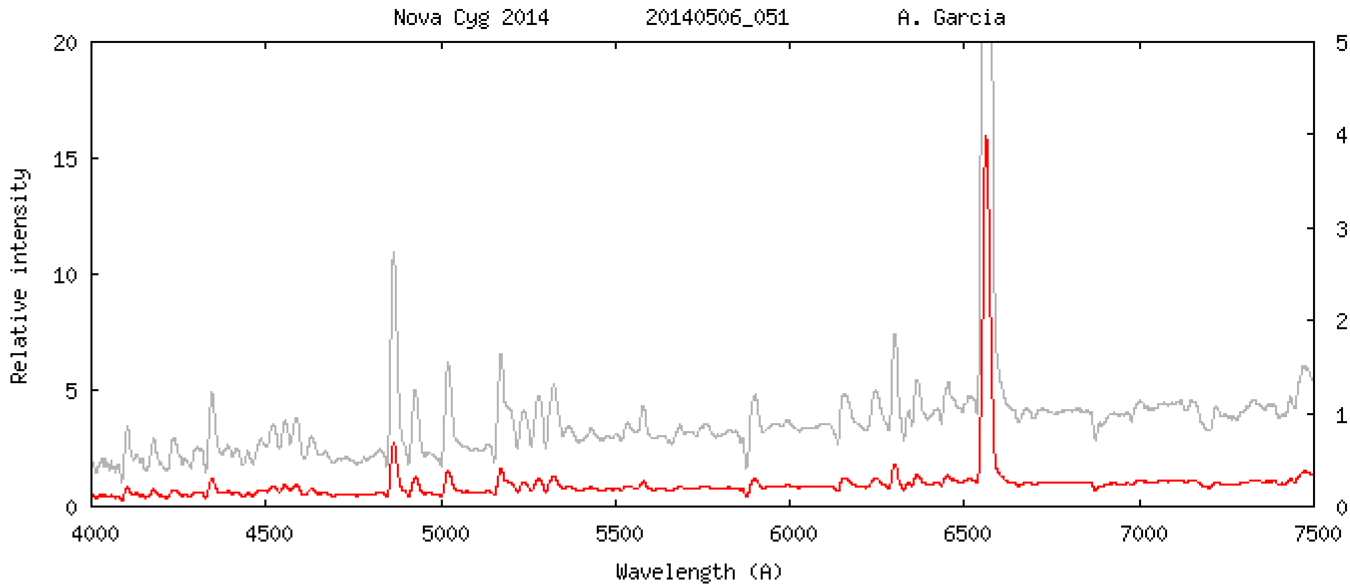
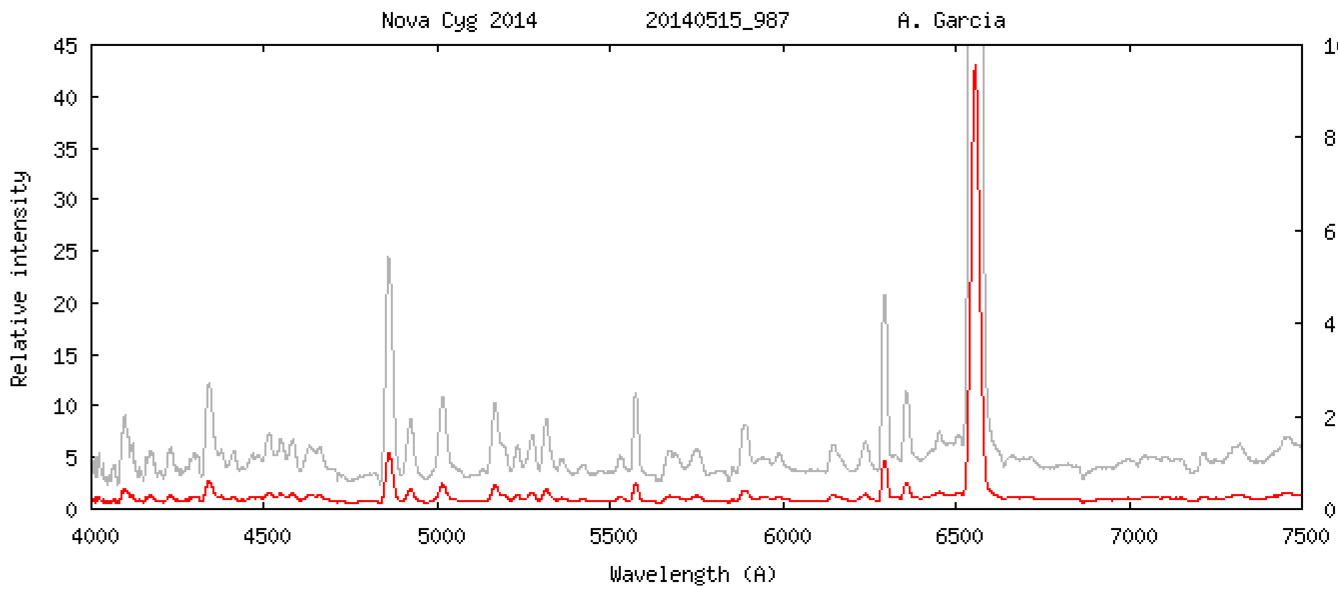
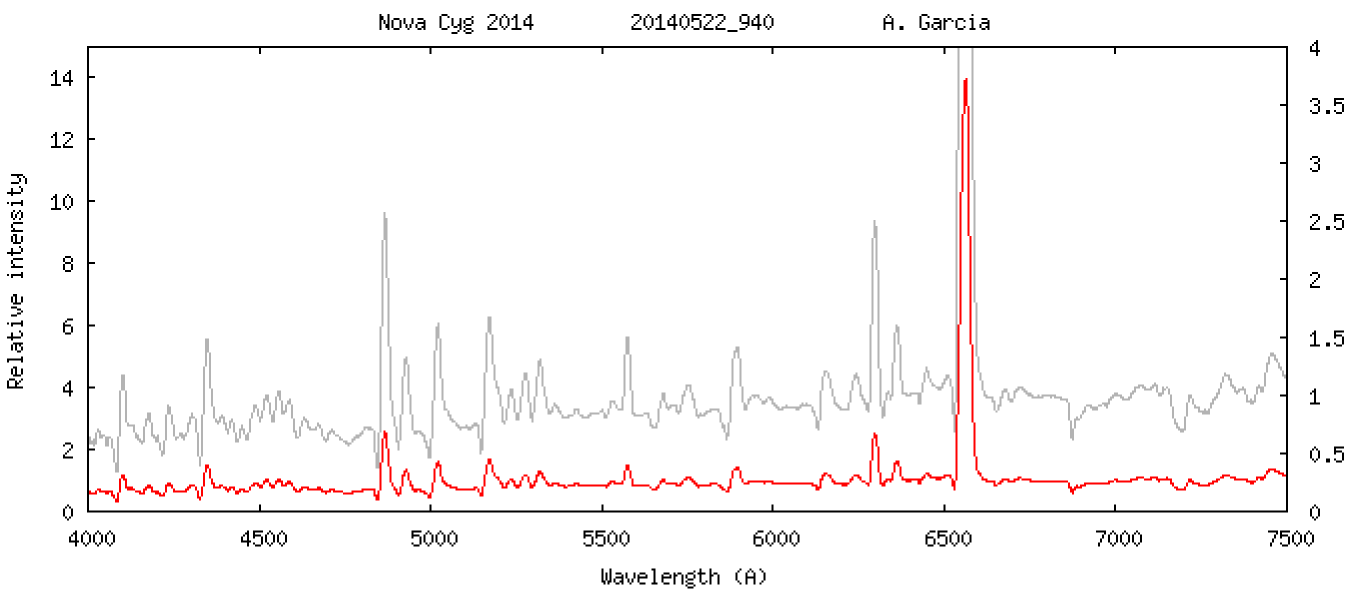
Nova Cyg 2014 Evolution in may throw Antonio Garcia's spectra

Noticely, appearence and disappearence of absorptions components







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Nova Cyg 2014

The Astronomer's Telegram http://www.astronomerstelegram.org

Atel #6132 based noticely on ARAS spectra

Posted: Within the last 24 hours

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ATEL #6132

Title: **The first detection of the Raman scattered O VI 1032 A line in classical novae - the case of Nova Del 2013 and Nova Cyg 2014**

Author: A. Skopal (Astronomical Institute of the Slovak Academy of Sciences, Tatranska Lomnica), M. Wolf (Astronomical Institute, Charles University, Prague), M. Slechta (Astronomical Institute, Academy of Sciences of the Czech Republic, Ondrejov), F. Teyssier, J. Montier, T. Lester, O. Garde, C. Buil, T. Lemoult, S. Charbonnel (contributing participants, ARAS)

We report on a transient emergence of the Raman scattered O VI 1032 A line in the spectrum of classical novae V339 Del (Nova Del 2013) and V2659 Cyg (Nova Cyg 2014). The result of this scattering process - a faint, broad emission feature located around 6825 A - has never been reported for a classical nova to date.

The Raman emission feature was indicated on the spectra obtained within the Astronomical Ring for Access to Spectroscopy initiative (ARAS) with resolutions ranging from 580 to 11000. In the case of Nova Cyg 2014, the presence of a faint Raman emission was confirmed by a spectrum obtained on 2014 April 17.043 UT at the Ondrejov Observatory using a single-order spectrograph attached to the coude focus of the 2-m Perek telescope (resolution of 12000 and the wavelength range 6406-6879 A).

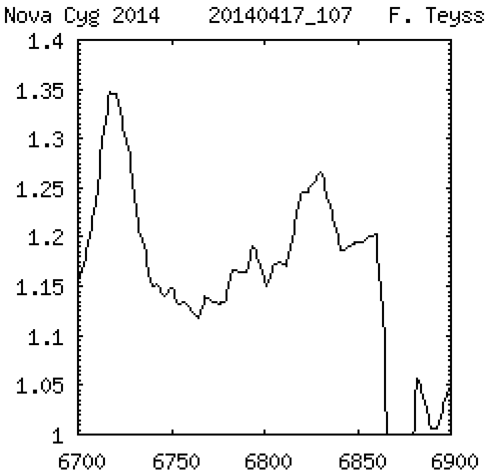
In our spectra of V339 Del, the Raman 6825 A line was seen continuously for more than 1 month, from Aug. 19 (day 5 after the nova discovery; see CBET No. 3628) to around the end of Sept. 2013 (around day 40, at the end of the first plateau phase in the light curve; see Munari et al. 2013, IBVS 6080).

In the spectrum of Nova Cyg 2014, we first indicated the Raman line on April 14, around day 4 after the V-maximum (see the AAVSO light curve) and lastly on April 24. On the following spectra, we obtained at the beginning of May 2014 around a secondary optical maximum, no Raman 6825 emission was detectable. The profile of the present lines (mostly of H I, He I and Fe II) changed again into the P Cyg-type. Such the evolution of nova V2659 Cyg and conditions for emergence of the Raman scattered 6825 A line suggest its re-appearance during following transition of the nova to a harder spectrum. Examples of the Raman 6825 A line in the spectrum of classical novae V339 Del and V2659 Cyg are available at http://www.ta3.sk/~astrskop/atel_052014/v339_ncyg_ra.png

On 2014 May 06.057 UT, the absorption component in the H-alpha profile was located at around -1200 km/s as we measured at the Ondrejov Observatory spectrum of V2659 Cyg. This value is more than a factor of 2 larger than was measured a few days after the nova discovery (see Munari et al., Arai and Ayani, CBET 3842; Tomov et al. ATel #6060) and still indicated in our spectra from April 10, taken during the first optical maximum.

The Raman conversion of the original 1032 A line to 6825 A emission requires the column density of the neutral H I atoms on the line of the incident O VI photons to be as large as 1E+24/cm^2. Therefore, the presence of the Raman scattered O VI line in the spectrum of classical novae puts constraints in determining the ionization structure of the nova ejecta during its early period of evolution.

http://www.astronomerstelegram.org/?read=6132



The line identified as “Raman 6830” by A. Skopal

About Raman scattering : read Steve Shore’s note p. 21
The possibility of Raman scattering in nova ejecta is debatable

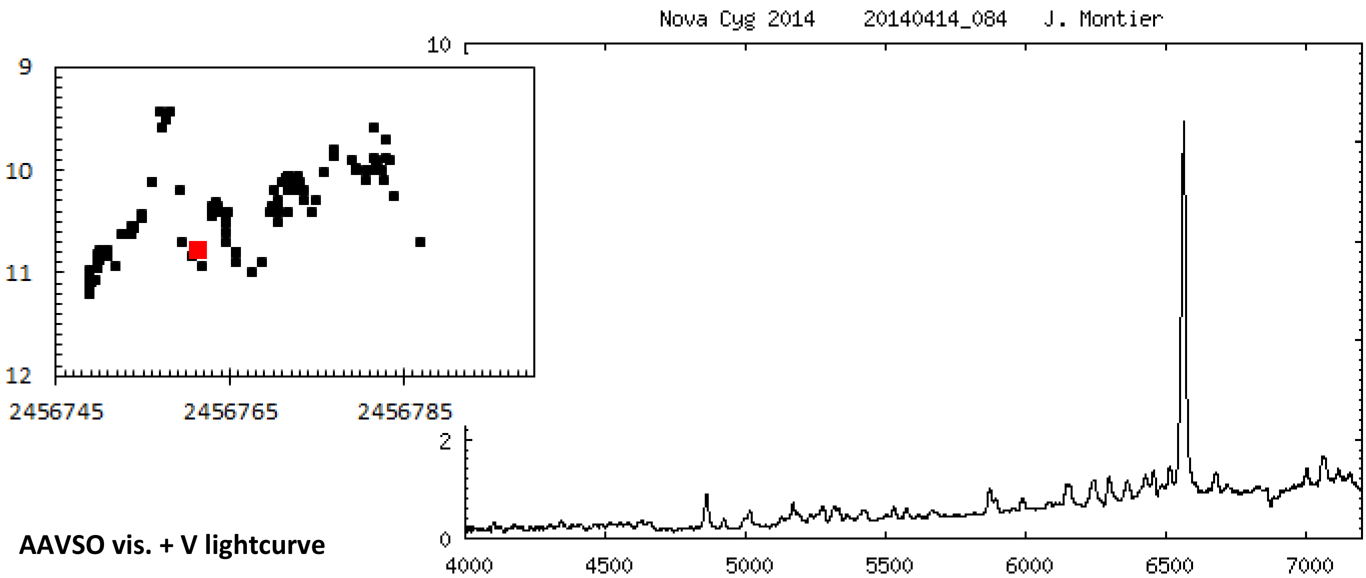
N O V A E

Nova Cyg 2014

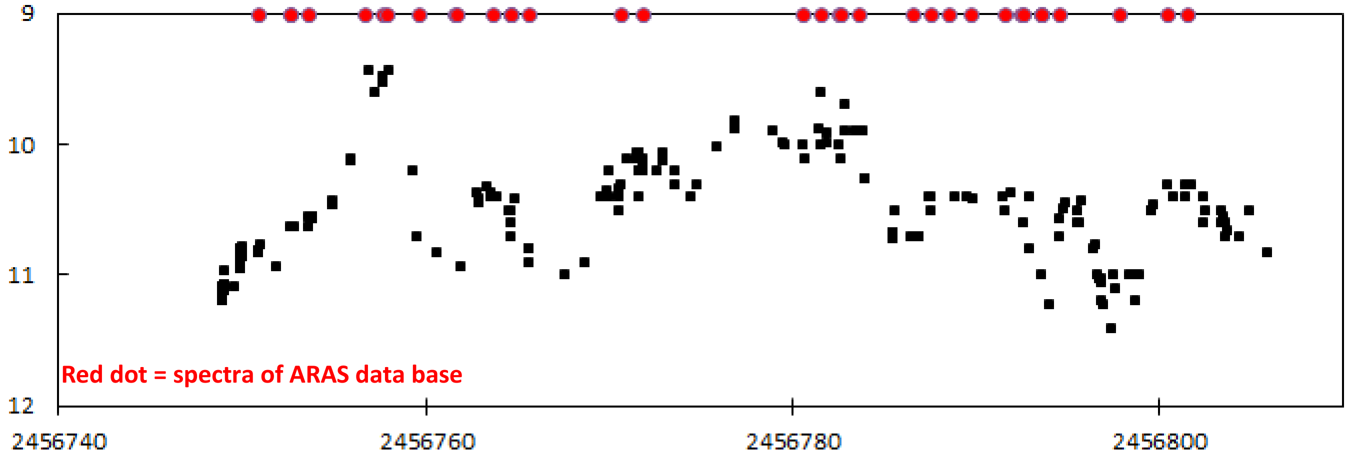
Notes by S. Shore about the peculiar light curve and oscillations

The very important feature of the current archive is the close sampling of the light curve variations. The fluctuations are similar, as you've no doubt noticed, to those in V339 Del and V1369 Cen. This wasn't seen in ONe novae (e.g. V382 CVel, V1974 Cyg) but that doesn't mean anything -- yet. The same behavior was seen in, for instance, CP Pup and the ever popular (or infamous) T Pyx. What these are caused by is an open question - the possibility that these are independent ejection events, however remote, remains an option. But they may be something passive, a radiative -- rather than dynamical -- response to changes in the illumination from the WD. The [O I] 6300, 6364 Å doublet appeared around Apr. 14, so the passive change in the illumination of the ejecta during the still optically thick stage.
Notice that at the brightest V excursion, around 14 Apr., the spectrum developed extremely narrow absorption and the emission almost disappeared. One explanation, and it's only a guess, would be a change in the covering fraction of the emitting gas. If there was a recombination event, the Balmer lines would weaken and the Fe II would become almost like a supergiant, a phase noted in the '40s by McLaughlin and once called the α Cyg (or Deneb) phase for its resemblance to the prototypical (but extreme) A0 Ia supergiant. The strongest optical continuum coincides with a strong absorption line stage, which would seem to point to recombination, timescales of a day indicate densities ~ 10^{12} cm^{-3} in the base of the ejecta for $v_{rm\ max}$ ~ 2000 $km.s^{-1}$ and could mean a column density as high as a few times 10^{25} cm^{-2}, the condition for the Fe curtain to be completely opaque. What happens at this stage to the WD remains an open question, we still (as you've seen from these last group of bright novae) don't have a unique phenomenology. The frequency of observations during these first stages has been enormously increased, though, thanks to *your* singular efforts!

The simplest picture I can suggest, for the moment, is to imagine a central light source that's varying in its effective temperature. The simplest example would be a pulsating photosphere. A variable luminosity produces a change in the radius of the photosphere since the WD envelope covering the nuclear source is optically thick. Then a change in radius produces a change in temperature, at its maximum the continuum peaks further to the red than in minimum (all relative). If this happens when the SSS is still obscured by the ejecta, a diffusion wave of radiation moves outward in the ejecta at a rate determined by the optical depth. A cause could be (and I emphasize the hypothetical here). Then the strong emission (and later even He I) could be at minimum V while the maximum absorption will be at maximum brightness. The test of this idea requires computing a nuclear shell instability on the WD so it's still in the works. But the diffusion is simple enough, it just smooths out the time dependence of the pulses into merged ``oscillations''. The timescale of about 1 week is very suggestive of a small overlying mass, about 10^{-8} M, based on the thermal timescale between the pulses. One interesting question, as always, is whether there's any indication of molecular contributors (the every popular CN and CH); the spectrum after 15 Apr also has an unusual feature of absorption/emission below 4500 Å. There is, as always, a lot here that's new so it will take time to digest the timing and phenomenology. Alas, this isn't being followed extensively elsewhere so your contribution in this early stage is really important. Remember, the early stages are the least understood part. There was no γ-ray source this time, hardly a surprise given the nova's brightness and likely larger distance than the detected Fermi sources.



AAVSO vis. + V lightcurve



Nova Cyg 2014

ATEL #6181

Title: **High-resolution spectroscopy of Nova Cyg 2014**
Author: Ashish Raj (Korea Astronomy and Space Science Institute),U. Munari (INAF Padova-Asiago), Byeong-Cheol Lee and Sang Chul KIM (Korea Astronomy and Space Science Institute), Sang-Joon Kim and Chae-Kyung Sim (Kyung Hee University, South Korea)

Posted: 28 May 2014; 10:05 UT

We report about high-resolution spectroscopy (resolving power 40,000) of Nova Cyg 2014 (PNV J20214234+3103296) that we obtained on May 1.78 and May 22.72 UT over the wavelength range 3800-8900 Angstrom with the BOES (Bohyunsan Observatory Echelle Spectrograph) attached to the 1.8 m telescope at Bohyunsan Optical Astronomy Observatory.

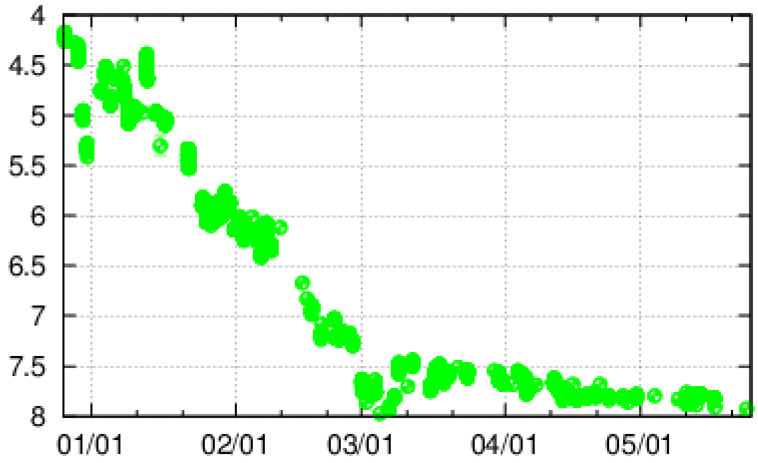
On **May 1.78** spectrum, all permitted emission lines display the same **two blue-shifted absorption components**: one at low velocity, which is remarkably sharp and displays a Gaussian-like profile; the other at twice larger velocity is much broader, with a trapezoidal profile. The FWHM of the sharp components ranges from the 45 km/s for OI 7774 (triplet line fully resolved) to 52 km/s for NaI, 60 for FeII 42, 100 for H-beta and 130 km/s for H-alpha.
The width at half intensity of the broad trapezoidal absorption component ranges from 185 km/s for NaI, 200 for FeII 42, 220 for Balmer lines and OI 8446, and 400 km/s for OI 7774. The heliocentric radial velocity of the narrow component is remarkably similar for all lines, -585 km/s (rms=7 km/s). The same occurs for the heliocentric radial velocity of the photocenter of the broad component, which is -1125 km/s (rms=13 km/s). The profile of permitted emission lines (except for CaII triplet) is Gaussian-like, with a FWHM ranging from 855 km/s for OI 8446 to 1050 km/s for higher Balmer lines. The profile of forbidden [OI] 5577, 6300, 6364 emission lines and permitted CaII triplet is instead rectangular, of 805 km/s width, with superimposed two feeble peaks separated by 530 km/s. The interstellar absorption lines from NaI and KI appear composed by several components, some of them saturated for NaI, at -37, -12, -2, +15 and +30 km/s heliocentric radial velocities. The total equivalent width of the optically thin KI 7699 indicates a reddening E(B-V) = 0.63 following the calibration by Munari and Zwitter (1997, A&A 318, 269).

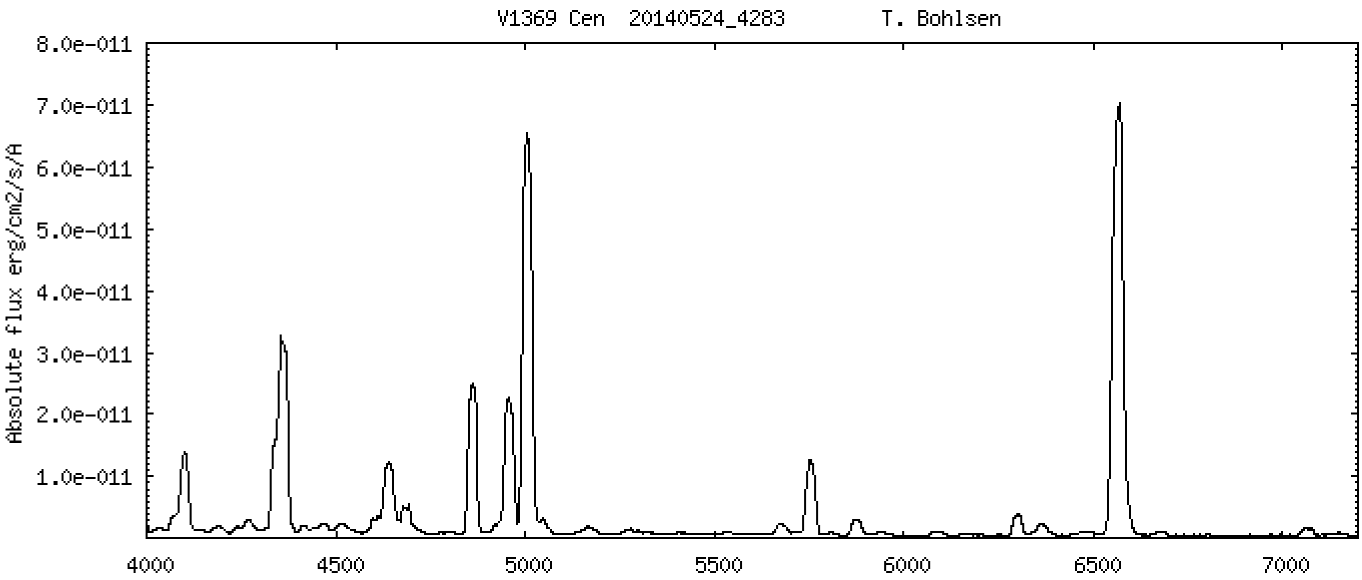
The appearance of the **May 22.72** spectrum is similar, with both absorption components wider and shifted to bluer wavelengths. The sharp component moved to -690 km/s, the broad one to -1380 km/s. Their profile changed too. While the sharp component developed a double peaked minimum (separation 30 km/s), the broad one developed into a series of sub-components different among the various lines. The forbidden [OI] emission lines retained the overall rectangular shape (width 900 km/s) on top of which six distinct peaks now appear. The CaII triplet is this rectangular with the two superimposed peaks now stronger and separated by 650 km/s.

Nova Cen 2013 = V1369 Cen

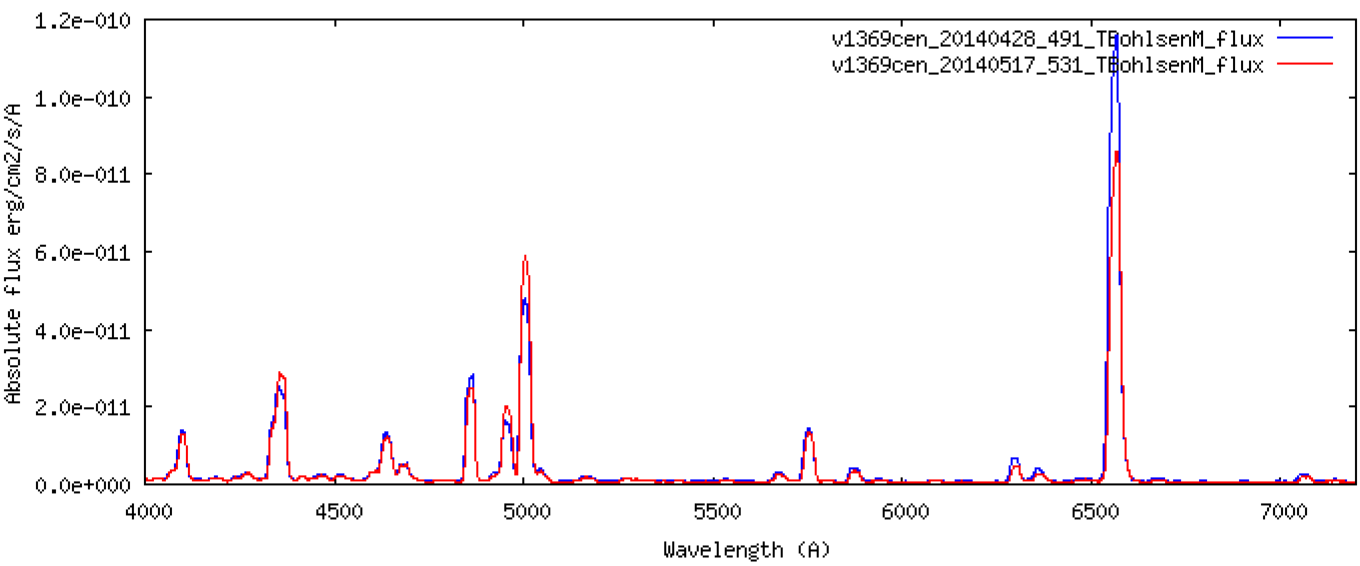
Luminosity
Mag V = 7.8 (23-04-2014)
Plateau phase, slowly declining, about 4 mag under maximum luminosity

Observing
New spectra from Terry Bohlsen
Pretty constant spectrum during this plateau phase
[OIII] lines increase





V1369 Cen by T. Bohlsen 17-05-2014 - Flux calibrated



V1369 Cen evolution from 28-04 to 17-05-2014

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

ARAS DATA BASE : 144 spectra **http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cen-**

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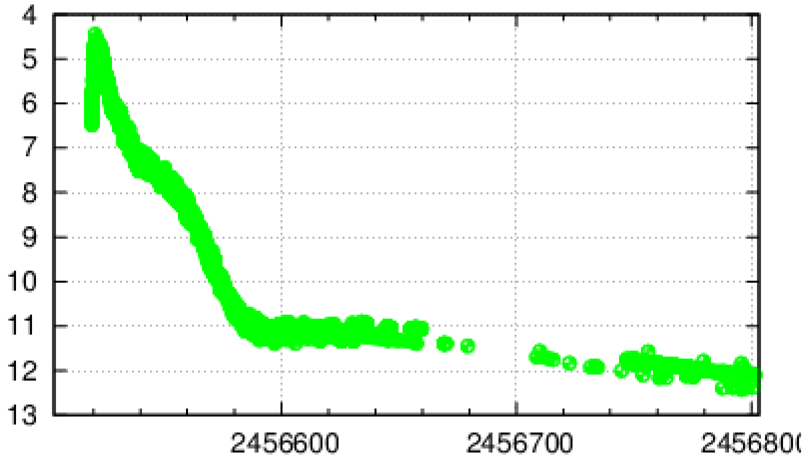
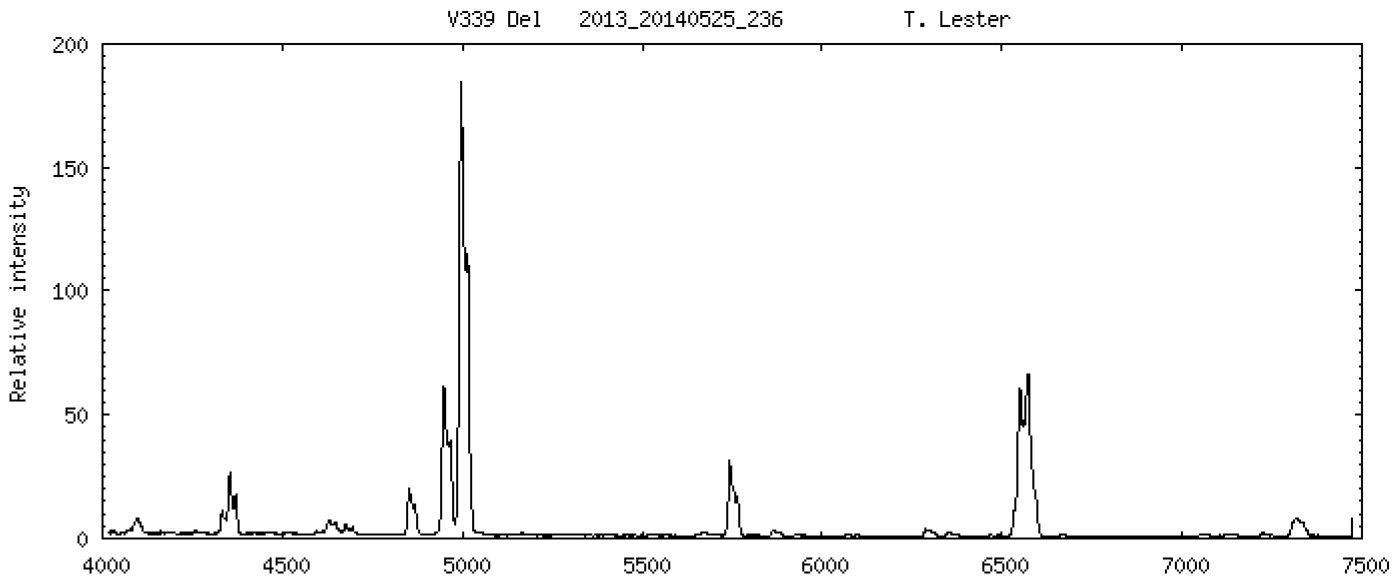
Nova Del 2013 = V339 Del

Luminosity
Mag V ~ 12 (10-04-2014)
Always in the very long plateau phase, slowly declining

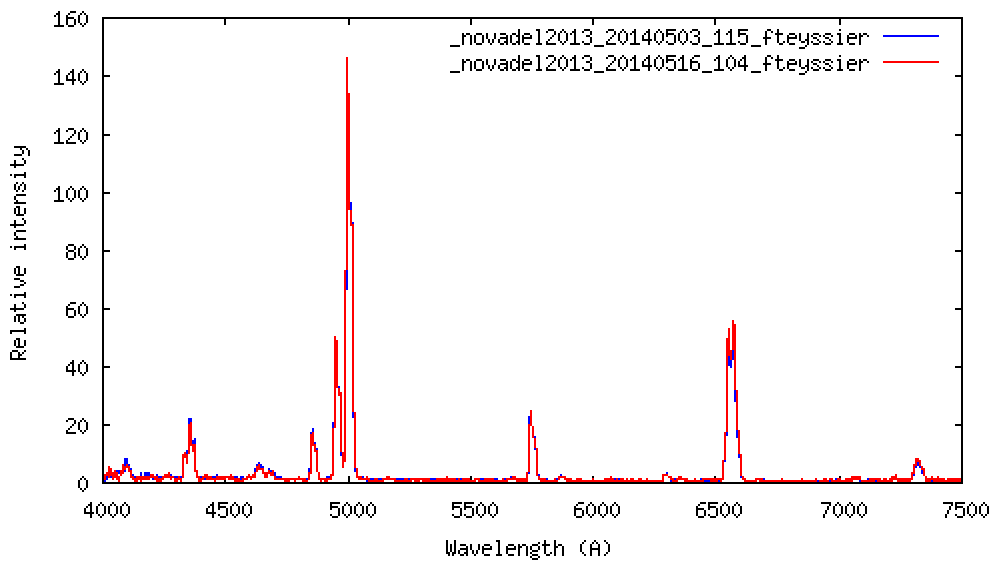
Observing
Spectra required (one a week)
The nova is now higher in the morning sky and easy to observe

ARAS data base : 1114 spectra





Pretty constant spectrum during the long plateau phase



Observers (2014) : Christian Buil - Tim Lester - Francois Teyssier

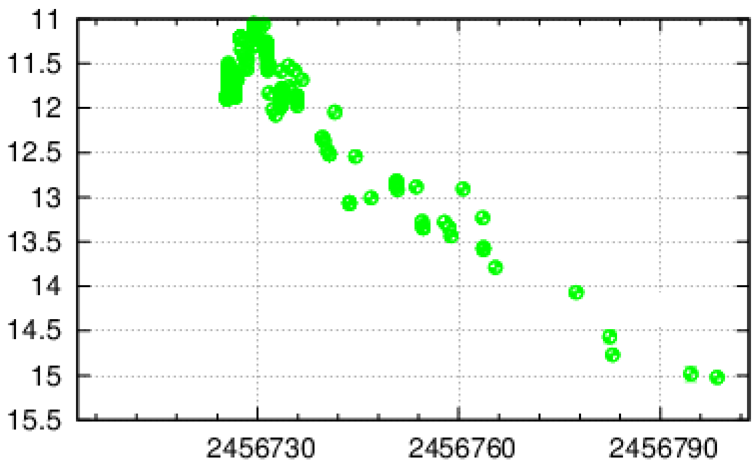
ARAS DATA BASE 2014 | 11 spectra| http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Del-2013_2.htm
ARAS Web Page for Nova Del 2013 : http://www.astrosurf.com/aras/novae/Nova2013Del.html

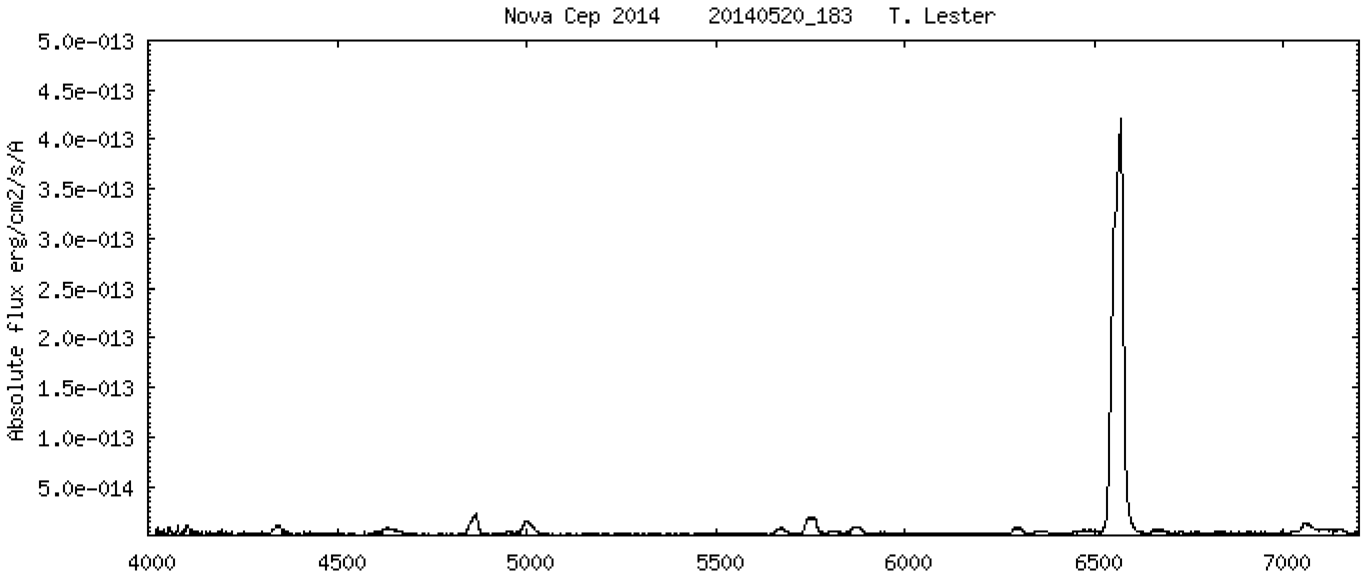
N O V A E

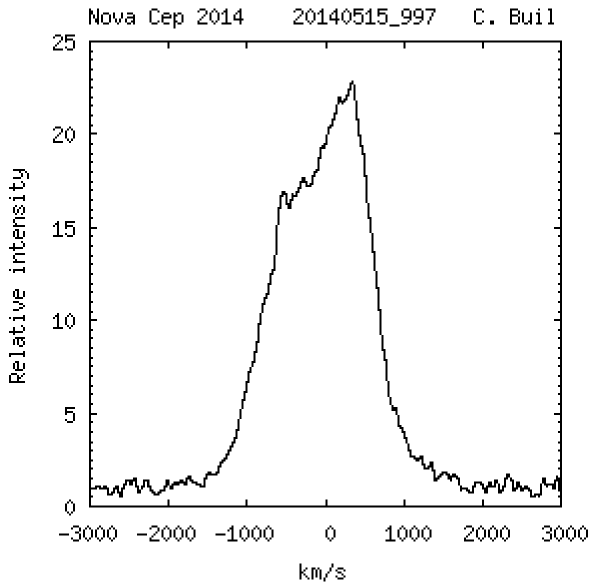
Nova Cep 2014 = TCP J20542386+6017077

Luminosity
Mag V ~ 15 (25-05-2014)
Declining

Observing :
New spectra from C. Buil & T. Lester







Hα profile (in km/s) at R = 2200 (MEDRES sepectroscop)

Observers : C. Buil | R. Leadbeater | P. Gerlach | O. Garde | T. Lester

ARAS DATA BASE | 15 spectra | http://www.astrosurf.com/aras/Aras_DataBase/Novae/Nova-Cep-2014.htm

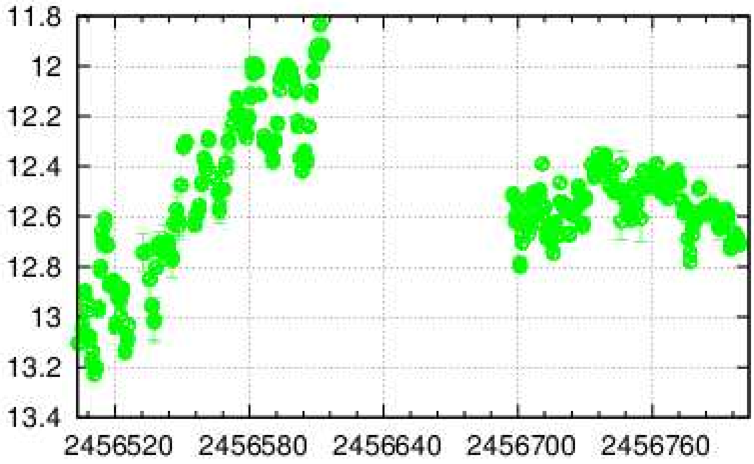
N O V A E

Symbiotic nova VVV-NOV-003

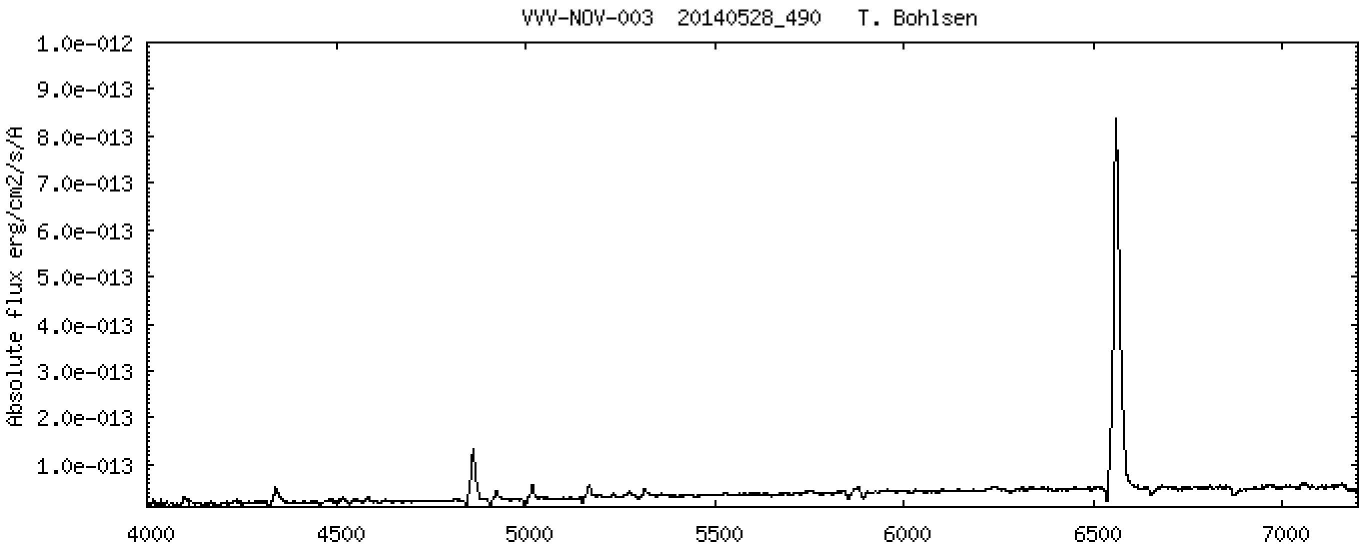
Peculiar nova discovered by VVV Survey data (vvvsurvey.org)

Coordinates (2000.0)	
R.A.	17:50:19.27
Dec.	-33:39:07.3

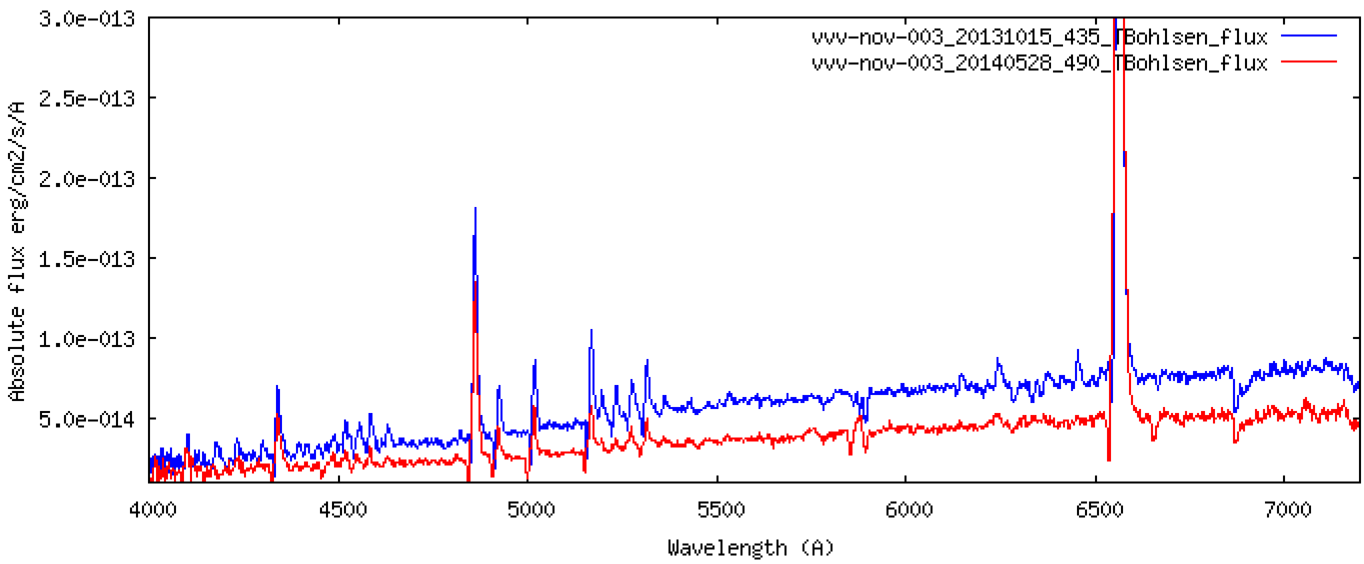
Luminosity
Mag V = 12.7 (29-05-2014)



Observing :
First spectrum of the year by T. Lester
Despite its low declination, VVV-NOV-003 can be observed in southern europa



Balmer and Fe II lines with absorption component



Evolution of the spectrum since 15th Oct., 2013

Observers : C. Buil| O. Garde | T. Bohlsen
ARAS DATA BASE | 23 spectra| http://www.astrosurf.com/aras/Aras_DataBase/Novae/VVV-NOV-003.htm
ARAS Web page : http://www.astrosurf.com/aras/novae/VVV-NOV-003.html

S y m b i o t i c s

Selected list of bright symbiotics stars of interest

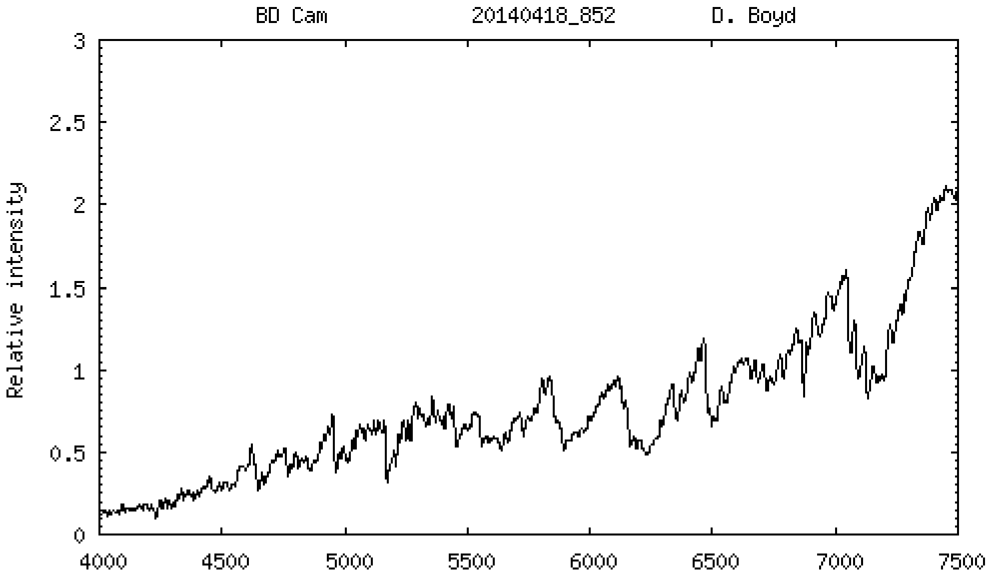
Target						Refrence Star					
#	Name	AD (2000)	DE (2000)	Mag V *	Interest	Name	AD (2000)	DE (2000)	Mag V	E(B-V)	Sp Type
1	AX Per	1 36 22.7	54 15 2.5	11.6	++	HD 6961	01 11 06.2	+ 55 08 59.6	4.33	0	A7V
2	UV Aur	5 21 48.8	32 30 43.1	10		HD 39357	05 53 19.6	+ 27 36 44.1	4.557		A0V
3	ZZ CMi	7 24 13.9	8 53 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

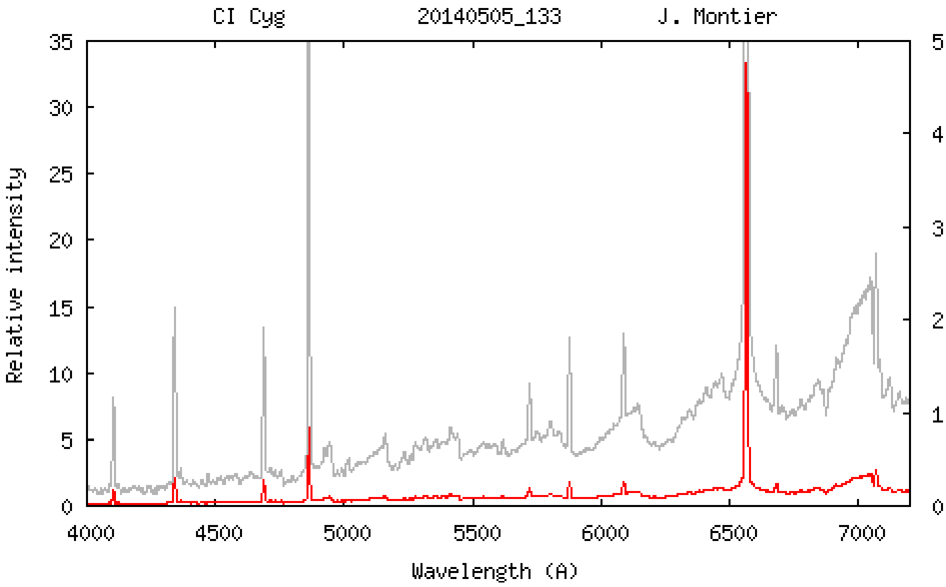
Mag V * : 01-04-2014

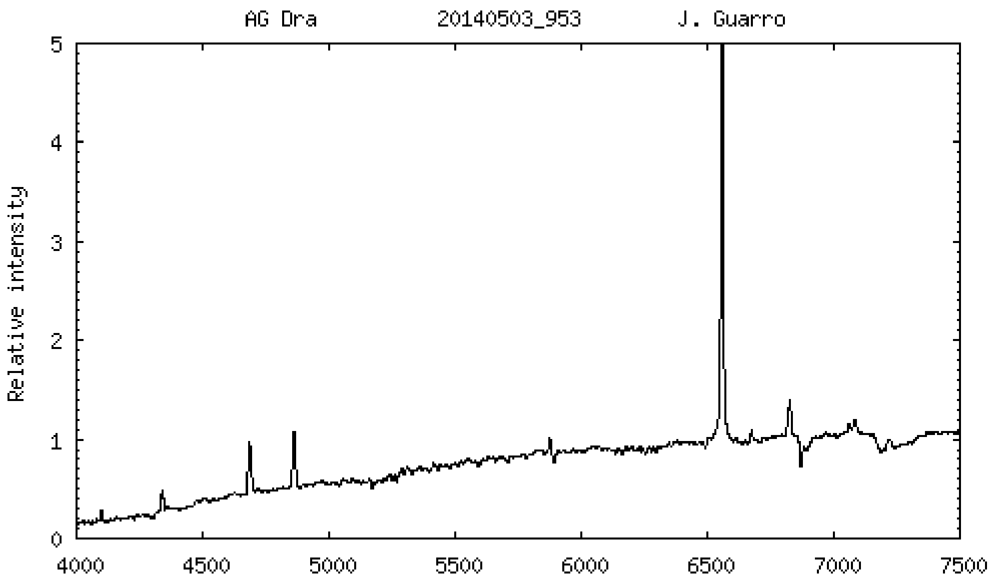
From 01-05 to 31-05

New spectra	
T CrB	3
AG Dra	4
V 443 Her	2
BD Cam	1
CI Cyg	2

BD Cam CI Cyg AG Dra

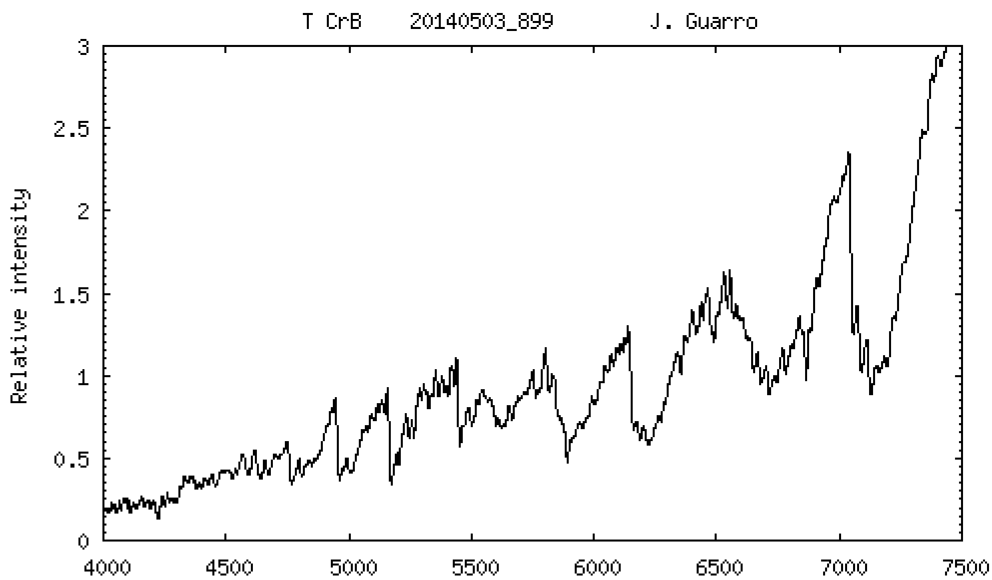




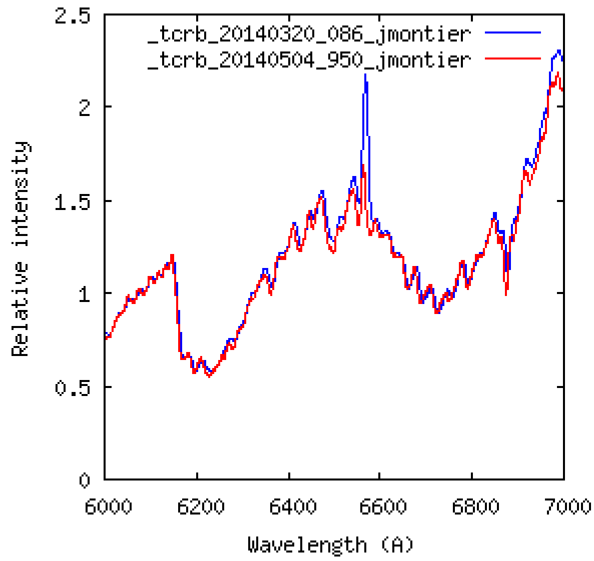


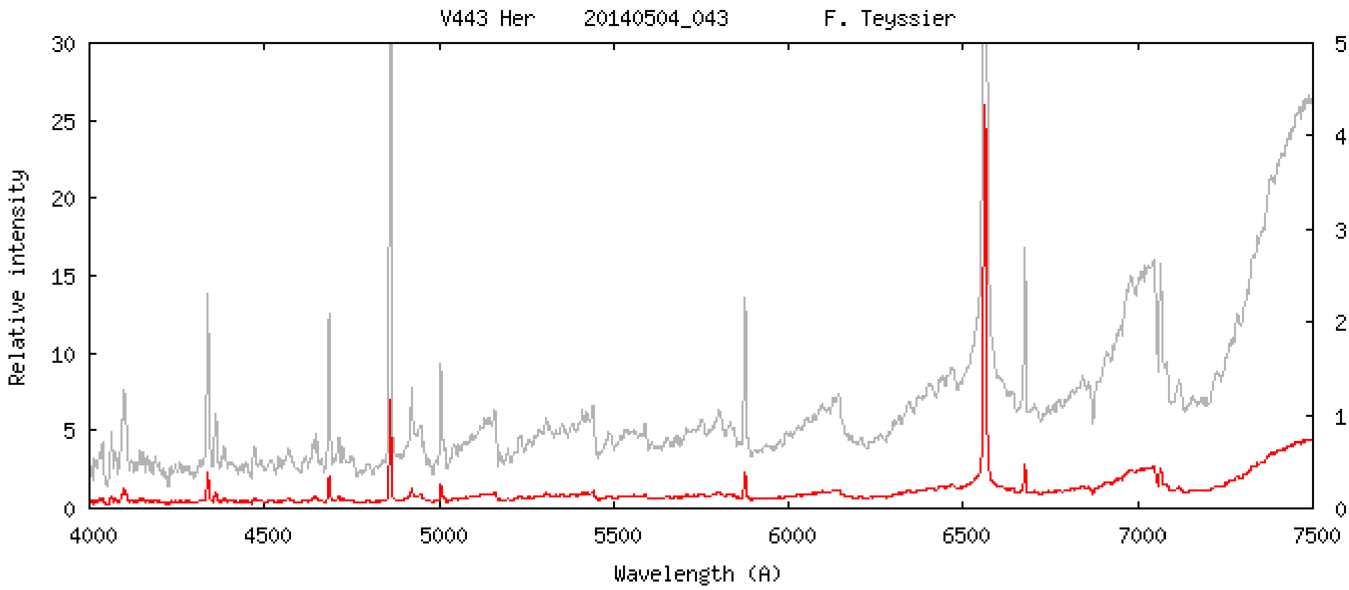
ARAS DATA BASE | http://www.astrosurf.com/aras/Aras_DataBase/Symbiotics.htm

T CrB V443 Her



Evolution of Hα line in 1,5 month

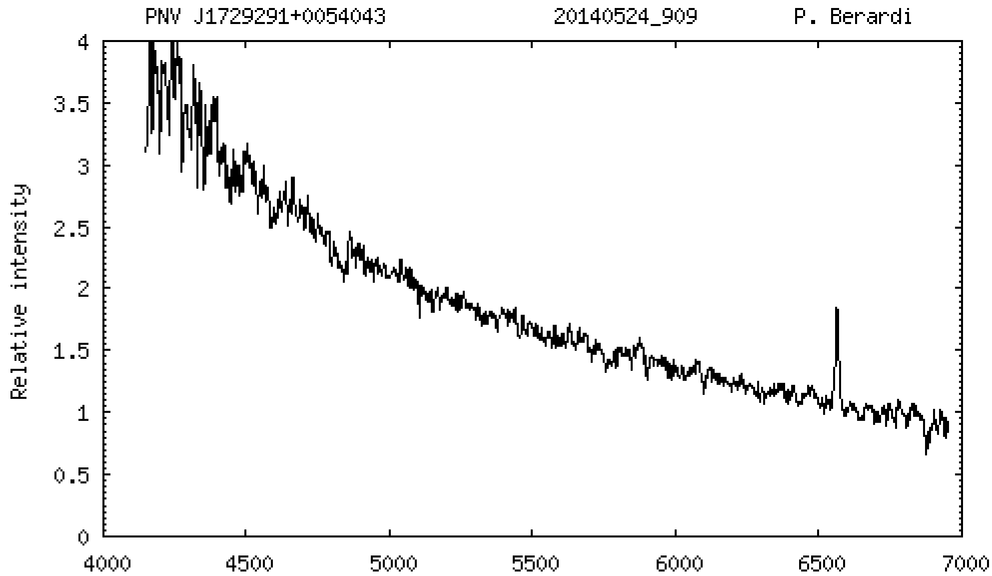




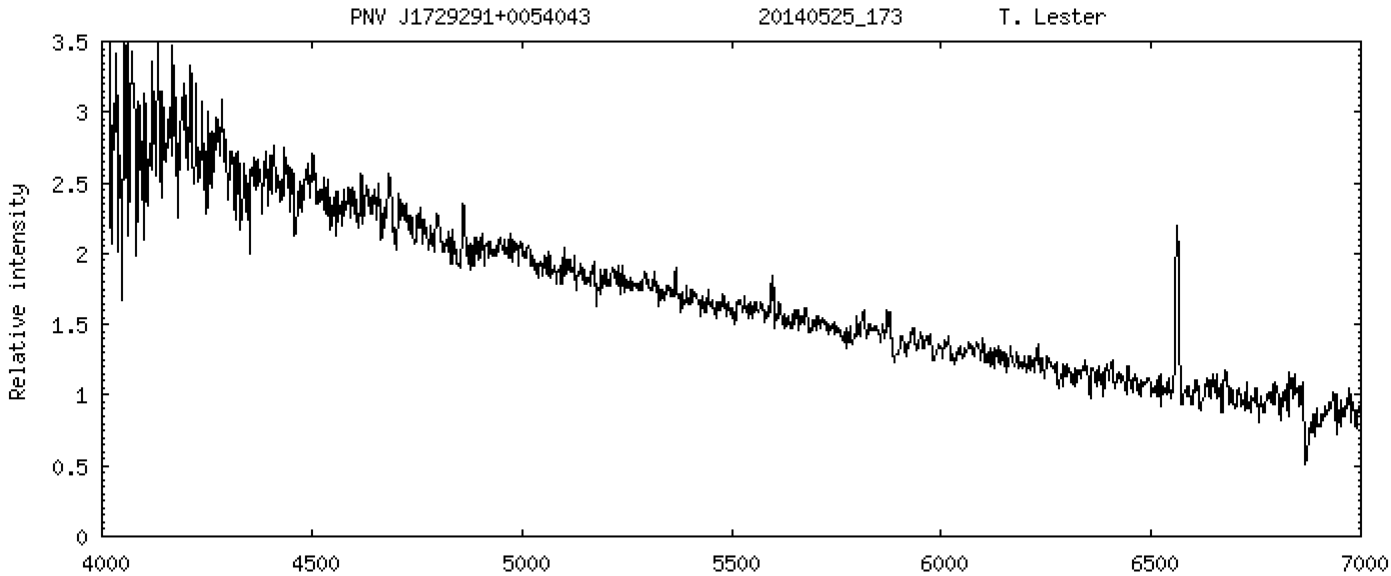
PNV J17592412+2520317

Superoutburst of a WZ Sge cataclysmic
In Ophiucus
PNV J17144255-2943481
http://www.cbat.eps.harvard.edu/unconf/followups/J17144255-2943481.html

Spectrum obtained by P. Berardi
2014-04-14
At mag = 10.8



The spectrum obtained by Paolo Berardi, typical of a dwarf nova outburst



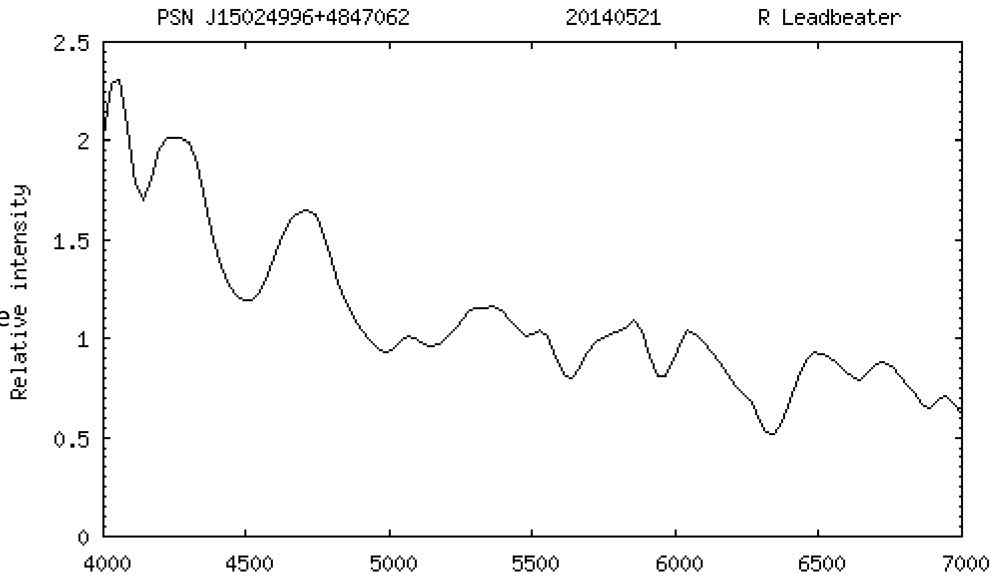
One day later, Tim Lester's spectrum show a narrow emission in the broad absorption of Hβ, He II, He I 5876

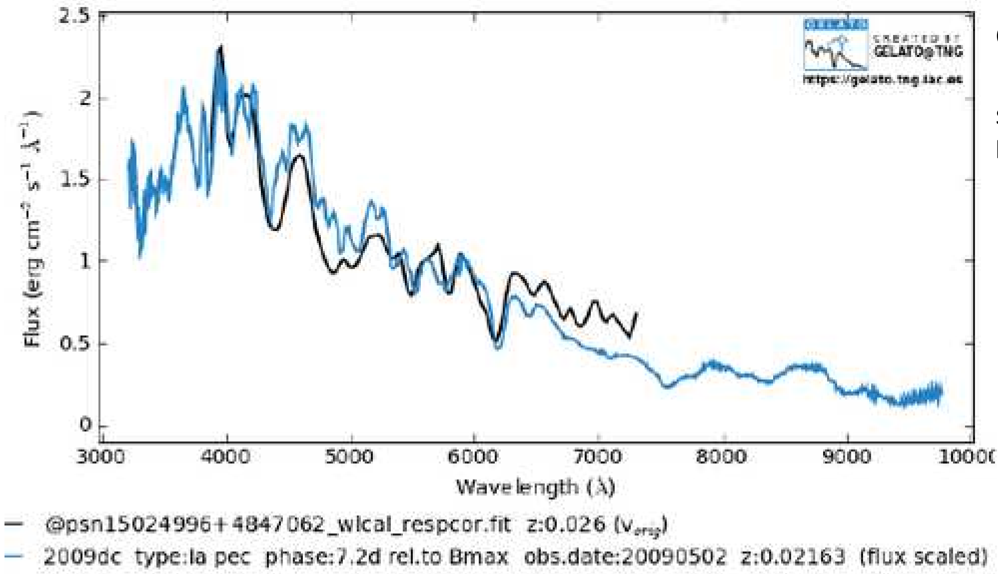
PSN J15024996+4847062

Transcient discovered by R. Gagliano, J. Newton, T. Puckett at mag 16.3

Robin Leadbeater obtained this spectrum at **mag ~ 16** with a modified Alpy600 (“Alpy200”) and a 11” scope

http://www.cbat.eps.harvard.edu/unconf/followups/J15024996+4847062.html



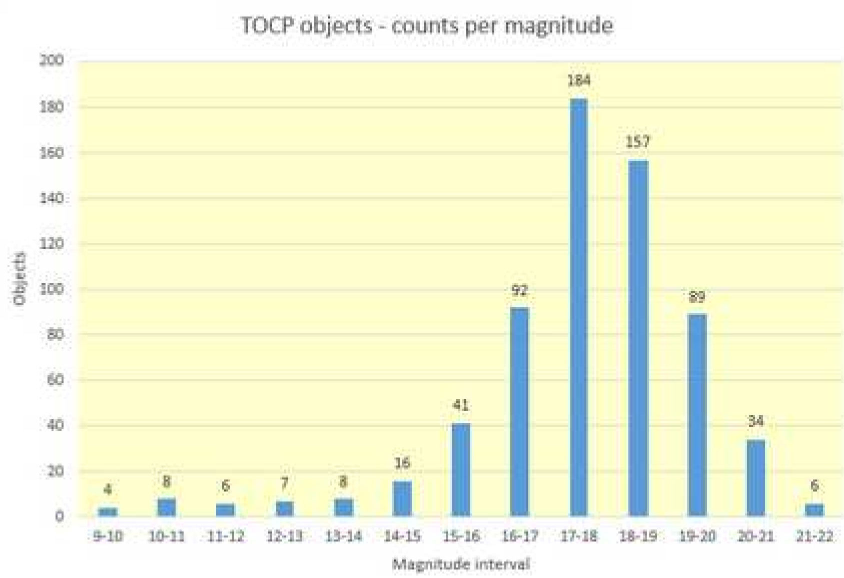


Confirmation by Robin Leadbeater of the Type Ia spectrum using GELATO https://gelato.tng.iac.es/login.cgi

Robin has modified an Alpy600, using a SA 200

See :
http://www.spectro-aras.com/forum/viewtopic.php?f=8&t=808
And :
http://www.threehillsobservatory.co.uk/astro/ALPY200_VdS_2014_poster.pdf

This statistic extracted by Paolo Berardi from CBAT TOCP page shows the interest of luminous spectroscops to identify new SNs



Symbiotic stars and accretion phenomena in binary systems - Part 3.

Steve Shore **1/5**

The accretion process

So far I've been concentrating in these notes on the specific objects, novae, that started this series of discussions. Now let's get to the central issue -- the physical process of mass transfer and accretion. It doesn't matter whether we're talking about compact systems such as cataclysmics, symbiotic stars, binary Be stars -- the conditions for any of the phenomena I've been discussing require that something external to the activity site serves as the driver.

To start with a basic point, consider the evolution of a *single* star. Summarized in a few words, and this isn't to oversimplify[1] stars are self-gravitating objects in global hydrostatic balance (mechanical equilibrium) and in thermal balance (that they emit the totality of the energy they internally release) of sufficient mass that they reach the temperatures and densities at which thermonuclear reactions can ignite and remain self-regulated. The key is that nuclei, structures of protons and neutrons, have a finite binding energy that can be released when the addition of other nuclei produces a more tightly bound state. This is an analog of what happens in atoms when, in passing from an excited to a lower energy state, photons are emitted. The strong interaction, the nuclear force, is attractive at short enough length scales that if the energetic conditions are right ambient charged particles can overcome the long-range electrostatic repulsion of the similarly charged particles and become bound. This is a random process in stellar matter, an ordinary gas that reaches sufficiently high temperatures and pressures in the interior of such an object that a mean rate of capture is established. The rate, which depends on temperature, also depends on the nuclei involved. For instance, as you know, the solar luminosity is generated by proton capture on hydrogen (the so-called proton-proton chain) that, because it doesn't require any heavier nuclei, is the basic reaction. It is a very slow process because the first step requires conversion of a proton to a neutron to form a stable state but this happens with a very low probability, but it happens. The result is the irreversible loss of energy that's released, in the form of photons (but also neutrinos, although not the dominant loss mechanism) and the net conversion of H into He, the next stable nucleus. In more massive stars, since the higher core temperatures permit the reaction, the next most abundant nuclei also participate and, in fact, dominate: the CNO cycle (Fig. 1) . In this, pH is converted through a range of successive captures and decays into He with the C nuclei serving as a catalyst. The reaction is much faster than the pp chain, and the luminosity is greater, but the net product is the same. The core composition changes and the released energy establishes the pressure and density structure of the envelope of the star, yielding larger radii and higher luminosities for greater masses.

All subsequent nuclear reactions during the cycle of thermonuclear processing follow from this simple picture. Each stage produces a range of residual nuclei that can, depending on the stellar mass, subsequently ignite. Since each is more charged and each has a higher binding energy, the process becomes progressively more centrally condensed. Regions outside the core also ignite because of the heating from the core and the processed material, which has a chemically different composition than the unprocessed envelope, increases in relative mass. For instance, the region outside the He core ignites hydrogen burning even while the core itself remains merely hot because there's still a supply of hydrogen. The core, continuing to lose energy, contracts and raises its pressure and temperature, thus powering the overlying layers. This has its limits, most of the star will never undergo thermonuclear processing but an increasing portion does and this continues until the reactions are no longer releasing energy (when the Fe region is reached, in the most massive stars) or when the energy loss is predominantly from neutrinos (which stream, rather diffuse, outward from the core and don't additionally heat the envelope). The details are not essential at this point for most of the systems you've been following. For chemical evolution of the Galaxy, for winds and outflows, for supernovae, yes. But for the basic understanding of the mass transfer in close binaries no (we can certainly discuss this at another time, it's very lovely stuff).

Suffice it for the moment that the more massive the star, the higher up the periodic table the nucleosynthesis

[1] Eddington is famous, among other things, for the global viewpoint concerning stellar evolution, summarized in the phrase ``At terrestrial temperatures matter has complex properties which are likely to prove most difficult to unravel; but it is reasonable to hope that in the not too distant future we shall be competent to understand so simple a thing as a star.''

proceeds. For stars below a couple of solar masses, the process essentially stops with core helium, or helium plus a CNO-processed shell. More massive stars ignite the core helium and convert it to carbon, those still more massive reach N, O, and eventually Ne through subsequent addition of the He nuclei α processing), but neon is the practical limit and those stars below about ten solar masses that then finish their nuclear cycles and simply cool. Well not quite ``simply''. There are several auxiliary stages of shell burning of CNO and He but that's it and these are shortlived relative to the main core processes. Once thermonuclear processes end, the core continuing to cool contracts and the outer layers, by expansion and continued heating, are lost in a wind. The mechanism for this stage is also still not well understood. But to connect with what we've already discussed, this is the stage in which the companions of the WDs in symbiotics find themselves, and also the stars in planetary nebulae at their initiation. The wind strips the envelope of the star, leaving a compact, eventually degenerate, core behind that we see as a white dwarf. The composition differs in these beats according to their progenitor's history. Those from solar mass stars are predominantly He, those from more massive parents are CO, while the most massive reach ONe. This, you may recall, is the distinction we drew when describing the WD on which the thermonnuclear runaway of the nova event ignites.

This nuclear reaction sequence also occurs for stars in multiple systems if they can evolve as single objects, that is if they are not so close that their envelopes merge (the so-called common envelope binaries) and the individual stars going through this nuclear processing (from now on called ``burning'') are known as the *main sequence* . The name, as you surely know, is because the stage is the slowest, hence longest, in the life of a star. Hence they are the dominant population in any ensemble of stars formed over time. The lower the mass of the star, the longer it stays in this state and for stars somewhat lower than the solar mass they last as hydrogen core burning objects for the age of the Galaxy to date (or longer).

Now put another star nearby. Much, but not everything, changes. For simplicity consider a binary system. The components, however the system forms, produce a mutual an external gravitational force that depends on their separation and masses. And radii. Every element of the mass of each is attracted by the other but, because the self-gravitation is dominant, the bodies distort without disrupting. This is the *tidal* force. Their centers of mass orbit, but to the next order there is a differential force for each. The closer portions of the star are more drawn toward the other than the center, and vice versa for hose more distant. Relative to the center of mass, the two ends appear to accelerate oppositely and, for a small perturbation, the distorted shape of the components is an elongated spheroid along the line of centers. The larger the radius, the greater the *differential* force even if the attraction is mutual. So if one of the stars is expanding relative to the other, it becomes progressively more distorted and, as its surface approaches the point of force balance between the two stars, progressively more asymmetric. The limiting radius, the point at which a mass element in a stars envelope isn't bound to either star, is the *Roche surface* (not because Roche was a distorted Frenchman, I should add). There's nothing particularly strange about the configuration if it's just a limiting orbit, this is the three-body problem is called the *inner Lagrangian point* or L_1 (Fig. 2). It is only coincident with the center of mass if the two masses are equal and always farther from the center of the more massive member of the system. The Roche limit is, therefore, the largest radius a star can have and remain, for all practical purposes, a single object.

The limit isn't a hard wall, as you might imagine from the usual description. It's something like the approach to a toll booth. The pressure remains on one side, but the cars are free to accelerate on leaving (and, on the autostrada, certainly do with gusto). But there's a continual supply from the other side. The acceleration isn't identical but the mean is the same and the point of no return is the same but the cars start accelerating at slightly different points. In a stellar envelope, there's a pressure on one side (the envelope itself) and on the other just the open vista of the other more compact star. So matter accelerates toward the companion driven by a flux of mass from below and the pressure gradient adjusts to permit a steady outflow as if from a nozzle. The side of the region in contact is quite small relative to the radius, of order the distance over which the pressure can drop (the it *pressure scale height*, but for our purposes it can be taken as simply a small orifice through which material is flowing and lost from the star. The flow isn't direct, however. Were the two stars nailed to the sky so they can't orbit, it would be. But because of angular momentum, there's a deviation of the flow (the Coriolis acceleration, to be technical) that causes the flow to -- now supersonically -- follow an orbit of its own around the companion. Over time, and only a few orbits is needed, the self-intersection produces shocks and further energy loss and heating, and the flow circularizes around the companion. We can now pass to a new terminology: the two will be called the mass loser and mass gainer. This avoids the often confusing distinction of ``primary'' and ''secondary'' since it doesn't make any assumptions about the relative mass and/or luminosity of the stars.

How the circularization proceeds is still poorly understood although observationally evident: a circulating disk of continuous supply is formed that is maintained by the flow of mass from the loser and the collision of that stream with the outer parts of the flow. This is an *accretion disk*. But to pass from circulation to accretion requires that the angular momentum of the matter change, decrease, which requires in turn a torque. Some of this dissipation can occur in a hot spot, the impact site for the incoming stream at periphery of the disk. This is seen in both emission line variations (in fact, the basis of the so-called tomographic reconstruction of the disk that uses the variation of the emission line velocities with phase to reconstruct the orientation of the emission site) and also produces a bright phase in the light curve that leads the eclipse of the WD (in systems that eclipse). The shock redirects the flow continually and is thought to be a source for turbulence, at least locally. Something must act to slow the orbiting matter and convert angular into radial motion. And now we come to the Pandora's Box of accretion: how does the matter in the disk exchange its orbital kinetic energy with other parts of the disk so there is a net inward drift?

The accretion process and why it's a disk: a bit more in detail

Mass transfer through L_1 is dynamically very close to the blast from a firehose nozzle, if the hose is also on a carrousel. Since the mater was accelerated in a rotating system, there's a net acceleration from the motion. To be more precise, the Coriolis acceleration is a deviation in the flow because it's angular momentum doesn't match that required for strict corotation. Thing of sitting on a moving a carrousel, on one of the horses on the periphery. Aim the nozzle toward the center. The flow is starting with some angular momentum that depends on its distance from the center so that is higher than the inner parts. If you aim at one of the horses, the flow will inevitably miss because it's deviated by its different angular momentum. To slow it down requires some kind of torque and, for a free stream, there isn't anything available unless it's dragged by contact with the platform. The same is true, by the way, for motion on a sphere if the flow is meridional (along lines of longitude) but {\it *not*} zonal, along lines of latitude that are axially symmetric circles. The difference is that in line center of the binary system carrousel there's a gravitational source, a mass, that deviates the flow so if it starts from a bound state and at the sound speed of the envelope of the star filling its Roche surface, the initial speed is well below the escape velocity within the environment of the companion and the stream orbits. As I'd mentioned, this stream, can self-intersect, moving at an orbital speed that is the Keplerian velocity of the intersection point, and this is very fast and very supersonic (at the surface of a WD, the orbital speed is about 3000 km.s^{-1}, with the escape speed being about 40% higher. The mater spews out of the L_1 point at high pressure but essentially at the sound speed so it spreads but not much, especially in the vertical direction. In fact, since the stream is -- in this sense -- cold, it never reaches a significant height above the orbital plane before falling back in a precessing orbit. So the motion of the stream, and the subsequent dispersed matter after self-intersection, is confined to a plane with a thickness that depends on the distance from the center but is approximately given by the inverse of the Mach number times the distance, $\Delta z/r \sim c_s/v_{orbital}$ where c_s is the sound speed. The outer parts of the disk are thicker because the Mach number increases with distance (the orbital velocity is lower even if the disk temperature is constant), a thin flaring disk, but it is still quite thin, a few percent of the distance.

The problem is not the formation of a disk, this is unavoidable in a rapidly rotating system, but accretion requires a net transfer of mass toward the companion. To do this requires some kind of internal stress. A global stress, for instance a magnetic field of the WD, would couple of the star to the surroundings. But since the orbital velocity is always greater than the stability limit of matter bound to the WD -- that is, it's always orbiting faster than the maximum allowed rotational velocity -- the field can act as a propeller to expel material from the system (and the mechanism is so named, in fact). Instead, some kin of local, collisional, random motion that leads to heating and dissipation of orbital kinetic energy will also force the material to slowly drift inwards. The rate is almost sonic but it's a sort of diffusion, random fluctuations on all scales up to the local disk thickness are the most effective. Since they're local interactions, any one fluctuation (OK, call it a blob), interacts with those around it to produce the same effect as a viscous coupling, shear driven by the differential motion of the disk, that transfers angular momentum outward while forcing the matter to fall slowly inward. The last step is at the WD-disk interface where the infalling matter finally loses the last part of its energy and that's the next item on our agenda.

Magnetically dominated accretion, magnetospheres and polars

If there's a magnetic field that is strong enough to support the disk, the standard picture is a funneling of matter toward the poles of the star where the accretion is confined to something like the auroral zone on the planets in the presence of the solar wind (Fig. 4) . Rotation of the field modulates the intensity of the observed emission, both line and continuum, as the pole change sits aspect relative to the observer with rotational phase. This is a *polar*, the signature of a magnetized mass gainer. Tidal forces acting over long enough time can (but don't necessarily) produce synchronous rotation - the WD rotational period is the same as its orbital period, analogous to the Earth-Moon system. If the spin of the WD and its orbital period differ, a so-called *intermediate polar*, there will be a phase shift between the line and orbital variations. The details are interesting but, for our general purposes, not critical. The bulk of the matter in the accretion disk has a standoff distance from the surface of the magnetic WD because of the magnetosphere (think of pictures you've seen of the van Allen belts of the Earth in the Solar wind) that depends on the field strength. So a signature of a magnetic WD is pretty direct but *only* in quiescence.

Boundary layers

The alternative is when there isn't a strong enough field to impede the inward motion in the equatorial plane of the star and the accretion occurs through a boundary layer. This is one of the most poorly understood aspects of turbulent fluids in general but here it's even more extreme. In a cup of coffee, if the cup is set into rotation, there's a drag from the rigid boundary that diffusively spins up the fluid. Eventually, at least a part of the fluid is co-rotating with the cup but the center may still lag. Over time the state of dissipative forcing yields a column of coffee that seems to rigidly rotating with the walls. Stars, on the other hand, have fuzzy boundaries and the disk is forcing the spin-up, not vice versa. As the material slows to the corotating state it loses energy that heats the boundary to more than 10^5 K. The emission extends into the UV and, if hotter, into the X-rays (Fig. 5). This emission also flickers, like a noise, and you see this in cataclysmics. The temperatures can get even higher if the central object is a neutron star but those are not the sorts of systems we're dealing with; in novae it should reach only (!) a few million K but this can be seen in quiescence from X-ray satellites. The disk is continuous in this case with no inner boundary other than the star. Another, important but also poorly understood feature of this layer is the shear mixing it may produce with the underlying WD. Remember that the matter coming in has a different composition than the star onto which it's falling. The mass loser is not a WD, even if it's not necessarily a normal main sequence star (or giant) it's likely hydrogen rich (unless somehow that part of the envelope has been remove and the helium core or shell has been exposed). So how the mixing takes place is important for understanding the ignition of the TNR.

Some of this may be recorded in the composition of the ejecta, and there could be mass loss from a wind produced by the boundary layer (this is implicated in protostellar disks such as T Tauri stars), but much of this remains in the ``open but frequently asked'' question category.

Wind accretion

One last point, since you've had the patience to bear with this discussion. If the WD is immersed in the wind of a mass losing giant, all of these processes still occur. There's a disk, not as massive or as observationally evident and not as well defines as with a stream. But observations of flickering in the light curves of symbiotics is a pretty good indication of a disk. There are other effects, a bow shock caused by the WD as an obstacle to the supersonic wind that also forms a trail behind the WD (an accretion wake) but all of these are happening simultaneously and to date, only a few systems have been observed for a long time to understand what's happening (an encouragement, I hope, to those of you who are interested in such systems). Again, the infall of matter into the strong gravitational field of the WD produces UV and XR emission but now the radiation is absorbed by the surrounding junk of the giant's wind. This is the source for the signature emission lines that define the symbiotic stars. Of the novae occurring in such systems, the few known seem to be extremely massive WDs but that's the main difference. Once the matter gets onto the star and mixes into the envelope of the gainer, how it gets there really isn't ``remembered'' by the system. At least at the moment that's the thinking.

a few last comments

The main point, that the matter accumulates over the whole equatorial region for an unmagnetized WD or predominantly at the poles for a polar, is what matters. In outburst you don't see any of this, either for a symbiotic binary or a nova. The ejecta hide whatever is happening in the innermost parts of the system because of their initially high opacity. But when the smoke clears and the system returns toward quiescence (whatever that means) the emission comes from the environment tied to the WD. It is usually stated that the quiescent presence of He II 4686 Å emission is the evidence for a disk. This is OK if there's otherwise no indication of the ejecta. The reason is simple: the disk is hot. Not so hot that it is thick, that would require temperatures above 10^7 K locally to approach the orbital speed, but at least a few tens of kK. That is hot enough to produce He II recombination emission. The characteristic line profile would then be disk-like, maxima at high or intermediate speeds (depending on the disk inclination) and a double peak structure that is roughly symmetric about zero. I'll repeat that this is expected in *late* stages of the outburst, by the time the ejecta are so low density that their spectral contribution is negligible. But in the early spectra, those taken when the ejecta are still visible, there are many ways of getting the same profile so the evidence for early disks is not unique. On another, related issue, the polar shows itself by *periodic* signals (also polarization) so if the periods are different there will also be evidence of that in the spectral time series (as there was in V1500 Cyg 1975, for instance). This is a very good reason for pushing on high cadence when the systems are still bright, there may be evidence from key lines (the He and higher elements in moderate ionization states, not likely the Balmer lines that are formed everywhere!) . There's little known about this. The orbital periods of novae are less than a day, except for a few classical systems like U Sco and GK Per, so I mean rates of one per hour, for instance.

So now, in the sincere hope that this hasn't been too heavy going, we've reached a good place to stop. Thank you all for your continuing interest and wonderful work.

Steve Shore 22-05-2014

about a particular process: Raman scattering in stellar spectra

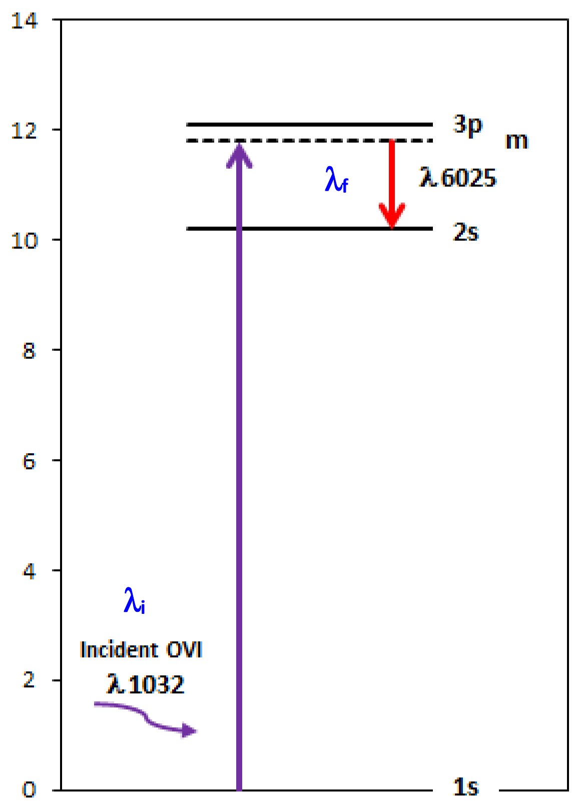
By Steve Shore

Raman[1] scattering is one of the most important early demonstrations of quantum mechanical processes in atomic and molecular systems ; it's not all that different from Rayleigh scattering.

When two systems are near resonance, the difference in the frequency can -- if the interaction is strong enough -- create a third frequency. A well known effect in nonlinear wave scattering (think of two waves colliding near a beach and how a third wave can be formed that is the sum/difference of the other two), in an atomic case if a strong line is near (and that's the key) another strong line in energy, the excited state of one can be reached through a conversion process. Although there's a mismatch in the energies, the difference can produce an emitted photon. The process had its astrophysical debut in a remarkable piece of detective work by H-M. Schmid, Harry Neugebauer, and the ETTH-Zurich symbiotics group. For many (!) decades, since they were first noted by Merrill, two extremely broad emission lines around 6825 Å and 7080 Å were associated with a large number of symbiotic stars -- and only with that class. While all laboratory attempts at identification failed, it was proposed by Schmid[2] and company that these (and other) lines could be due to this previously neglected process. Their predictions -- especially the polarization of the lines and their variation in strength and degree and angle of polarization with orbital phase, were quickly confirmed. The identified culprit is the scattering of the FUV resonance lines of O VI 1032, 1038 Å from Ly β 1025 Å . Notice the very close match and the fact that the scattering produces a doublet with a large separation and large width. The cited paper actually identified several UV lines in active galaxies with highly ionized states of Fe, {\it *not*} the O VI. But, presciently, they included a table that listed the O VI doublet (I chose this one because it's the ``first'' suggestion and especially clear, if a bit technical). Note that the main difference is that the line is *shifted*from the scatterer and the energy of the emergent photon is *different* than the incident photon. In the case of no change in the energy, you would have Rayleigh scattering. Here there's a coherent process, in just the same way, but the energy changes because of the resonant interaction. Perhaps the most important result is:

$$\frac{\Delta\lambda_f}{\lambda_f} = \frac{\lambda_f}{\lambda_i}\frac{\Delta\lambda_i}{\lambda_i}$$

the statement that the line width is a scaled (larger) value for the scattered line (left side) than the observed width of the responsible transition by the ratio of the wavelengths. So, for instance, taking the O VI example, the observed line is about 6 times the width of the FUV lines. Why this should happen in symbiotics is the key to understanding the importance of the process: the degenerate is accreting in the wind of tits companion giant *so there's a very long pathlength for interaction within the neutral circumstellar medium for the emission lines formed in the ionized region immediately around the WD*. It's just a conversion process. We've discussed similar conditions for couplings between ground state and excited transitions *fluorescence* and *line pumping* when dealing with the optically thick stage of nova ejecta at the start of the fireball (and later). Some of those you know well now are the [O III] nebular lines, the Bowen N III lines (4636 Å) and other cases of pumping. Here the process is a probe of the two regions. It requires the high ionization states (the O VI forms in a very strong FUV radiation environment) and a sufficient optical depth that the bulk of the hydrogen remains neutral (an



Schematic ernergy diagram (Y scale in eV) for Raman scattering of OVI 1032 photon by neutral hydrogen

[1] http://www.nobelprize.org/nobel_prizes/physics/laureates/1930/raman-bio.html
[2] http://adsabs.harvard.edu/abs/1989A\%26A...211L..27N

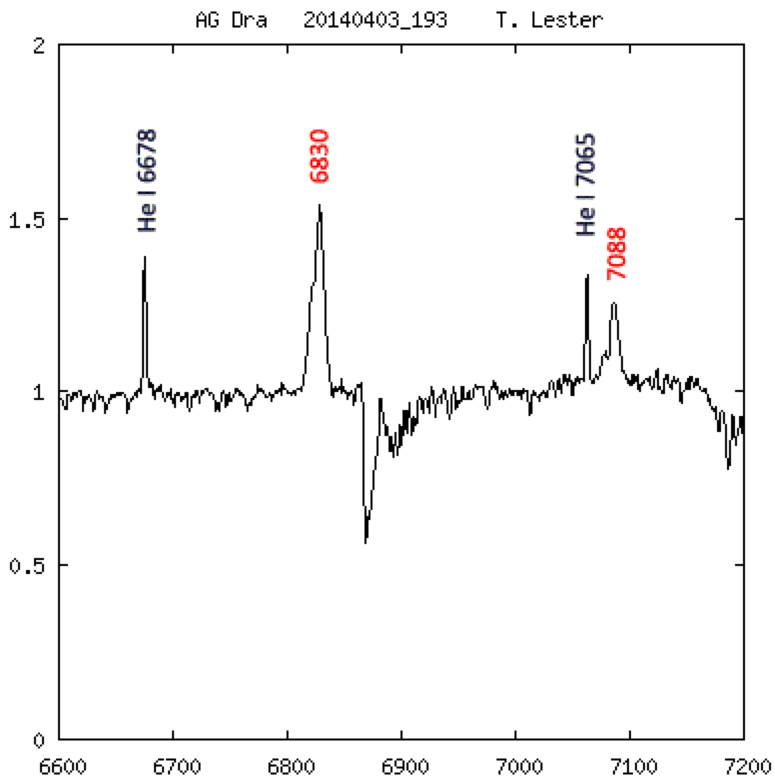
Raman scattering

Steve Shore

ionization bounded H II region). There are a number of possible additional lines that can form, but regarding the O VI this is a *doublet* and *both* lines must be present (see also http://adsabs.harvard.edu/abs/1998RvMA...11..297S).

In nova ejecta, there's another interesting possibility, one that's been sort of staring us in the face. The Raman lines were detected in RS Oph, not a surprise since this is a symbiotic-like system. The pair was *not* seen in V407 Cyg, and I don't know the final result for V745 Sco (the problem is the star was so faint that there isn't enough to go on in the otherwise water-dominated part of the spectrum). But in classical ejecta, the inner region may be ionized while the outer portions are neutral once the ionization starts to increase before the lifting of the veil toward the WD (and the SSS it harbors) and the inner ejecta may reach the O^{+5} ionization state. If, and it's a big ***if***, the outer ejecta are still sufficiently optically thick, there could be an internal Raman conversion. But this is not the same as in a symbiotic: this medium is not nearly static around the H II region of the WD. It doesn't matter if the WD has a wind or not, in fact the O VI lines are likely formed in an outflow. The medium has to be nearly stationary (and that only requires spherical symmetry, somewhere there will be an interaction). Nova ejecta have a very large internal velocity gradient so the H I lines are shifted with respect to their rest wavelength as seen by the inner ejecta. They're redshifted. This means the O VI lines are actually at a different frequency difference (energy difference) from the neutral medium and there should be a shift in the wavelength of any Raman scattered line. As an example, if the velocity difference is 2000 $km.s^{-1}$, at 1025 Å this amounts to a shift of almost 7 Å toward the O VI. Instead of $\Delta\lambda$ approx 13 Å, this is closer to 6 Å so the resulting line should be in the IR and unobservable. There might be other lines, instead, that could appear depending on the nearness of the Lyman series of neutral hydrogen. It's also possible that He I resonance lines could produce some effect, this has been suggested for symbiotics, but it's not likely to be important for novae.

The variation of the Raman lines in symbiotics is, on the other hand, the *unique* view we now have into the FUV and the immediate environment of the WD. The variation of this line has been studied by a number of groups, I'm including a reference list link from a paper we did on AG Dra as a guide http://adsabs.harvard.edu/abs/2012BaltA..21..139S but it's just a window into this (see also the special issue Baltic Astronomy, Vol. 21, p. 1ff from a meeting a few years ago at Asiago on symbiotics and related systems, edited by Siviero and Munari.



The two Raman OVI 6830,7088 in AG Dra Spectrum

About Raman scattering in symbiotics, see also :

http://www.astronomie-amateur.fr/feuilles/Spectroscopie/Methodes_Spectro/Raman_OVI_6830_7088.html

Recent publications

Novae

Life after eruption - IV. Spectroscopy of 13 old novae
C. Tappert, N. Vogt, M. Della Valle, L. Schmidtobreick, A. Ederoclite
http://arxiv.org/pdf/1405.3635.pdf

Recurrent and symbiotic novae in the OGLE data
P. Mroz, R. Poleski, A. Udalski, I. Soszynski, M.K. Szymanski, M. Kubiak, G. Pietrzynski, L. Wyrzykowski, K. Ulaczyk, S. Kozlowski, P. Pietrukowicz, J. Skowron
http://arxiv.org/pdf/1405.2007.pdf

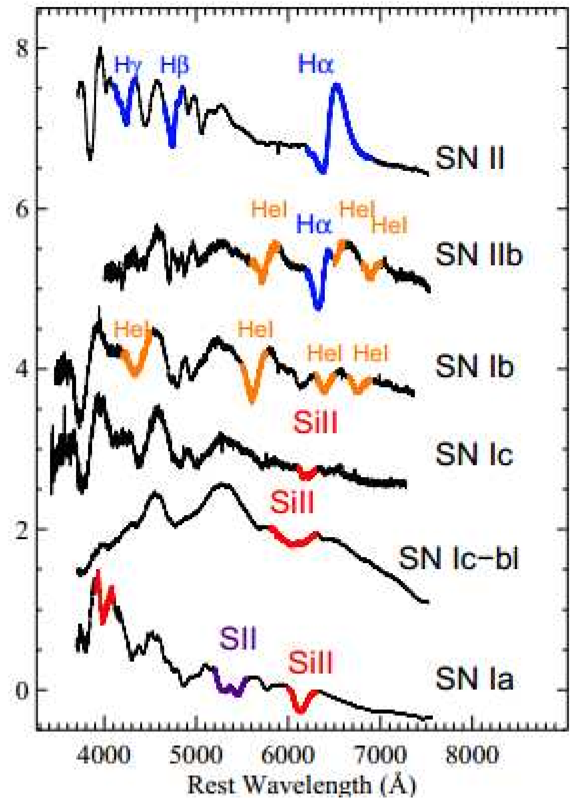
Identifying and Quantifying Recurrent Novae Masquerading as Classical Novae
Ashley Pagnotta, Bradley E. Schaefer
http://arxiv.org/pdf/1405.0246.pdf

Symbiotics

Raman Scattered Ne VII λ973 at 4881 Å in the Symbiotic Star V1016 Cygni
Hee-Won Lee, Jeong-Eun Heo, Byeong-Cheol Lee
http://arxiv.org/pdf/1405.3408.pdf

Supernovae

Optical Spectra of 73 Stripped-Envelope Core-Collapse Supernovae
Maryam Modjaz & al.
http://arxiv.org/pdf/1405.1910.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!

Contribution to ARAS data base
From 01-05 to 31-05-2014

T. Bohlsen
C. Buil
A. Garcia
J. Guarro
R Leadbeater
T. Lester
J. Montier
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