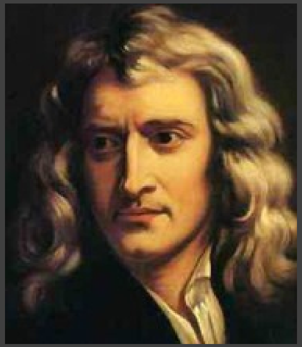
Novae

GK Per (Nova Per 1901) – Crédit : Adam Block/NOAO/AURA/NSF

F. Teyssier January 2021



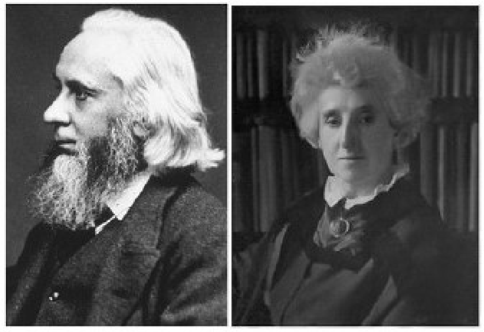
Newton (1726)

Une intuition géniale

Les étoiles fixes, qui se sont graduellement appauvries en éjectant de la lumière et des vapeurs durant très longtemps peuvent être régénérées par des comètes qui tombent sur elles ; et par cet apport de nouveau carburant ces vieilles étoiles, acquérant une nouvelle splendeur, peuvent passer pour de nouvelles étoiles.

William & Margaret Huggins (1866)

First spectra of a Nova



Lundmark (1920)

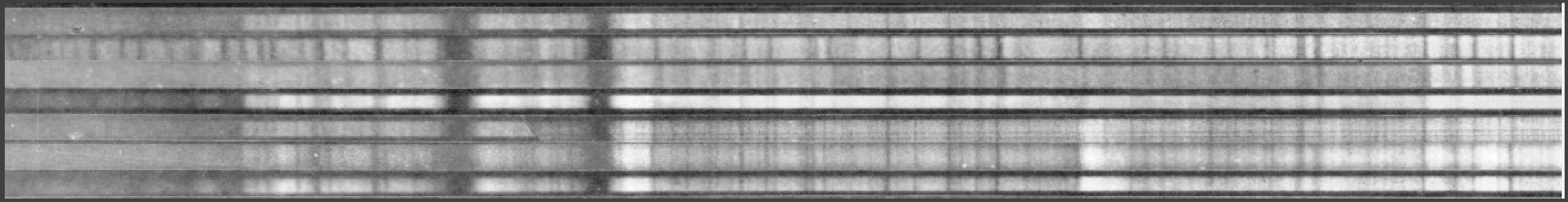
The « *Great debate* »

Classification of the 'new stars'' en 3 categories :

Supernovae – Classical Novae – Dwarf Novae

Mc Laughlin
Systematic study of the bright novae in the first part of the XXth Century

Nova Her 1936
First publication of the spectra secured by several observatories

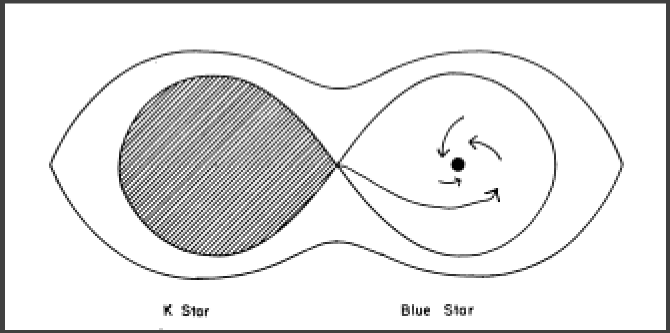


Cécilia Payne-Gasposhkin (1957)
Galactic Novae
First book about Novae

Walker,1954
DQ Her (Nova Her 1934) is an eclipsing binary star

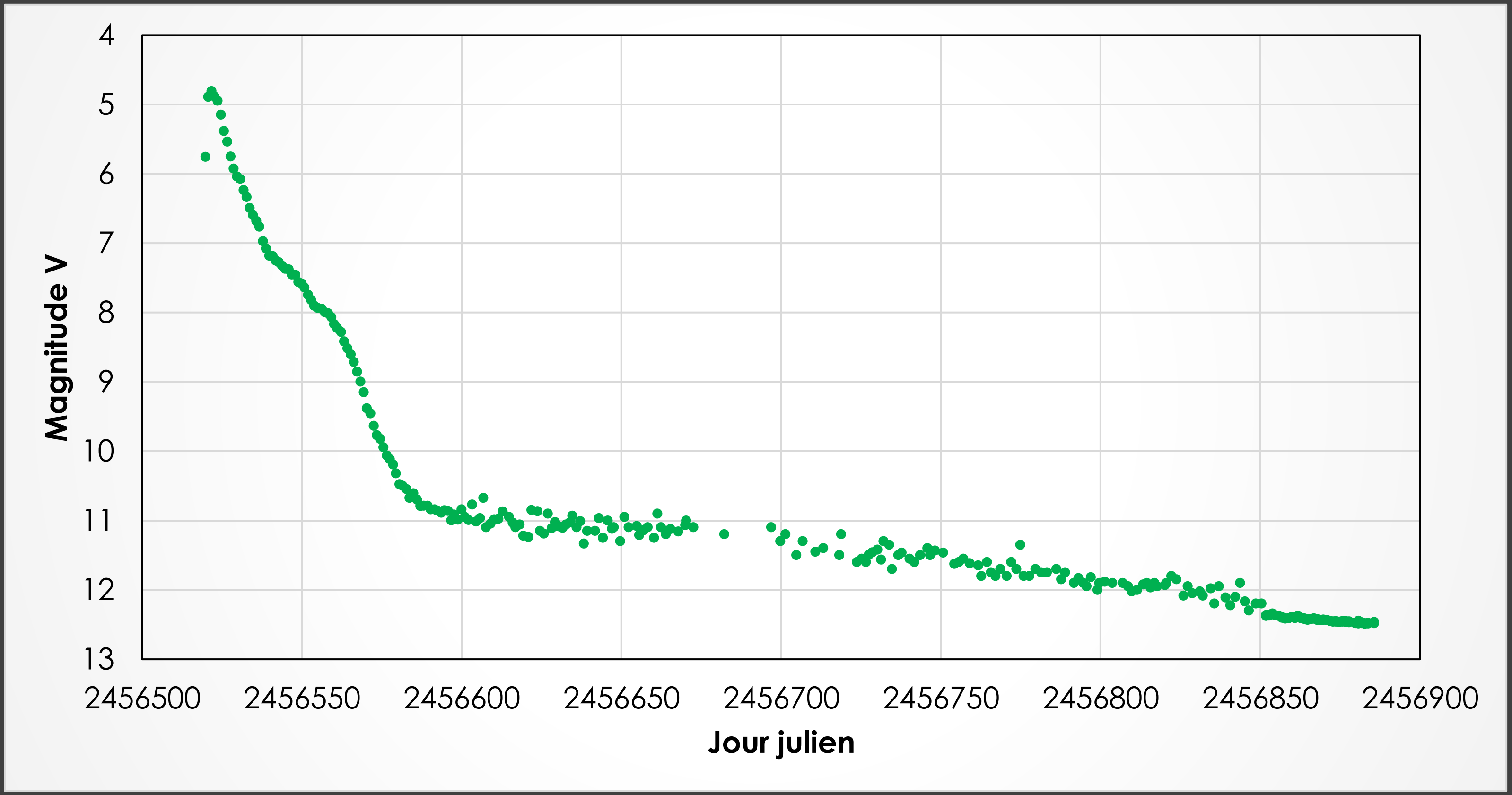
Kraft,1962
Hypothesis :

- All cataclysmic stars are binaries
- The novæ are produced by a nuclear explosion at the surface of a white dwarf



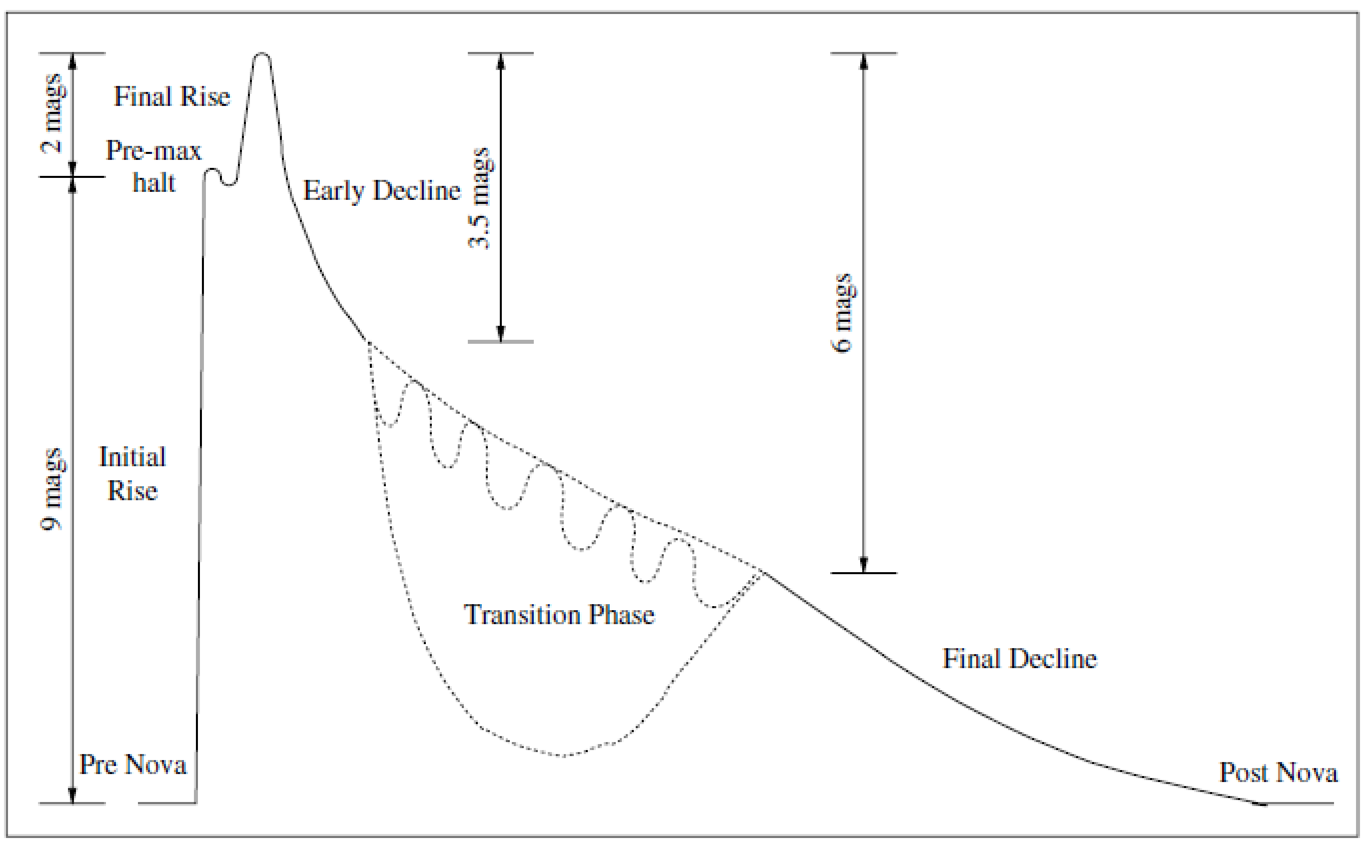
Model AE Aur
Crawford & Kraft, 1956

Luminosity curve (V) of a classical nova : Nova Del 2013

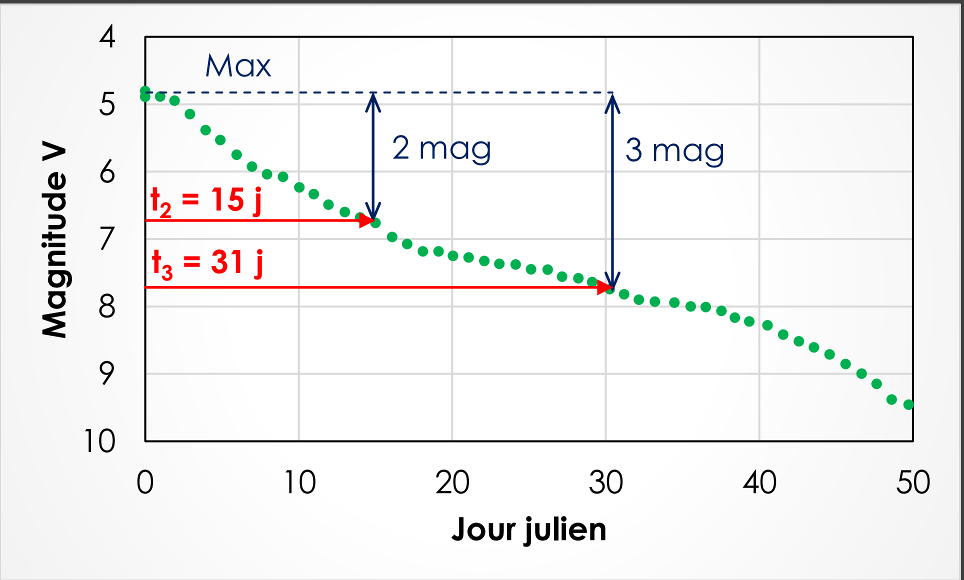


AAVSO DataBase

Classical luminosity curve



Classical Novae, first edition (Bode & Evans, 1989)
From Mc Laughlin



Speed classes

	T_2 (days)	T_3 (days)
Very Fast	< 10	< 20
Fast	11-25	21-49
Sparingly Fast	26-80	50-140
Slow	81-150	141-264
Very Slow	151-250	265-440

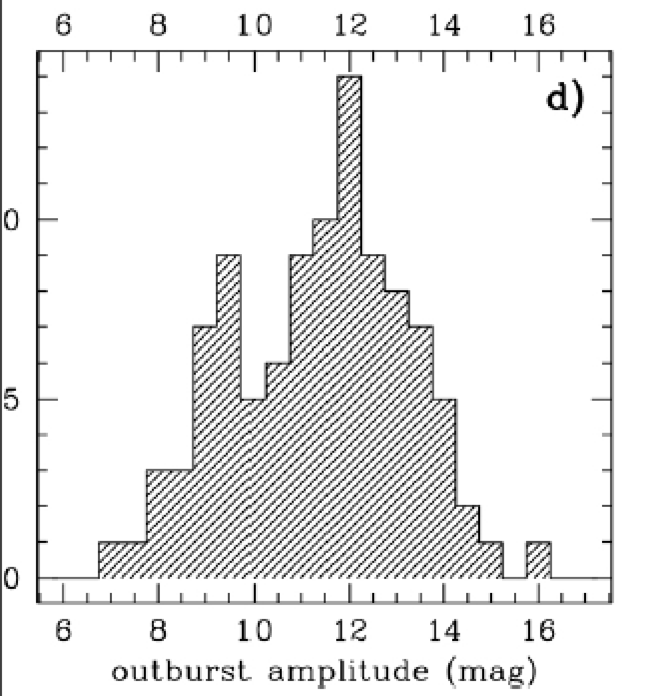
Payne-Gaposcschkin, 1959

Empirical relation t_2, t_3

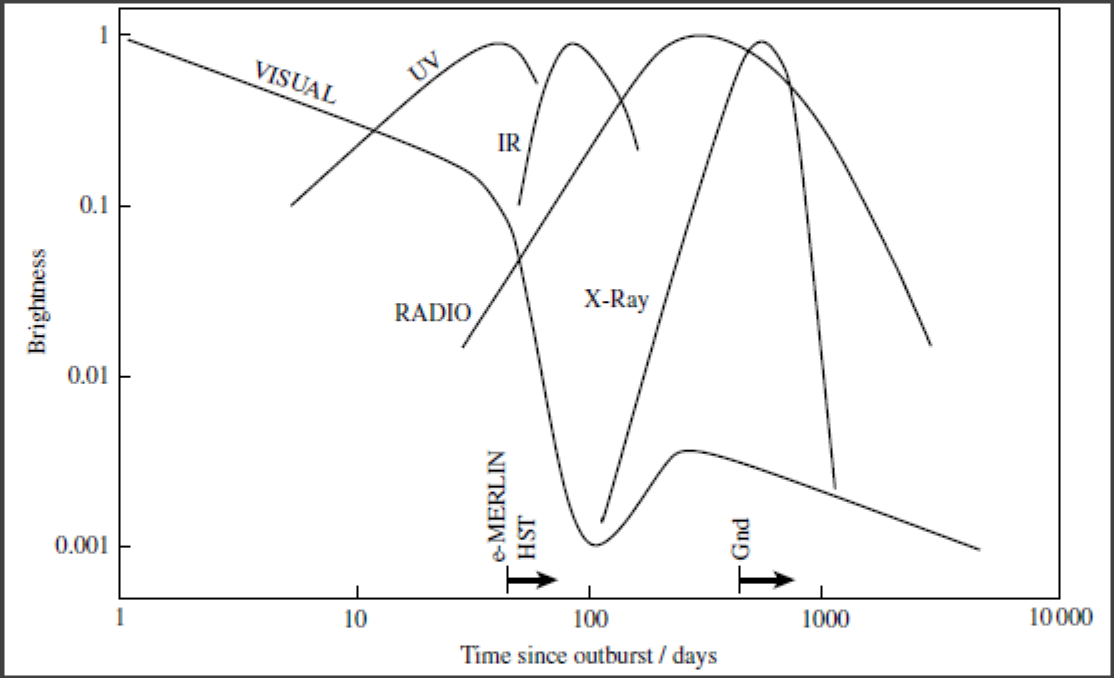
$t_3 = t_2^{0.88}$

Warner, 1995

Range of the Outburst



Bolometric luminosity: ~ constant



Energy released ~ 10^{46} erg (in 1 year)

~ 100 000 years of Solar activity

1erg (cgs) = $1 g.cm^{-2}.s^{-2} = 10^{-7}$ J

Abundances

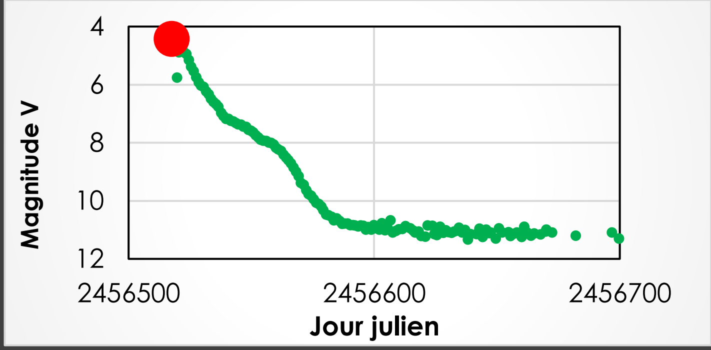
	H	He	Z	C	N	O
PW Vul	0.62	0.25	0.14	0.018	0.07	0.04
QU Vul	0.36	0.19	0.14	0.07	0.19	0.038
DQ Her	0.31	0.31	0.38	0.056	0.13	0.20
Soleil	0.71	0.27	0.027	0.0031	0.001	0.01

$X_{(H)} + Y_{(He)} + Z = 1$

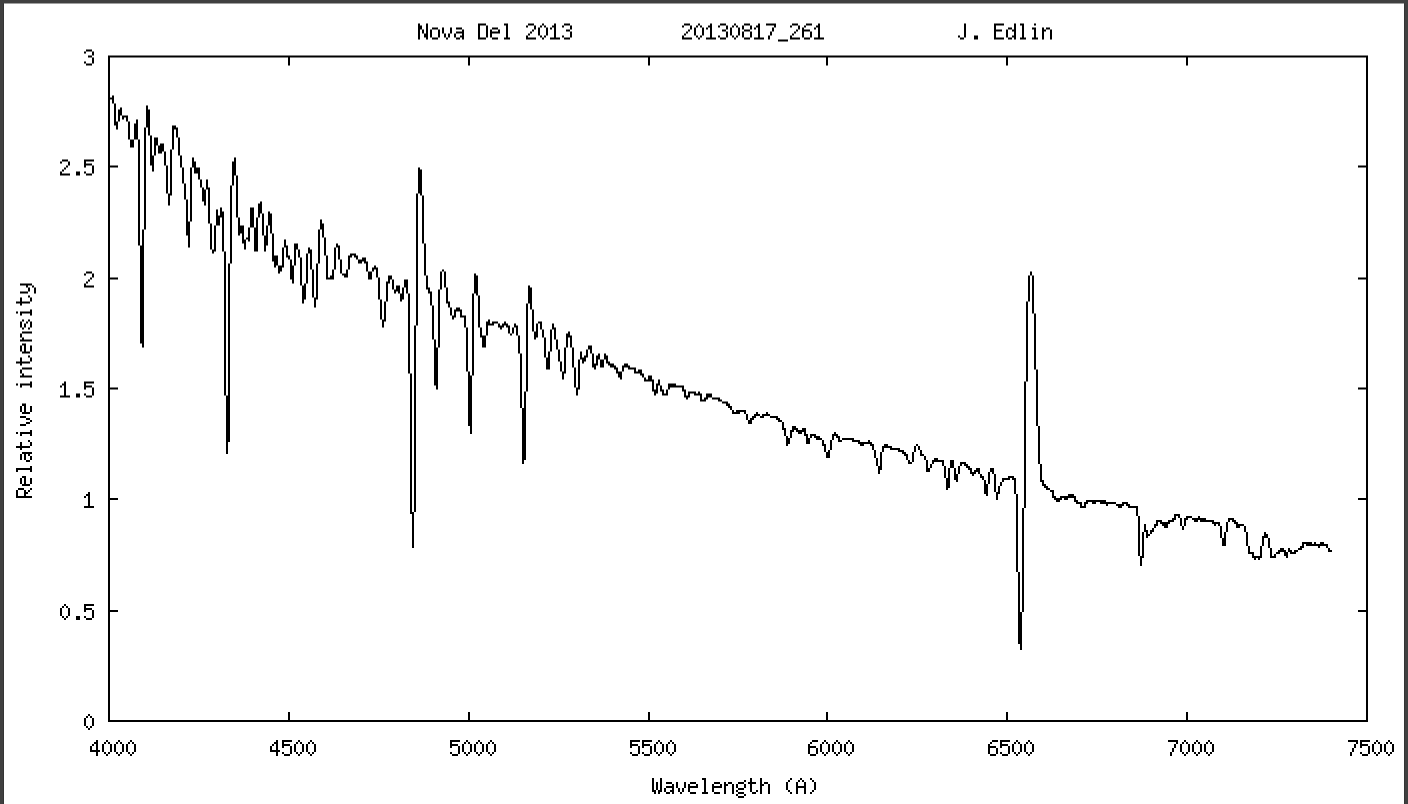
Enhanced abundance of « metals) (Z)
In comparison to Solar Matter
Enrichment of CNO

Mass of the ejecta : $2.10^{-4}\ M_{\odot}$ ($0{,}1$ à 3.10^{-5})

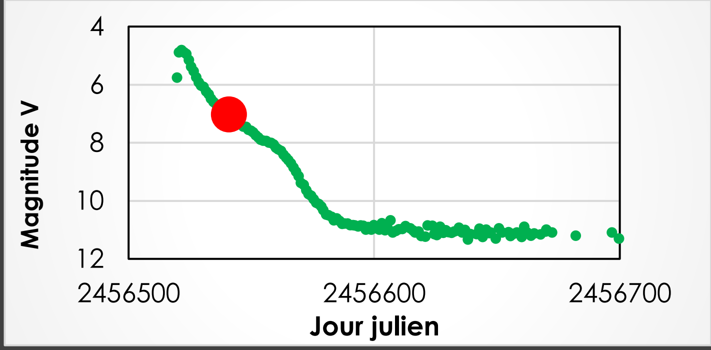
Evolution
➊ Maximum



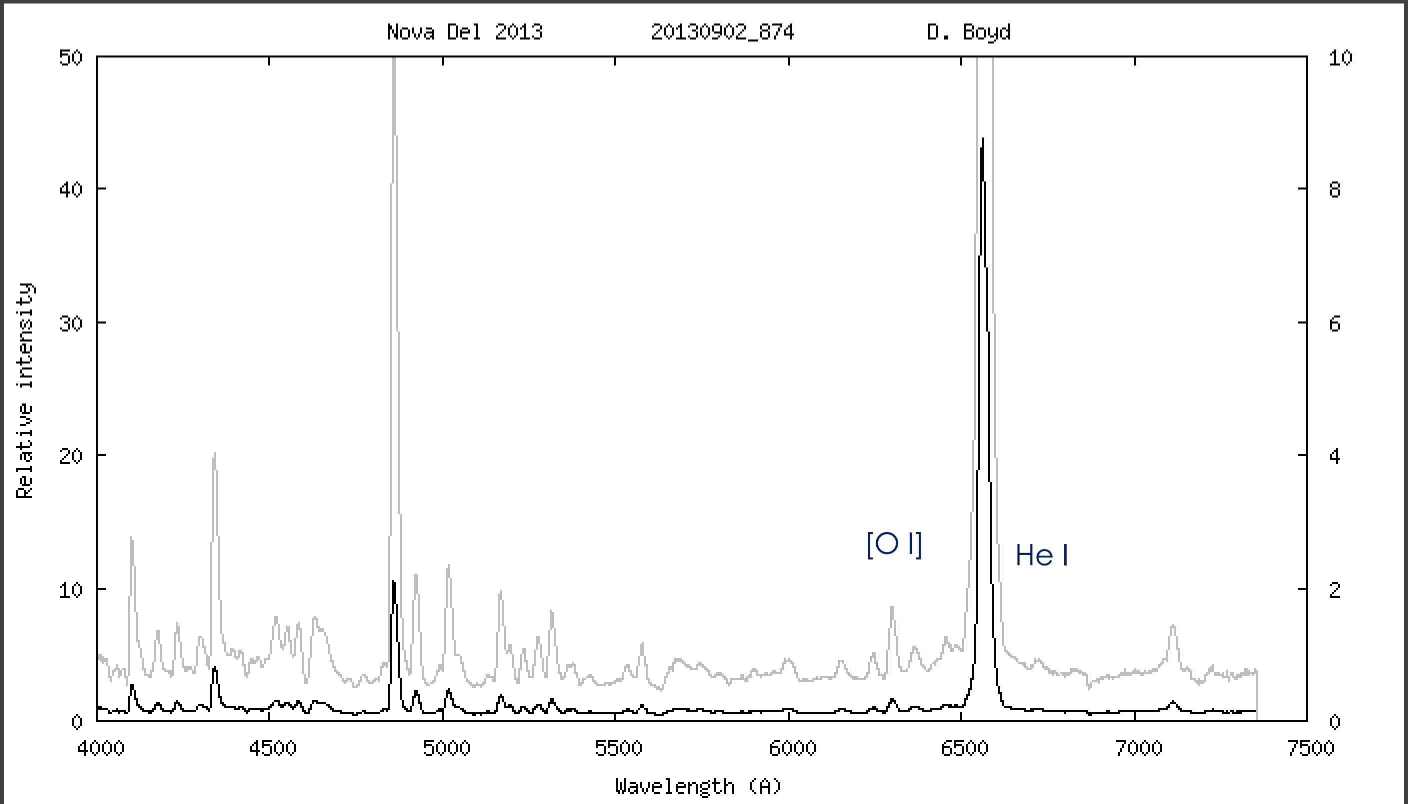
Blue continuum
Metallic lines in absorption
Faint emission (Balmer lines, Fe II (42)
P Cygni profiles



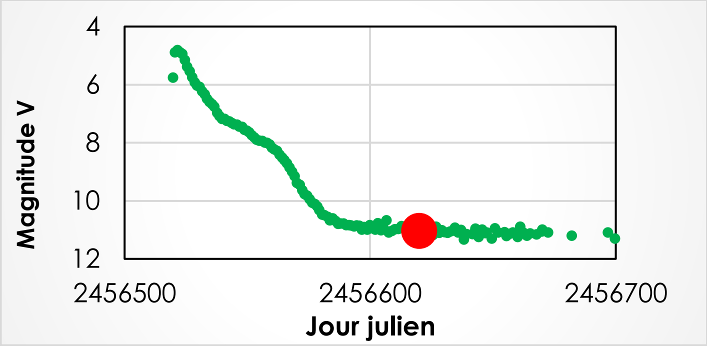
Evolution
❷ Transition



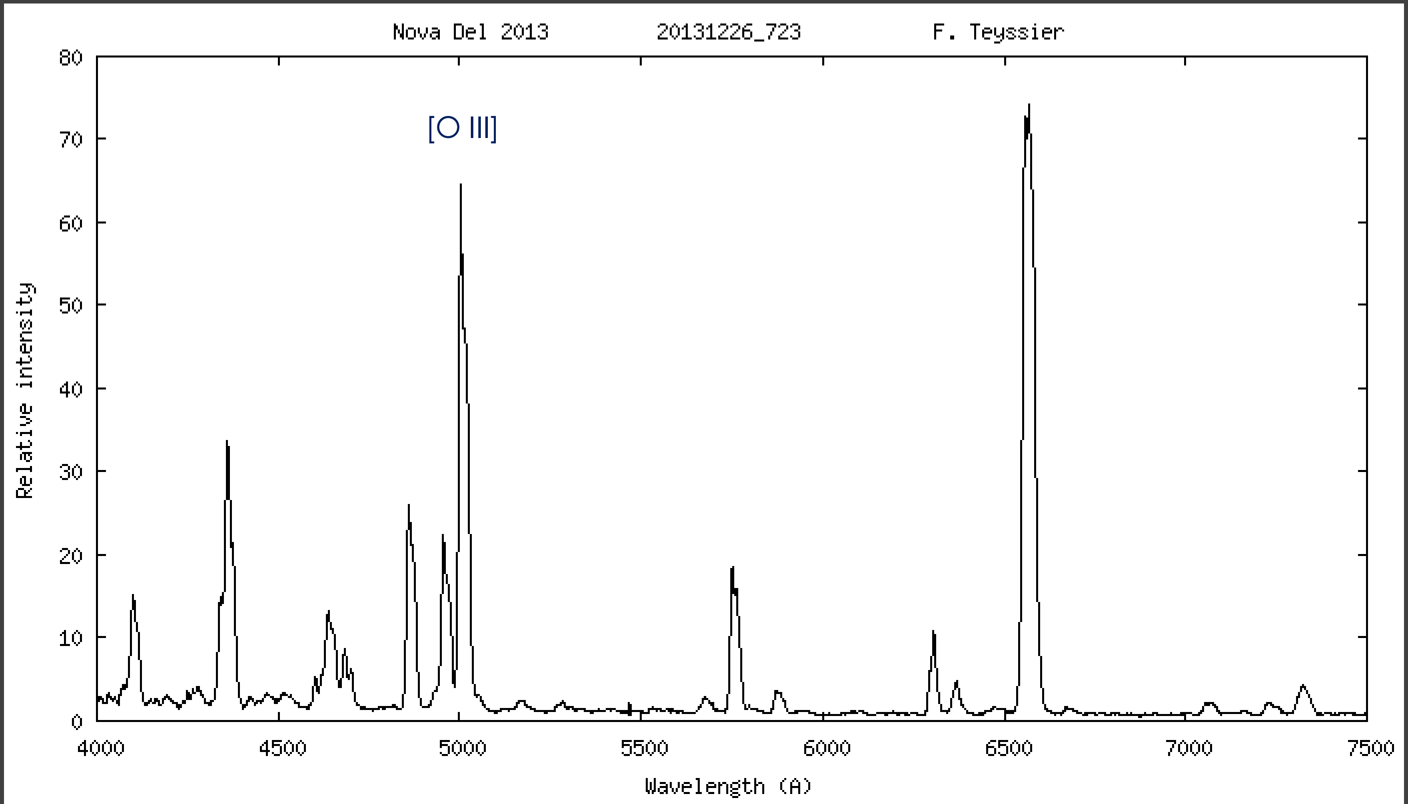
Fading of thecontinuum
Increasing of the emissions/Fading of the absorptions
Emergence of Nitrogen, Oxygen, Helium …
Apparition of « forbidden» lines: [OI], [NII], …



Evolution
❸ Nebular phase

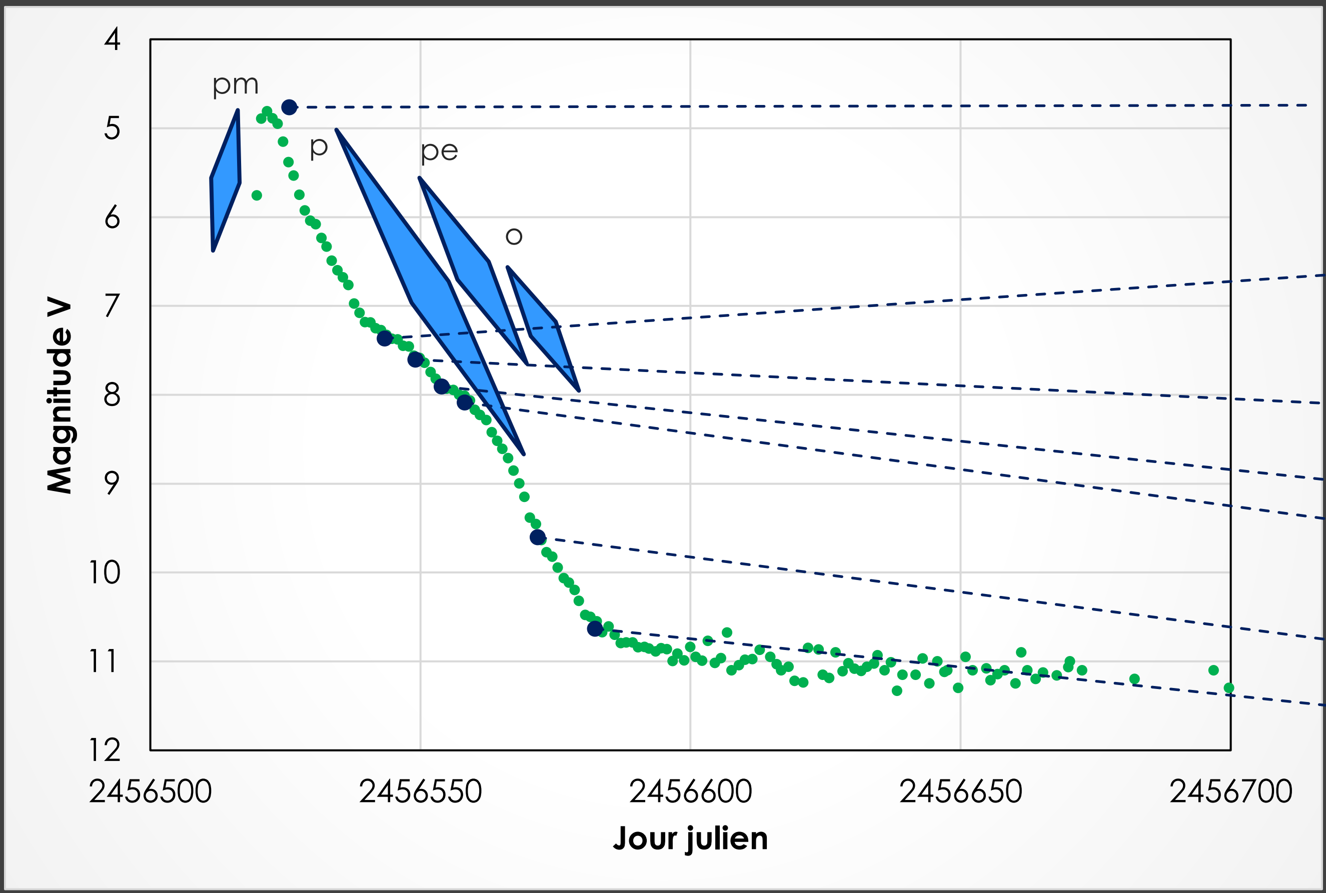


Very faint continuum
« Forbidden » lines very intense



Development of the spectrum

McLaughlin, 1942, 1943

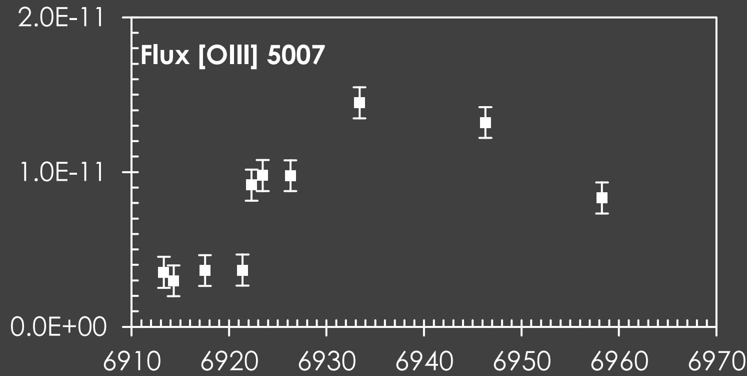


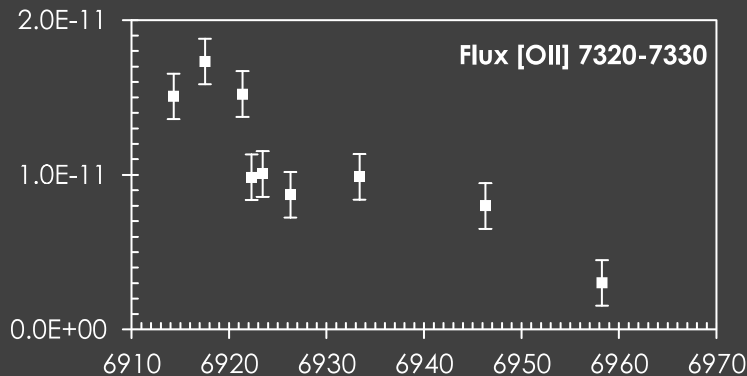
Delta mag/maximum

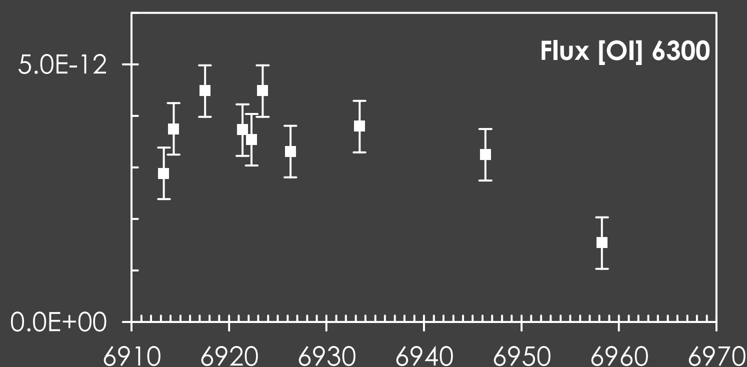
Premaximum absorption	1.5
Maximum light	0
Principal absorption	0.6
Diffuse enhance absorption	1.2
Maximum diffuse enhanced	2
Orion absorption	2.1
[OI] flash	2.6
Maximum Orion	2.7
Disparition diffuse enhanced	3
4640 emission	3
[NII] flash	3.3
Disparition Orion	3.3
Helium flash	3.6
[OIII]	3.7
Disparition Principal absorption	4.1
Disparition "4640"	4.7
[OIII]4363 = Hg	4.9
[OIII]5007= Hb	5.4
[OIII] 4959 = Hb	5.8
[OIII] 4959/Hb = 1.5	6.4
[OIII] 4959/Hb = 2.0	6.7
[OIII] 4959/Hb = 5.0	8.5
[OIII] max	9.5

Development of the spectrum

An example of flux measures



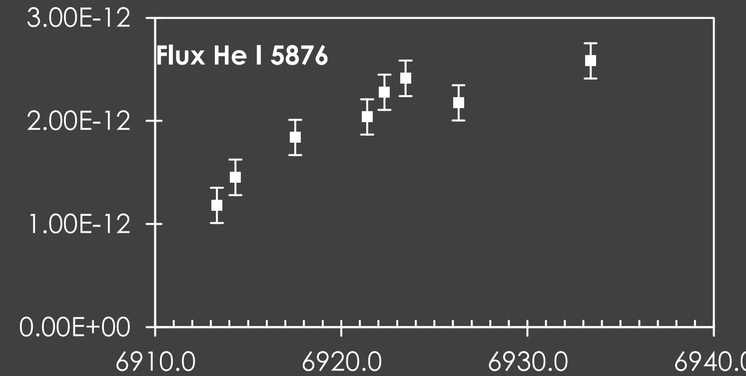


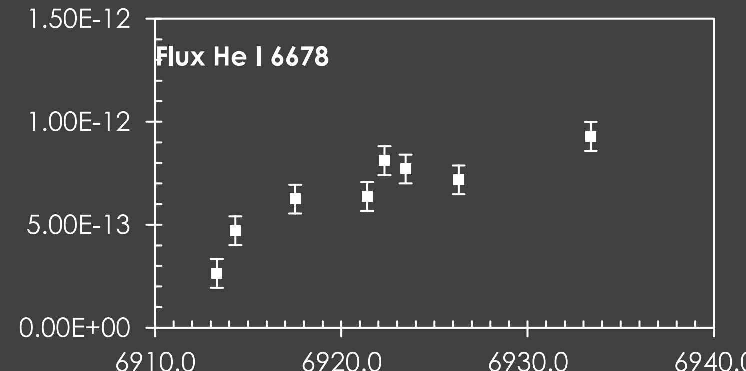


Nova Cyg 2014

JD – 2450000

Flux en erg.cm^{-2}.s^{-1}





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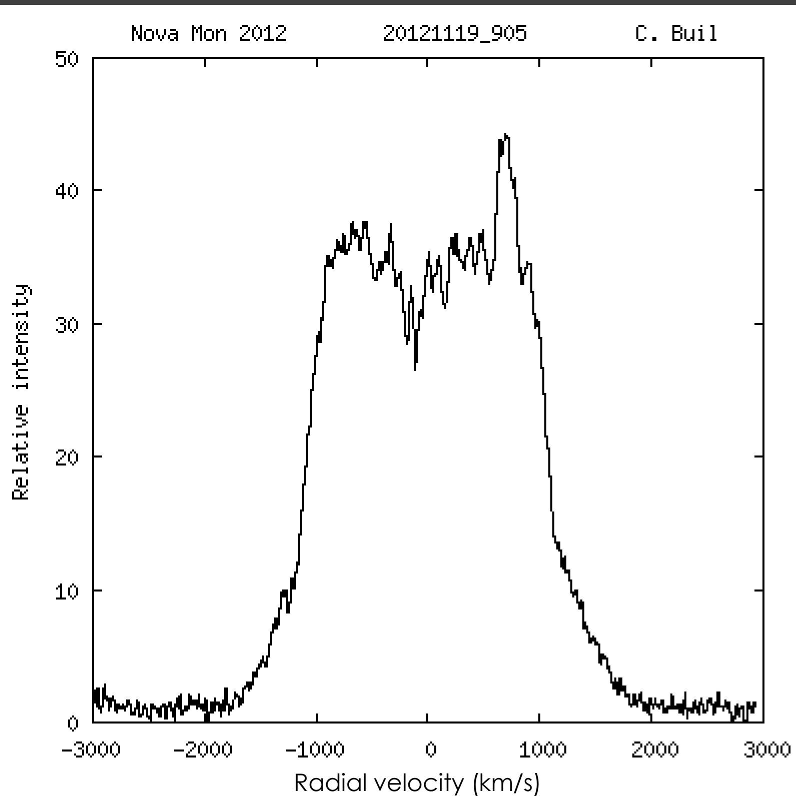
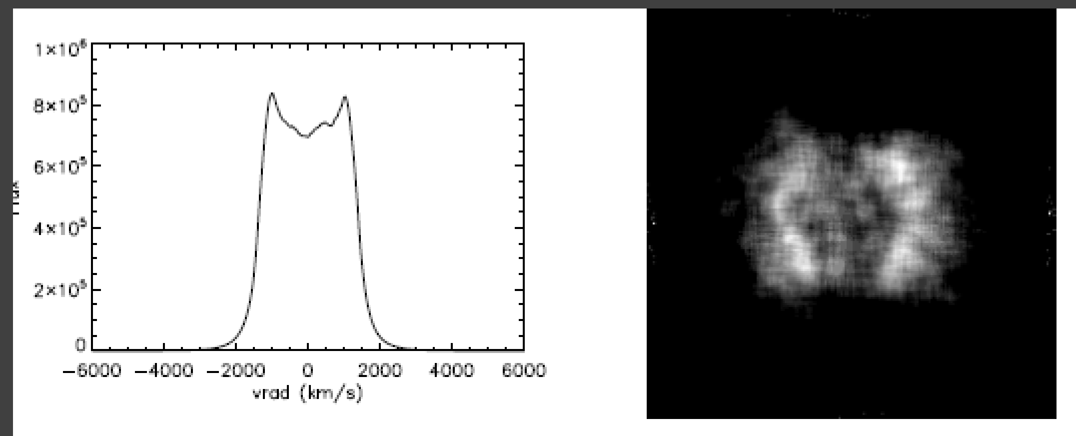
Profiles of the lines → Shape of the ejecta

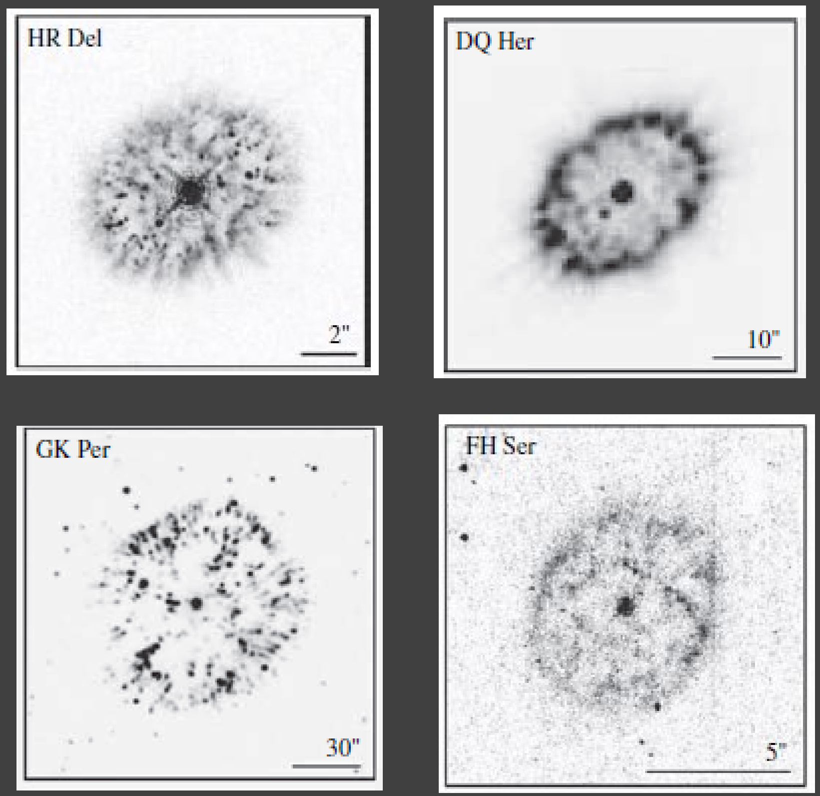


Monte Carlo



Shore & al., 2012

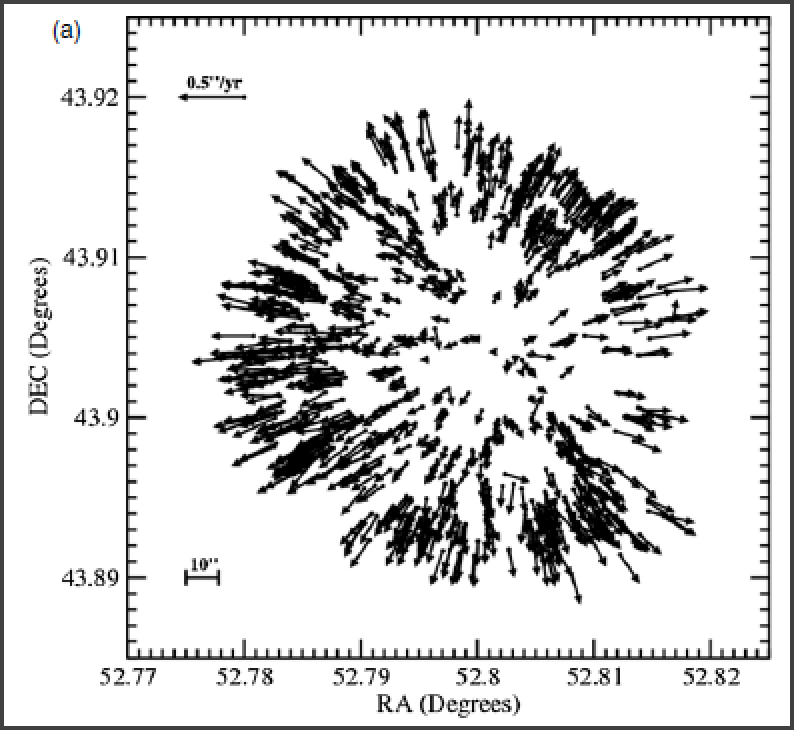
Remnants



O' Bien & Bode in Classical novae, 2008

Sperical,
often low excentricity :1 à 1.2 (1.4)
Clumpy
Sometimes rings, lobes

GK Per

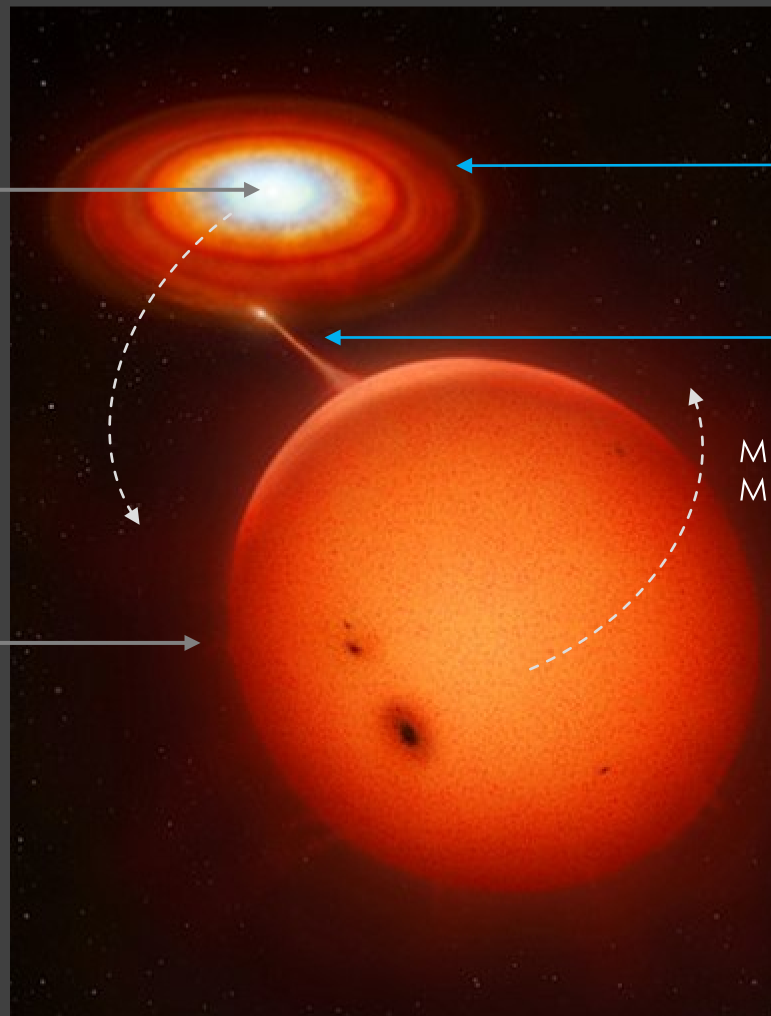


Shara & al., 2002 HST

~1 $R_\odot$

White Dwarf (WD)

Accretion disk
… but polars
(H, He)



Transfert de matière
(« solar composition »)
(H, He)

$M' = 10^{-10}$ à 10^{-11} $M_\odot$/year (Porb < 3.3 h)
$M' = 10^{-9}$ à 10^{-10} $M_\odot$/year (Porb > 3.3 h)

Donnor Star
Main sequence star
Type M-K
(cool, red)

Orbital period
~ A Few Hours

~1 $R_\odot$
~ 1 000 000 km

M' 3/10000 à 3/1000000 Mt

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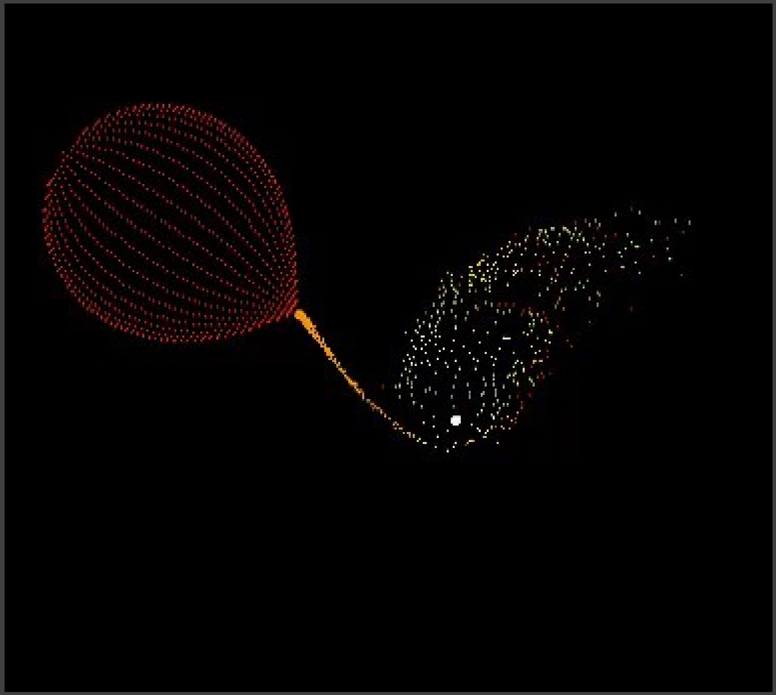
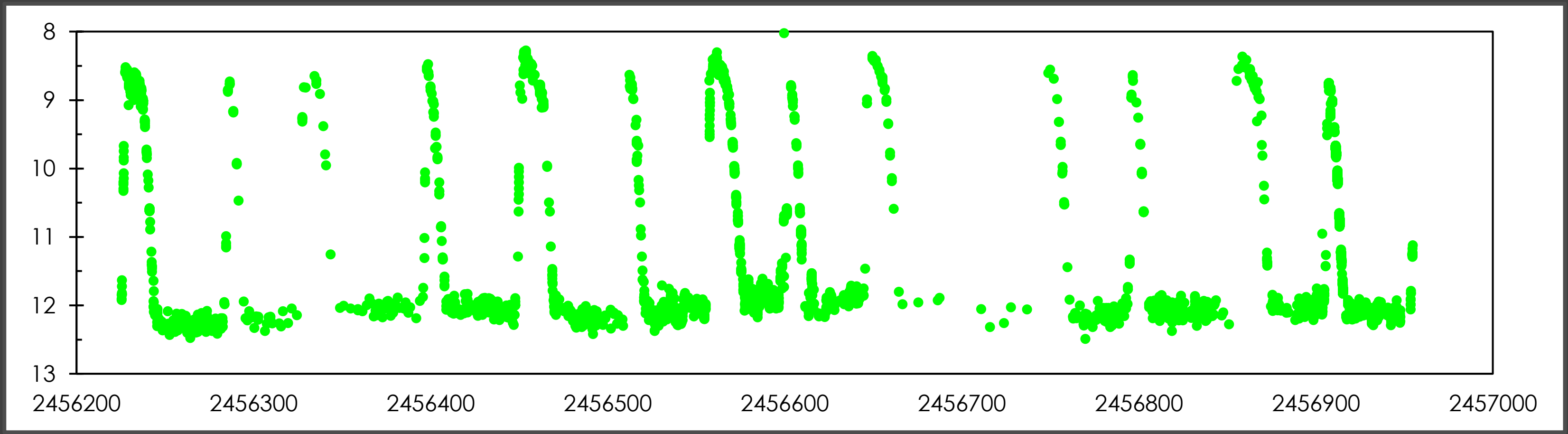


Accumulation of matter in the accretion disk
Increase of the viscosity
Sharp increase of the temperature (5000 → 15000 K)

= Thermal Outburst

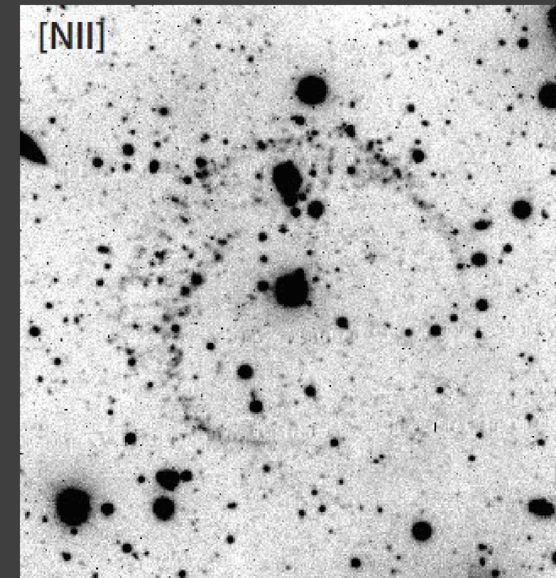
Amplitude : 2 - 8 mag
Frequency : days to years
Fast increase of the luminosity ~ 1 day
Duration : a few days

« Dwarf nova » outbursts



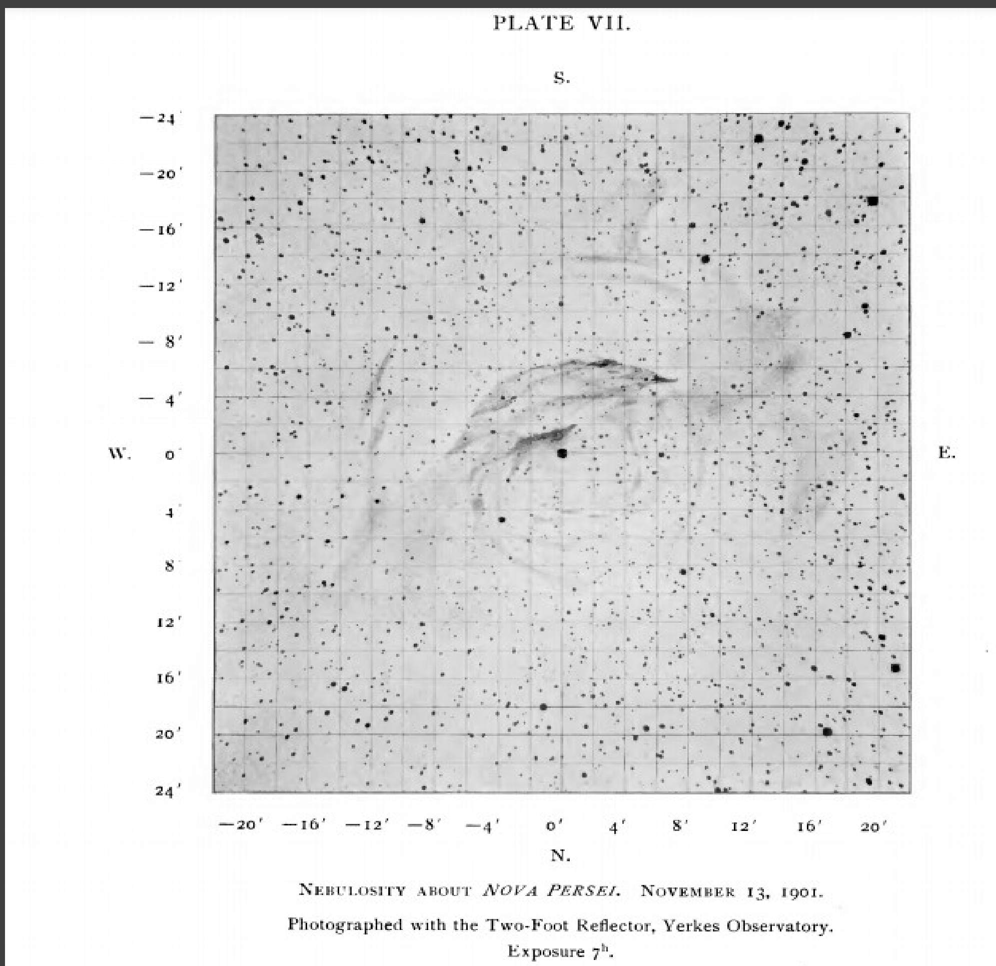
SS Cygni – Luminosity curve (V) – 2 ans - AAVSO

AT Cnc



Shara+, 2012

GK Per Nova Per 1901

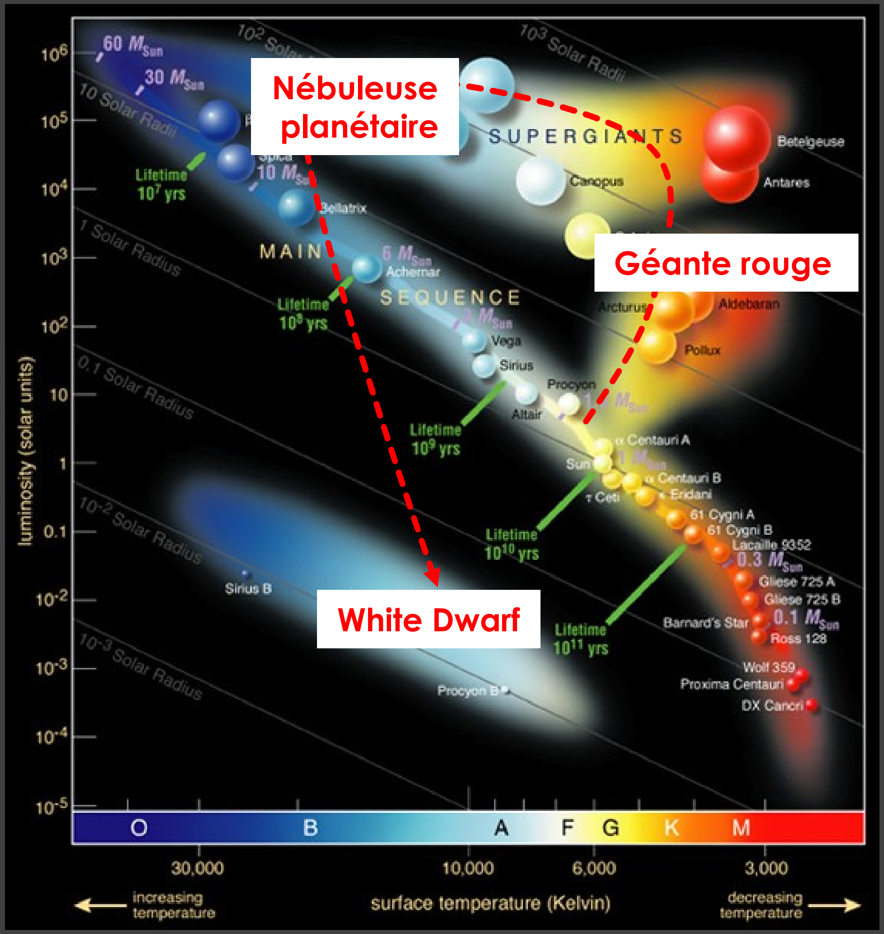


Nebulosities detected around a few catalymic stars

= remnants of « old » nova outbursts

White Dwarf

Terminal phase of the stellar evolution
for Stars < 10 $M_\odot$



End of thermonuclear reactions
Condensate matter « cool »
In the thermodynamic sense: nuclei are « frozen »
Only the move of electrons maintain the structure
Cooling (100 000 K →)

Several « savors » depending
of the masse of the progenitor

Type	Main	Initial mass	Masse finale
CO	**Carbone Oxygène**	**< 9 $M_\odot$**	**< 1.1 $M_\odot$**
ONe	**Oxygène Néon**	**9 $M_\odot$ < M < 11 $M_\odot$**	
He	**Hélium**		**Low**

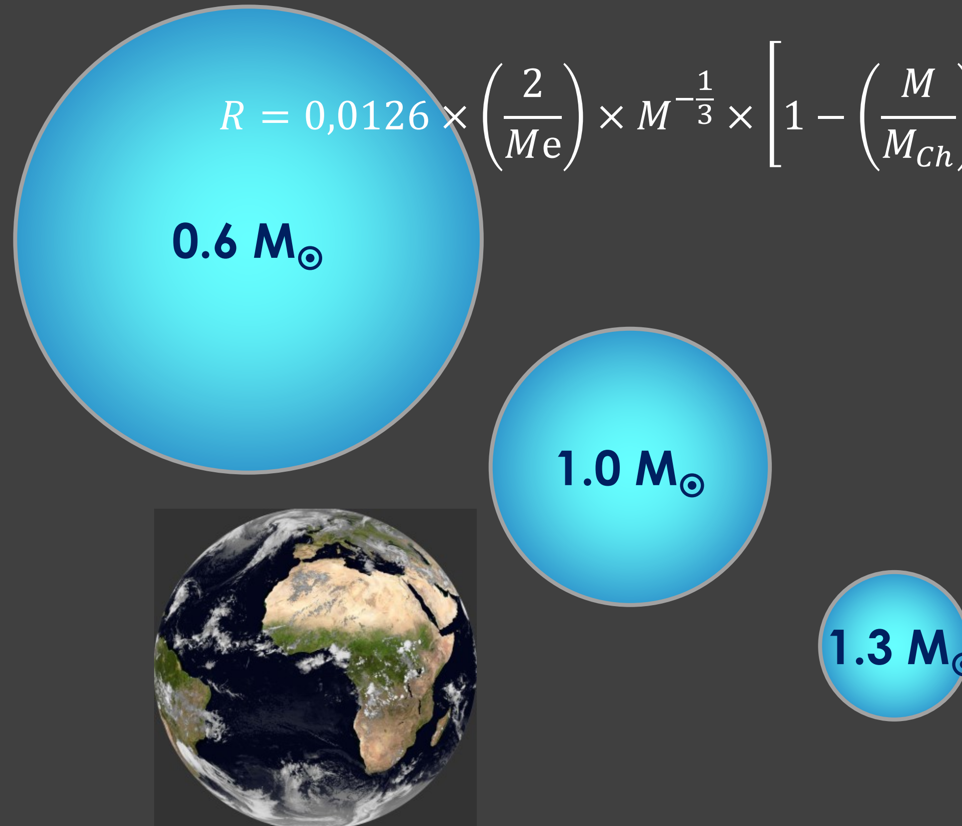
Valeurs approximatives
Voir Doherty & al., 2010

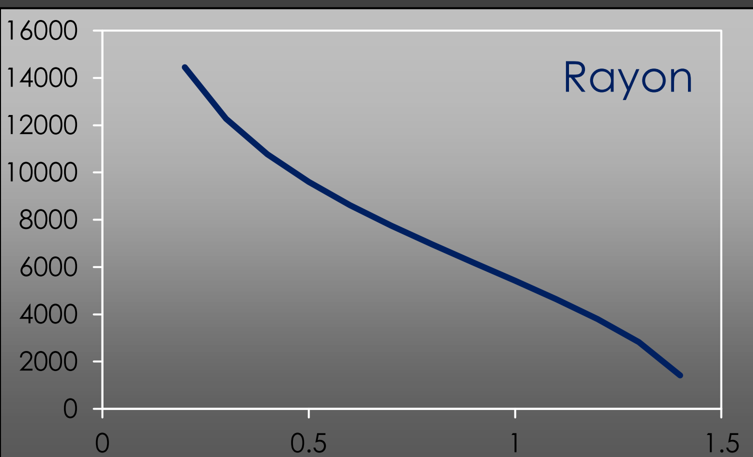
Mean masse= 0,6 $M_\odot$
If M > 1,4 $M_\odot$: supernova Ia
(Chandrasekar's limit)

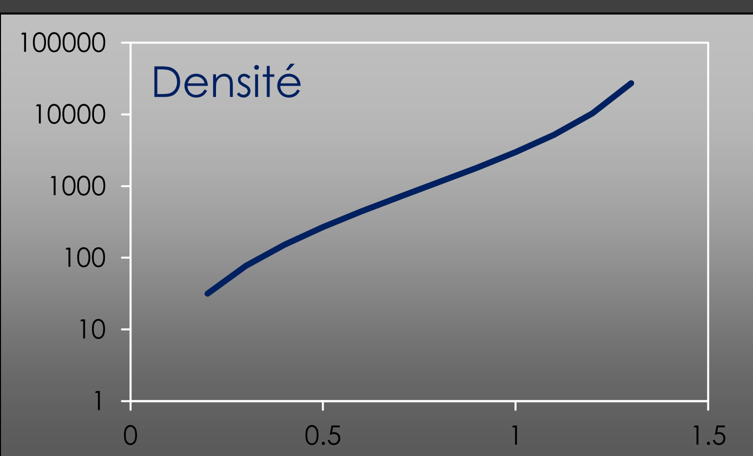
Magnetic field:
Great range from classical to polar (no accretion disk)

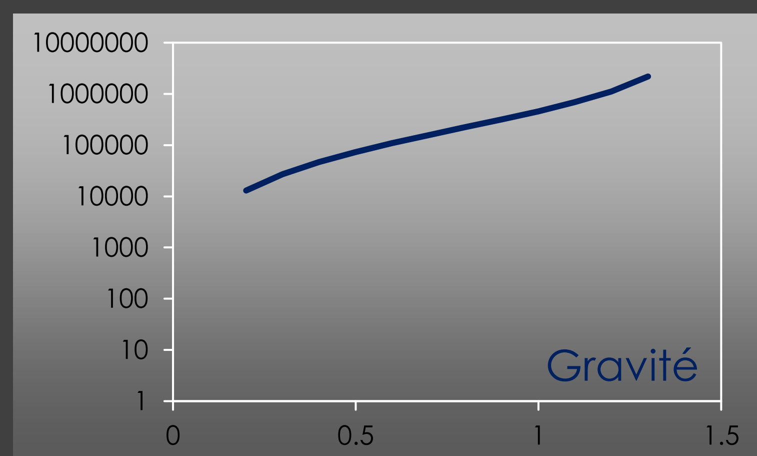
White Dwarf « WD »

$$R = 0{,}0126 \times \left(\frac{2}{Me}\right) \times M^{-\frac{1}{3}} \times \left[1 - \left(\frac{M}{M_{Ch}}\right)^{\frac{4}{3}}\right]^{-\frac{1}{2}}$$









Very large variations of the physical quantities as a function of mass

« Normal » Matter

Perfect gaz law

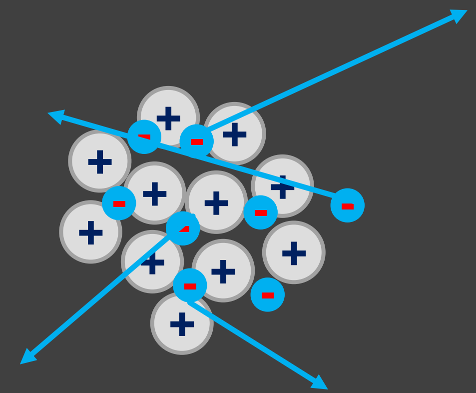
$$P.V = n.R.T$$

$$P \equiv \rho \; . \; T$$

En l'absence de confinement :

Temperature increase
⇨ **Volume increases**

Condensed Matter « degenerated »



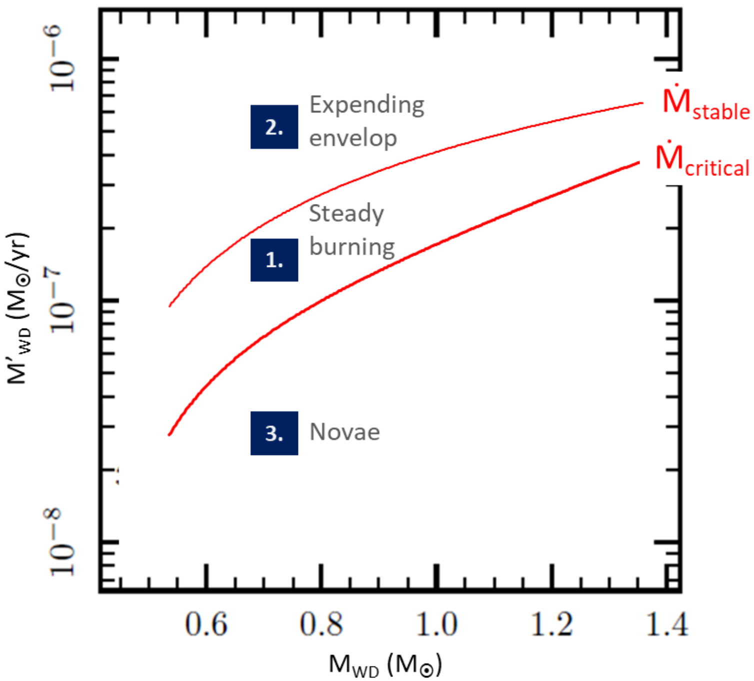
$$P \equiv \rho^{\gamma}$$

Increase of Temperature and Pressure
⇨ **The volume remains constant**

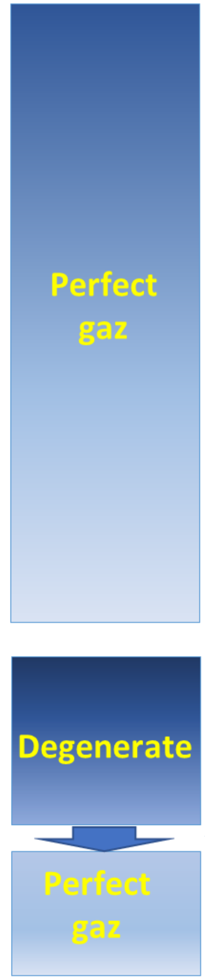
Thermal Energy of the électrons < Energie de Fermi
$3/2\; k\, T < E_F$

Hot Component

Accretion on WD: 3 regimes



Adapted from Wolf & al. (2013)



1. $\dot{M}_{stable} < \dot{M}_{acc} < \dot{M}_{crit}$ **Classical SySt at quiescence**

Steady H burning (p-p fusion)

Hot component releases energy at ~ constant rate
Accretion / Mass loss / Ionization in equilibrium

$T_h > 10^5$ K
L_h ~a few 10^3 $L_\odot$

2. $\dot{M}_{acc} > \dot{M}_{stable}$ **Classical SySt in outburst**

Accretion Increase → Increase of H burning

Expending envelop - Mass loss (Wind)

T_h ↘ as a result of the dilatation of the envelop
L_h ↗ (~ L_{edd}) : increase of the wing from the hot component

3. $\dot{M}_{acc} < \dot{M}_{stable}$ **Classical and SySt novae**

Hydrogen burning (p-p fusion) ~10 to ~1000 years
Thermonuclear runaway (CNO) A few minutes

Until Fermi Temp. (~350.10^6 K)

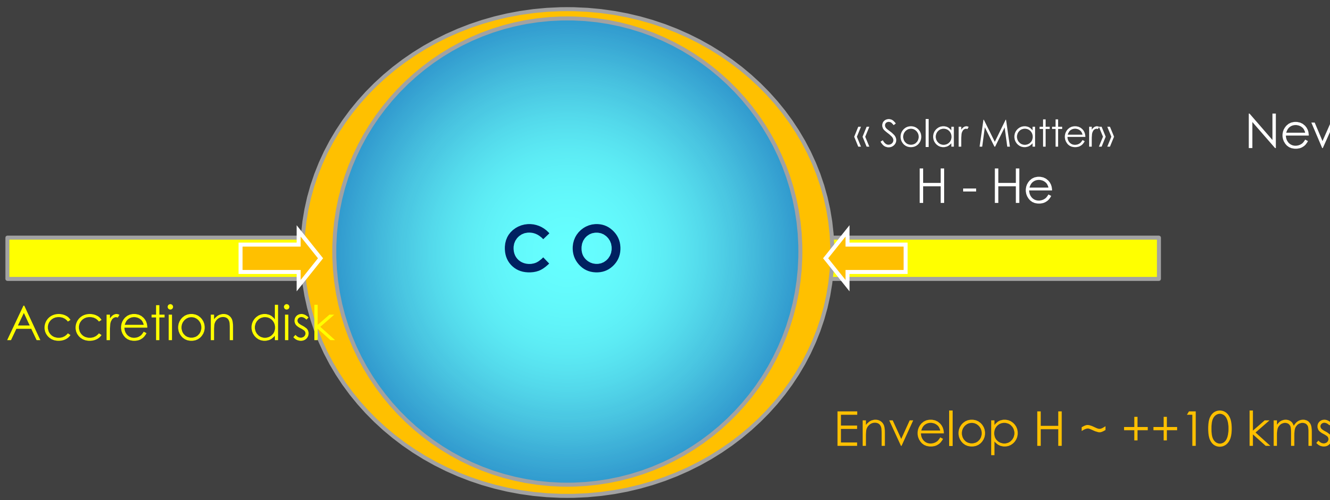
Nova outburst – Ejecta
T_h ↘↘
L_h ↗ ↗ (>> L_{edd})

SyN: AG Peg, PU Vul, V1016 Aql
Classical novae

Accretion

From the donor star via the accetion disk

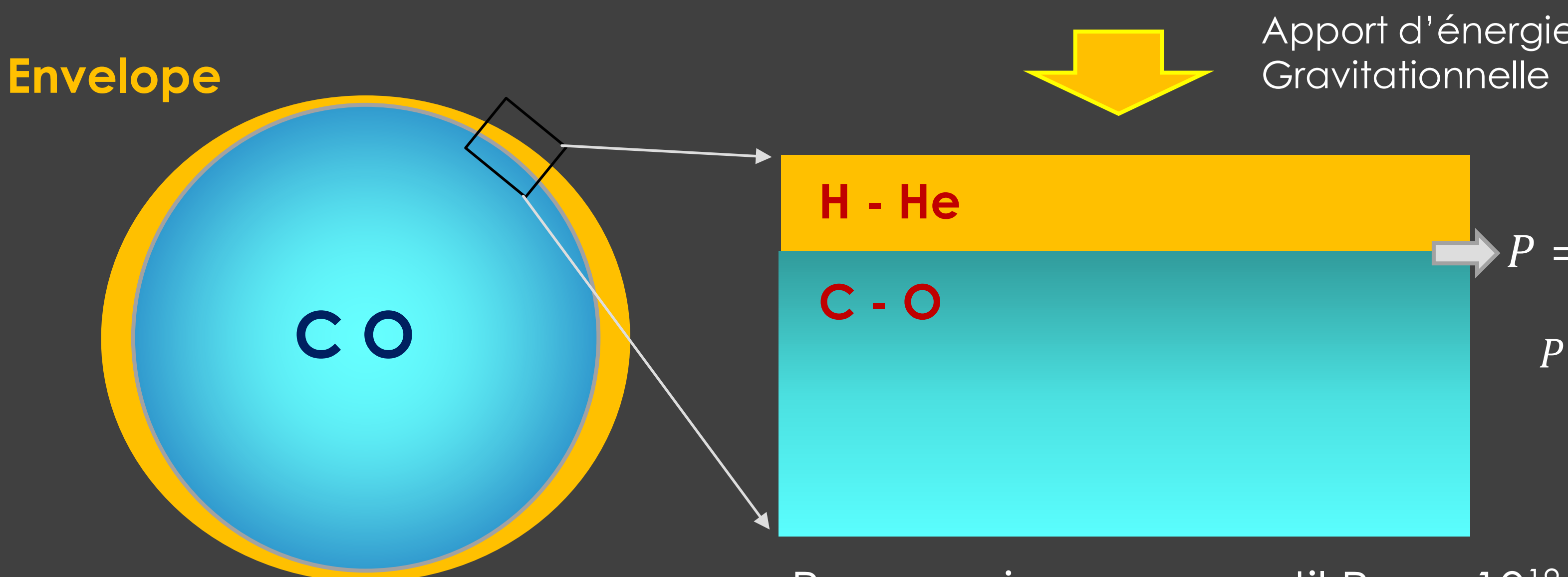
Constitution d'une enveloppe H, He, +++ at the surface of the White Dwarf



Newton's « Fuel »

Accretion at the surface of the WD

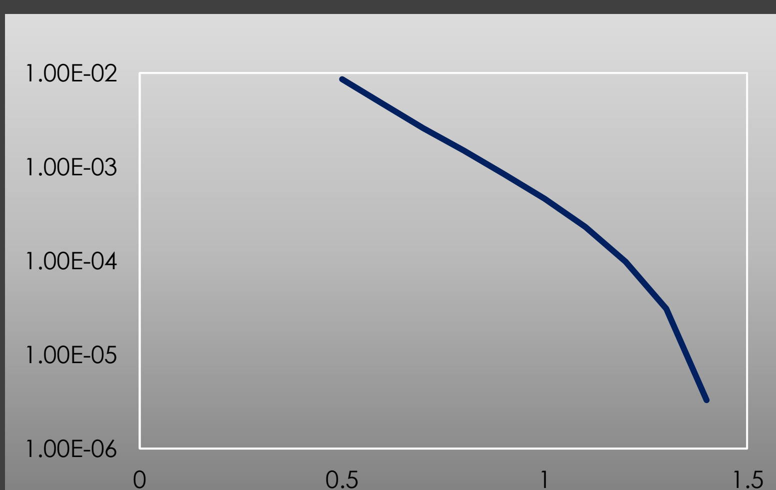
(+++ 1000 années)



$$P = \frac{G.Mwd.Menv}{4.\pi.R_{wd}^4}$$

$$P \equiv M_{wd}.Menv$$

Pressure increases until P_{crit} ~ 10^{19} à10^{20} dyn.cm^{2}



P_{crit} depends:

- **WD mass**
- Composition of the WD & accreted gas
- Accretion rate
- WD Luminosity

Mass of the envelop for Pcrit = 10^{20} dyn.cm^{-2}
As a function of the WD masse (in units of solar mass)

Starrfield, 1989

F. Teyssier January 2021

Model for:

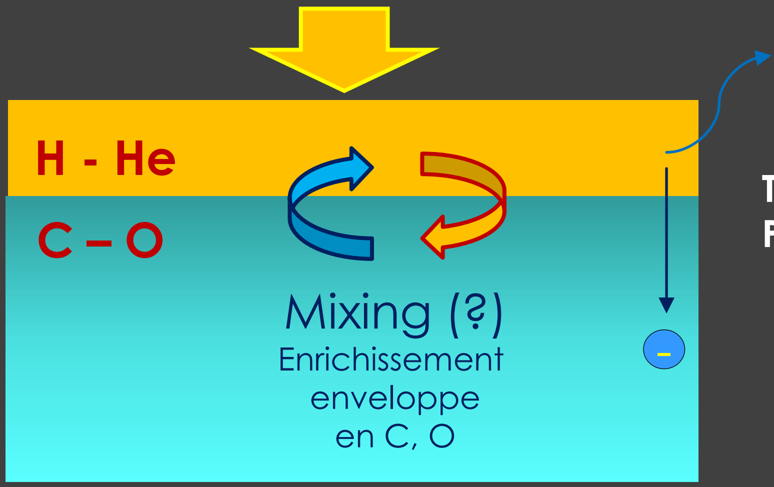
$M_{wd} = 1\ M_\odot$

$M_{env} = 10^{-4}\ M_\odot$

Accretion

(+++ 1000 years)

$M' = 10^{-8}$ à $10^{-9}\ M_\odot/an$



T ~ 1.2 10^7 K (12 000 000 K)

Pcrit = 3.10^{18} dyn.cm^{-2} (3.10^{-12} atm)

Proton – proton chain

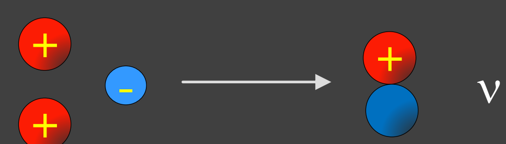
Constant Volume

(degenerated mateer)

Increase of the

- Temperature (slow: radiation, électrons)
- Density
- Pressure

+++ 1000 years)



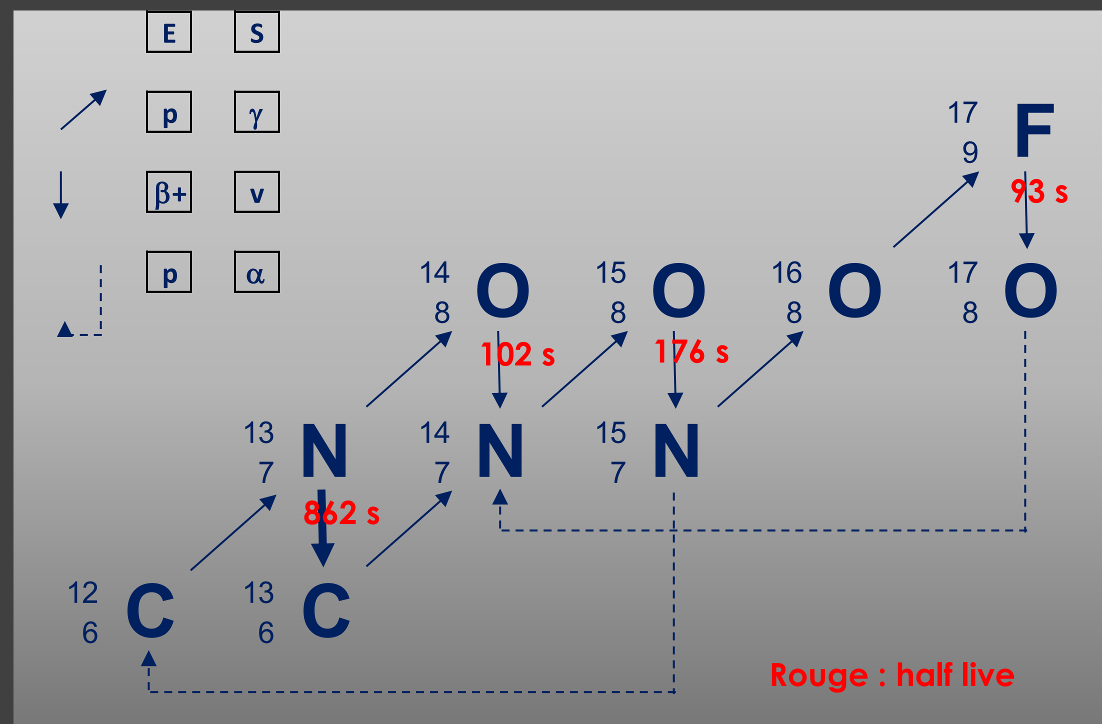
$^1H + {}^1H + e \rightarrow {}^1D + \nu$

T = - 1 month to -600 sec

The energy released by pp nuclear burning increases:
Strong increase of the temperature (radiation/electron conduction insufficient)

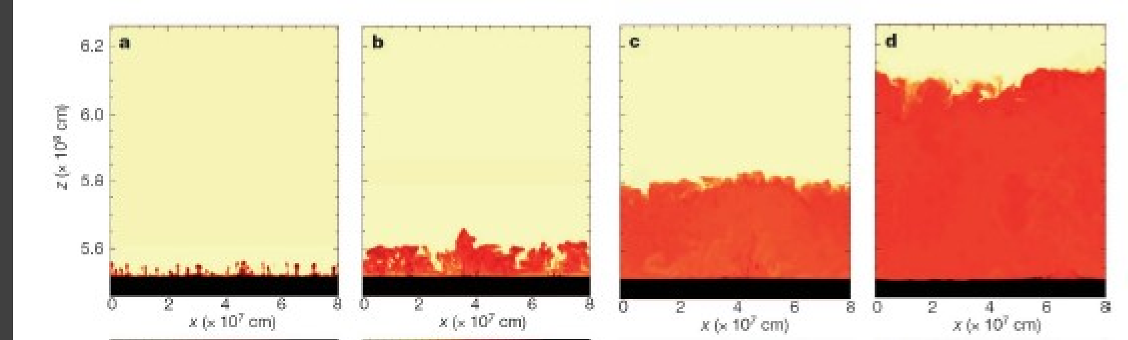
The TNR begins
Onset of the convection in a very thin layer

T ~ 2.5 10^7 K (25 000 000 K)

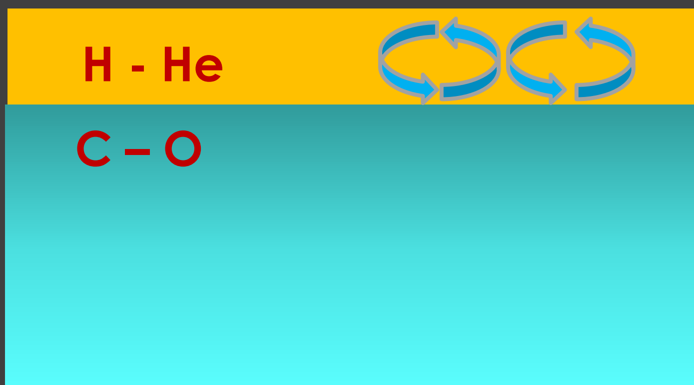


CNO Cycle « Cool »

T = 0 sec

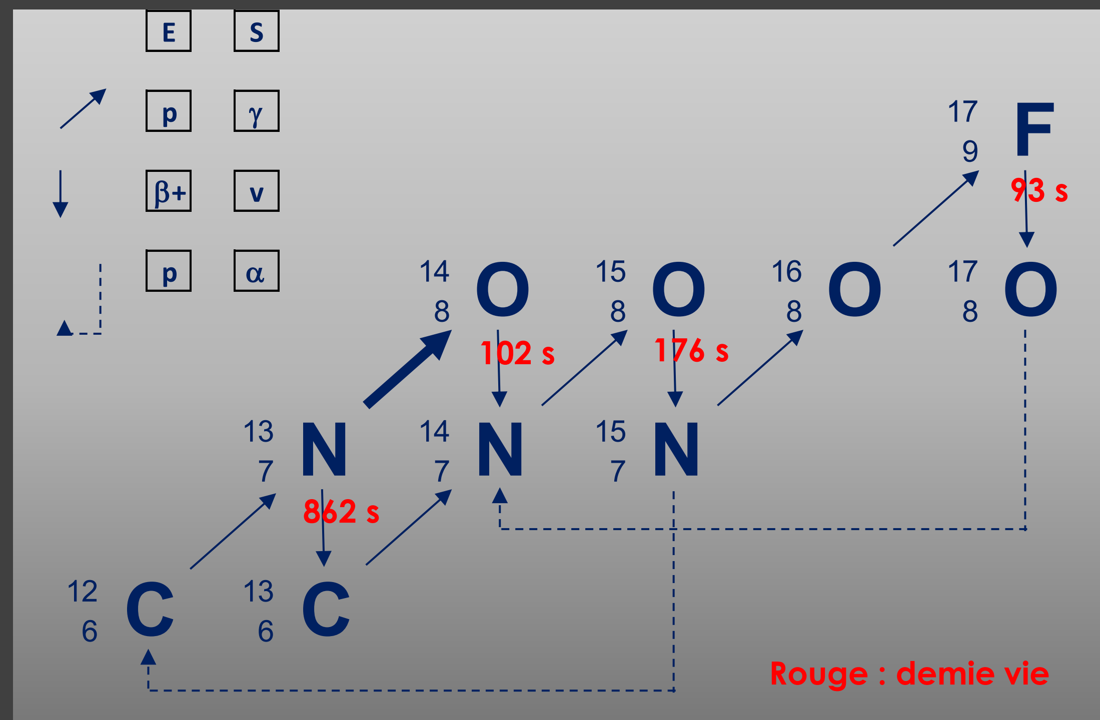


Convection reaches the surface of the envelope



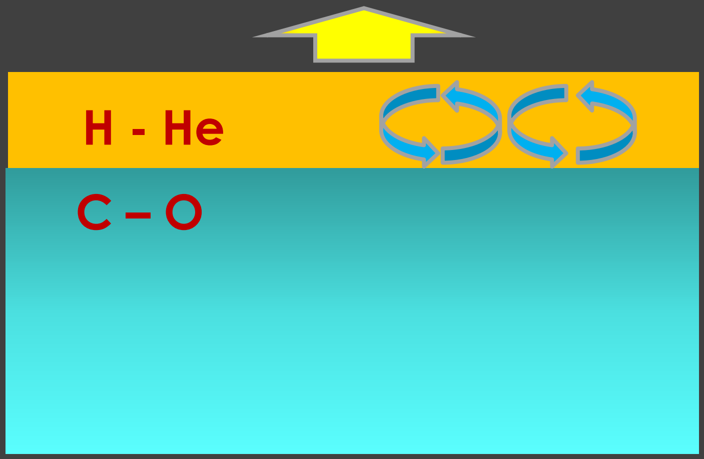
« Hot » CNO cycle

T ~ 6 10^7 K (60 000 000 K)



T = 600 sec

V ~ 10 km.s^{-1}



T ~ 8 10^{7} K (80 000 000 K)

3D simulation
Casanova & al., 2011

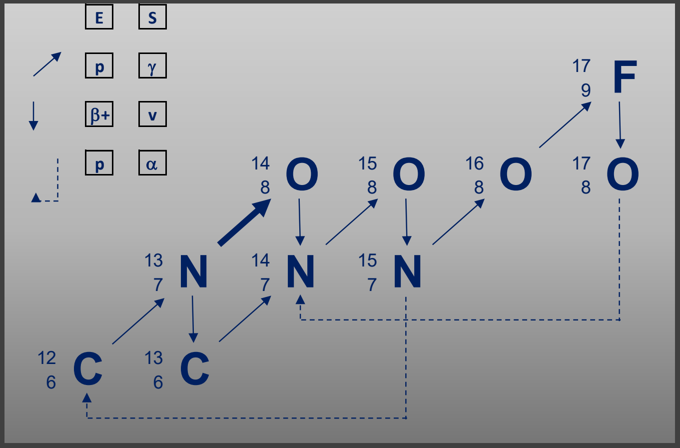
T > Fermi Temperature (T_F)

→ The matter of the envelope becomes « normal »

Expension of the envelope: Nova Event

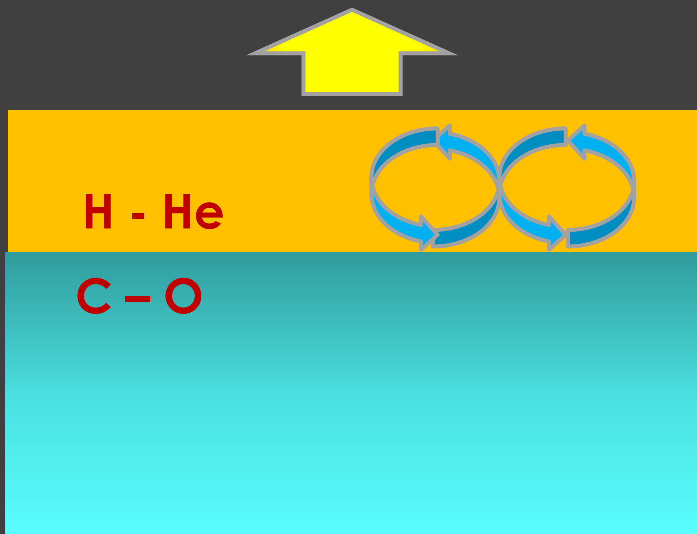
Energy production undergoes (β+ decay)

$$T_F = 3.10^7 \, x \left(\frac{\rho^3}{\mu e}\right)^{2/3}$$



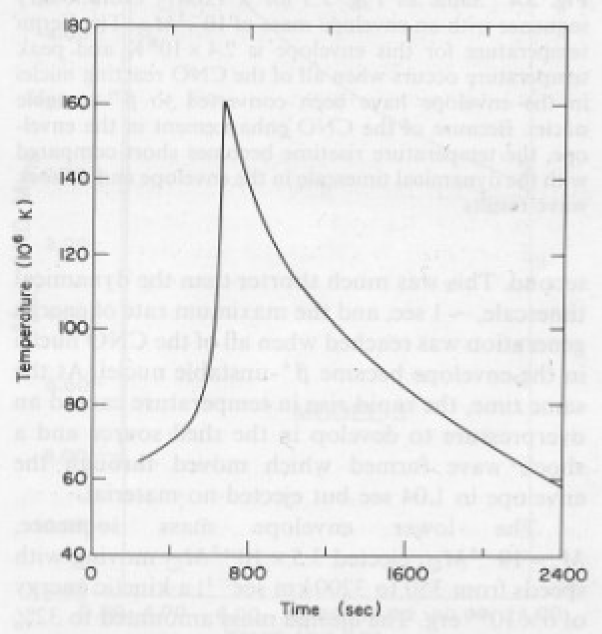
T = 700 sec

V ~ ++ 10 $km.s^{-1}$



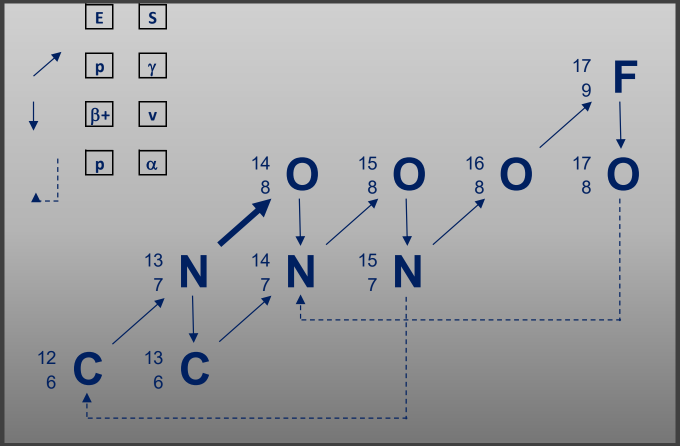
T ~ 1.6 10^8 K (160 000 000 K)

Maximum temperature

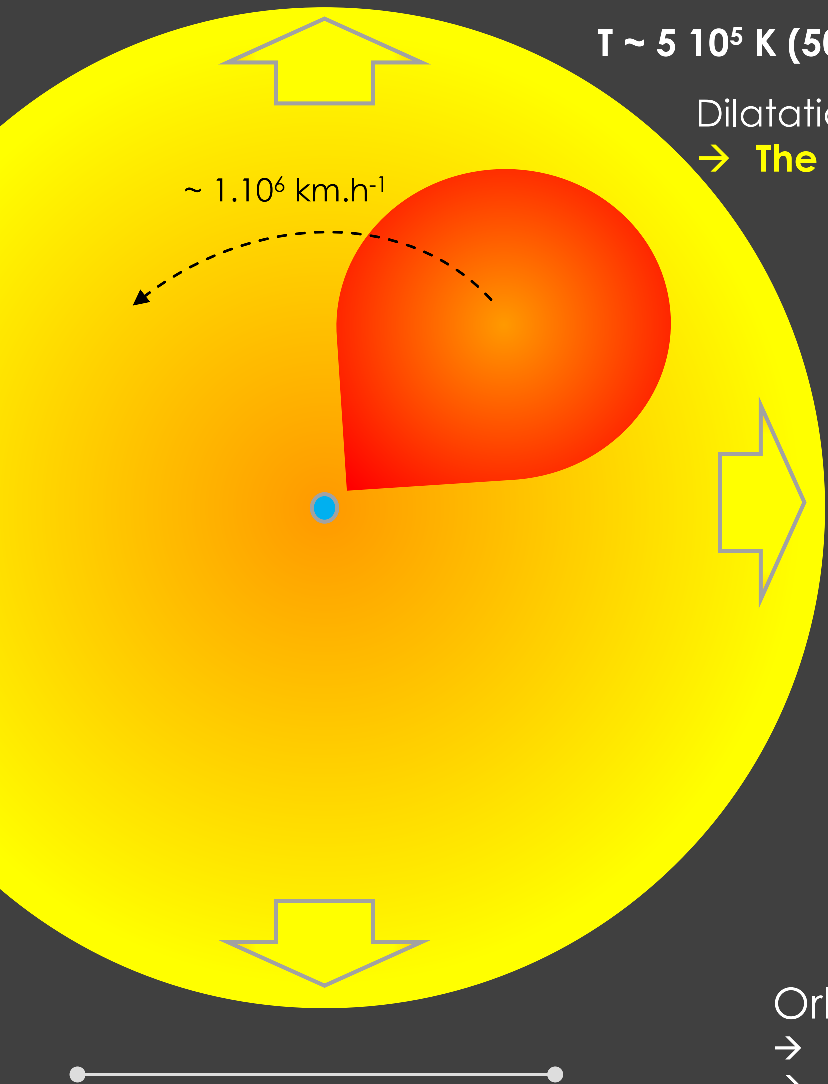


Runaway:
Very short time scale
+++ 100 secondes

E = 1.10^{15} $erg.g^{-1}.s^{-1}$ (25000 $kcal.g^{-1}.s^{-1}$)



t = a few hours



Scale ~1 million km

T ~ 5 10^5 K (500 000 K)

Dilatation of the envelope
→ **The temperature decreases**

Luminosity L ~ 10^5 L$\odot$

Luminosity near or above Eddington Luminosity (L_{edd})
→ Increase of the velocity

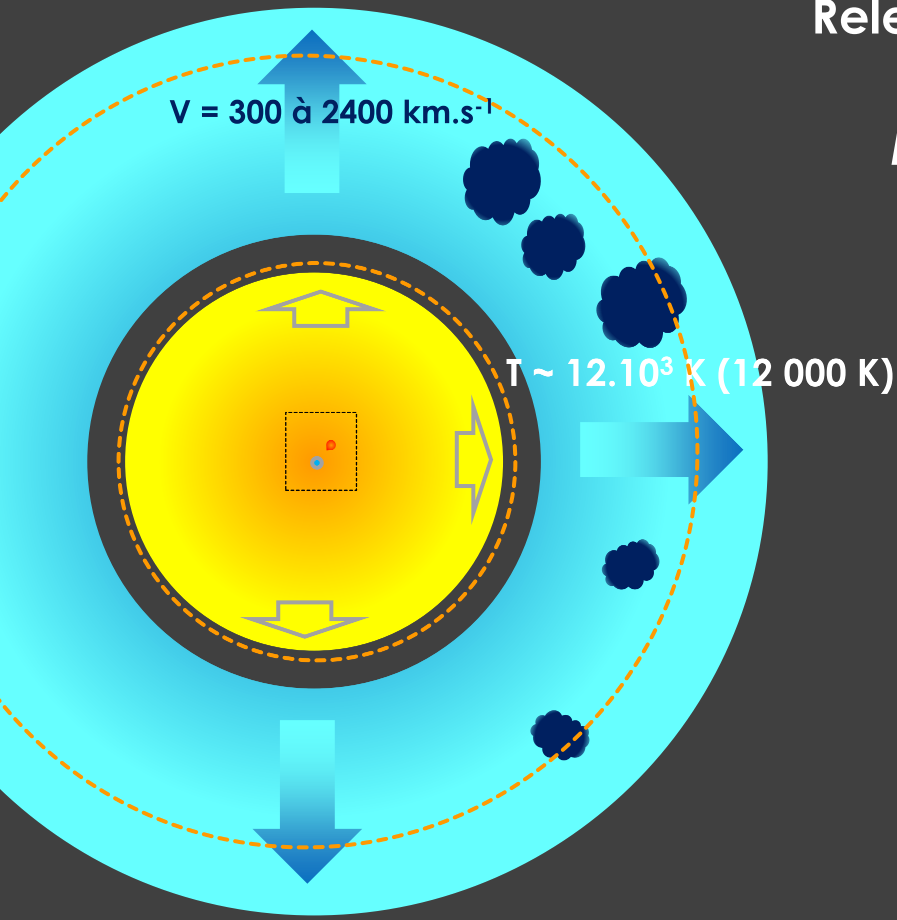
Valeur approximative

$$L_{\rm Edd} = 3.3 \times 10^4 \left(\frac{M}{M_\odot}\right) L_\odot$$

Orbit of the donor star inside the expending envelop
→ Speed of the ejecta (?)
→ Shape of the ejecta (?)
→ Blobs (?) from Lagrangian points (?)

Fireball stage

t ~ 1 day



Release of the ejecta (how and when?)

Mass of ejecta = 3,5.10^{-5} M$_{\odot}$

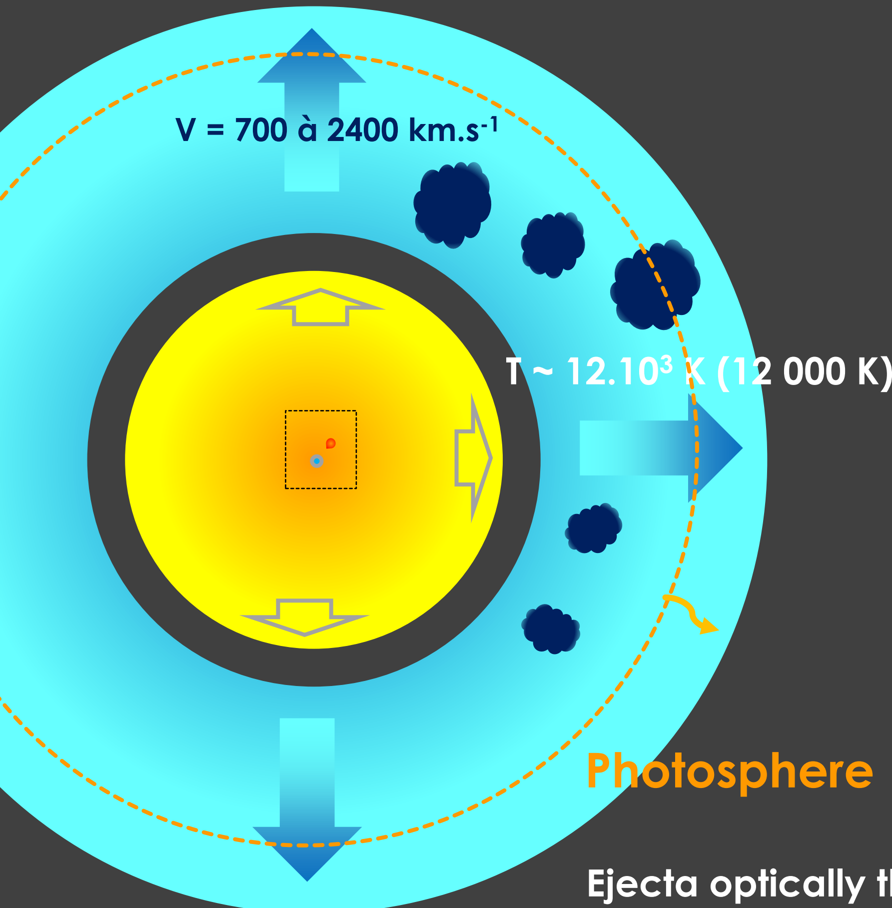
~ 1/3 envelope

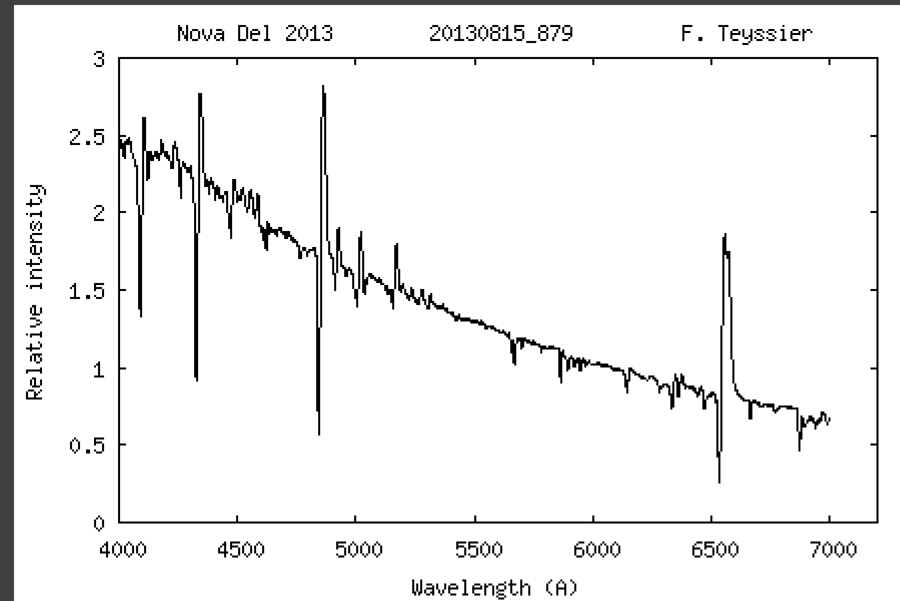
Heterogeneity
Bipolar lobs(?)
Rings (?)
…

Scale ~ 50 millions of km

Fireball stage

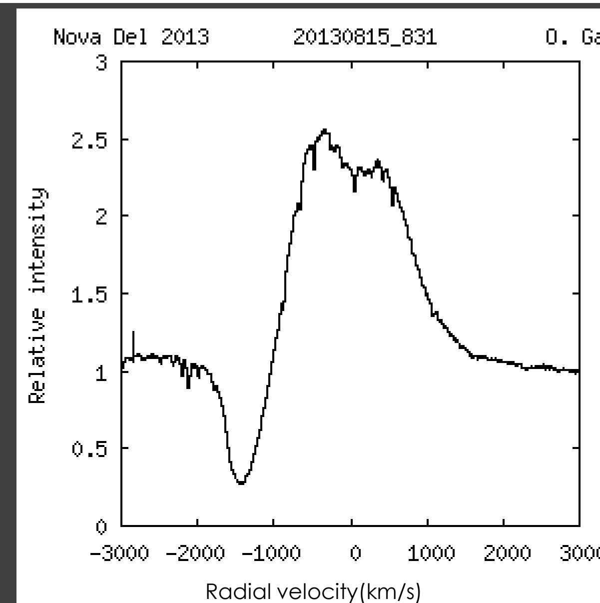
T ~ 1 day





Ejecta optically thick

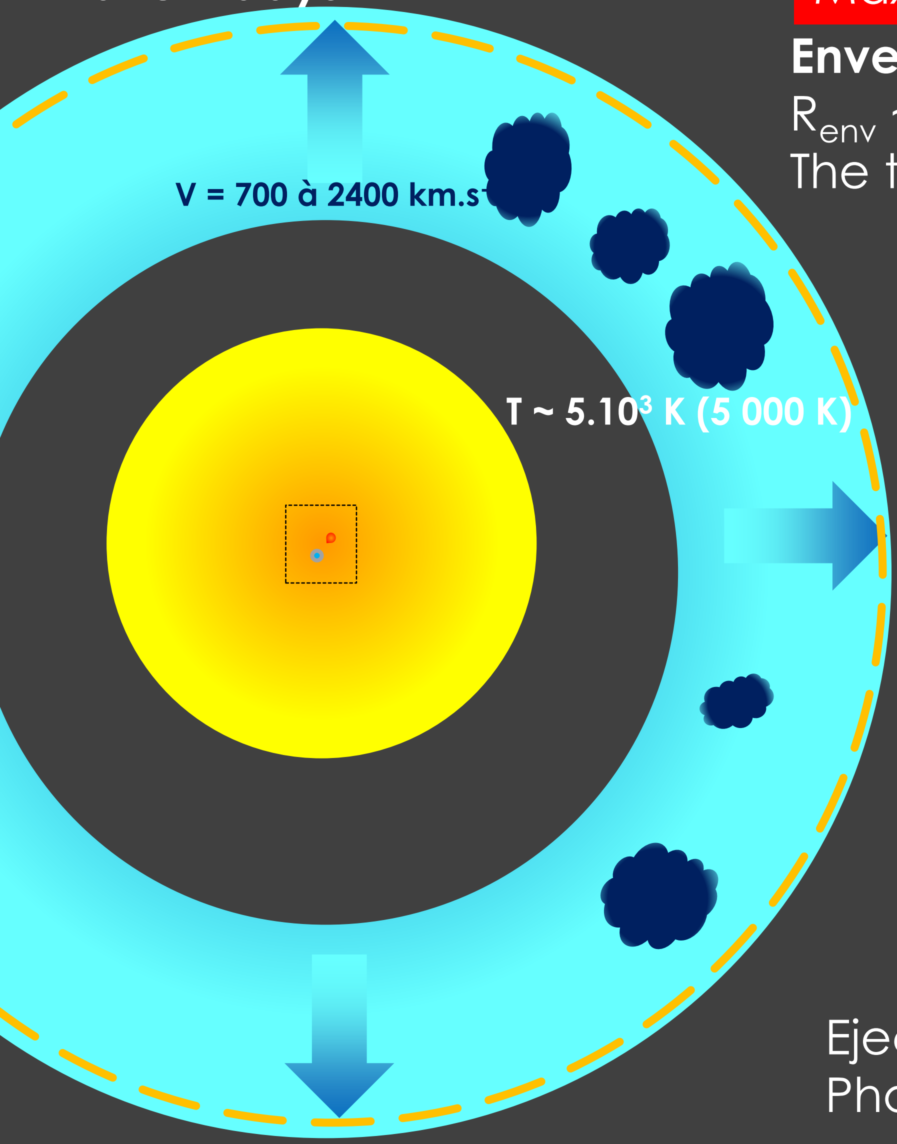
Many « metal » lines in absorption
« Iron curtain »
Fe II emission + P Cygni profiles
Balmer Lines (HI) : deep P Cygni profiles



Scale ~ 50 millions of km

F. Teyssier January 2021

t ~ a few days

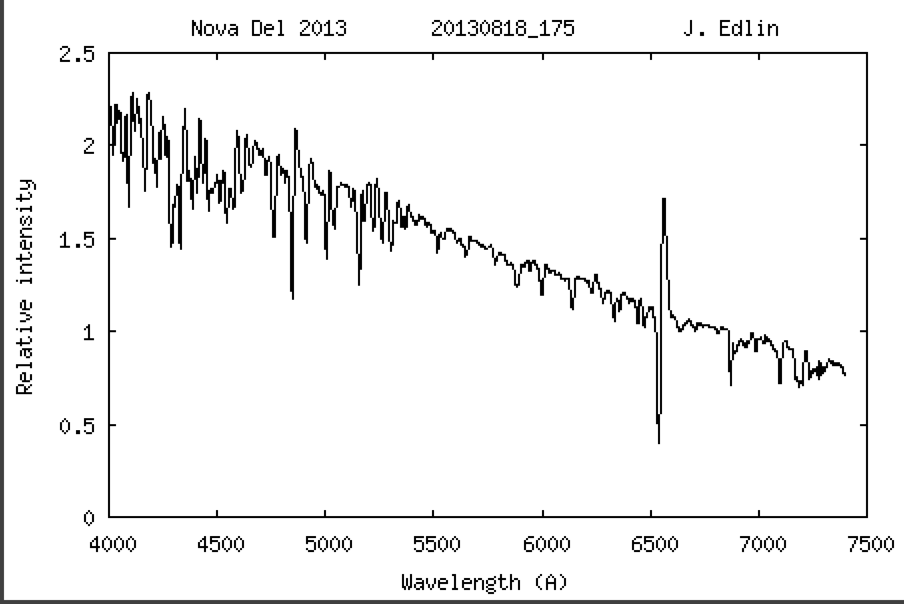


Max Luminosity

Envelop at its maximum radius

R_{env} ~ 300 $R_\odot$ (200.10^6 km)

The temperature lowers



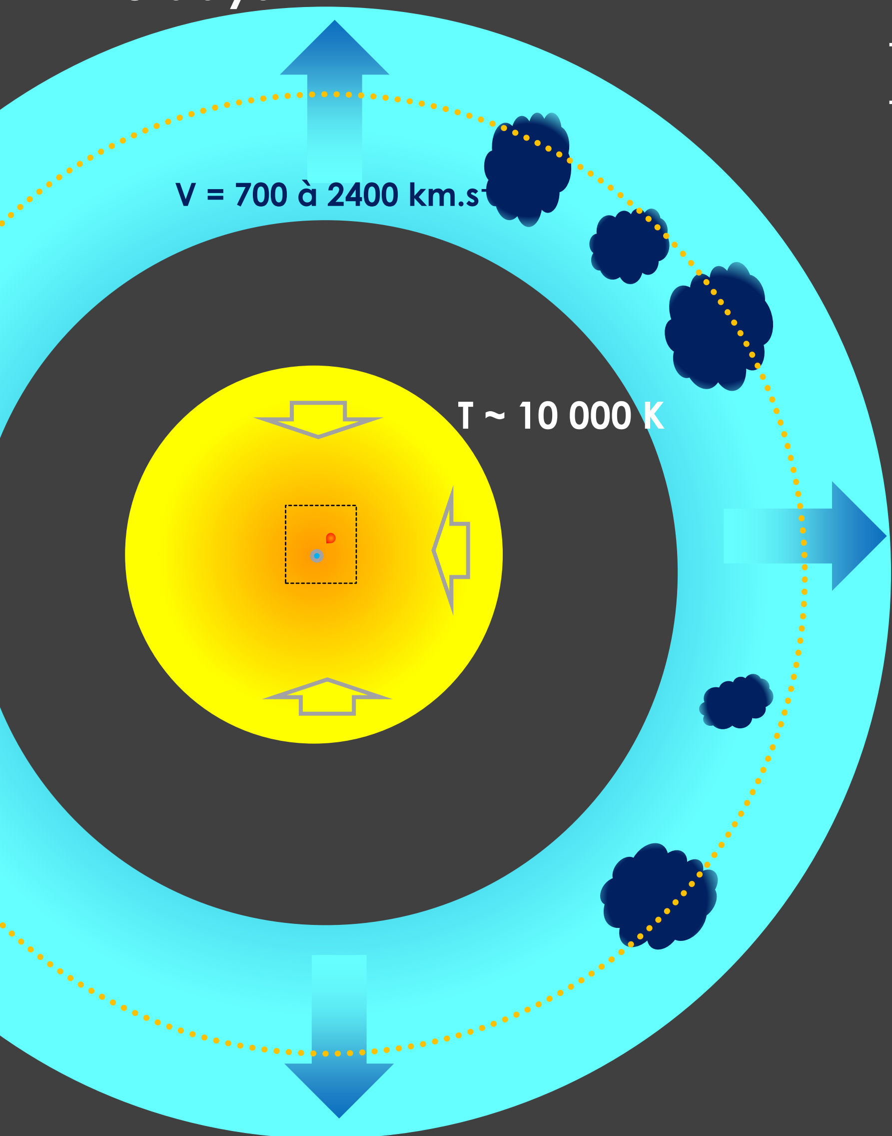
Ejecta optically thick

Photosphere near the surface of the ejecta

Scale ~ 100 millions de km

1st decline

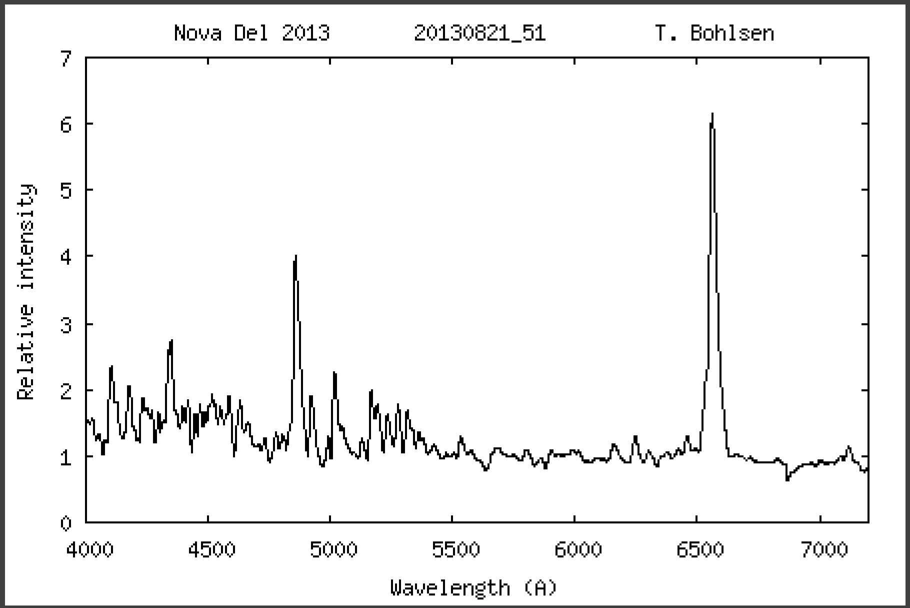
T ~ 10 days



The envelop recedes (Gravity)
The ejecta extends

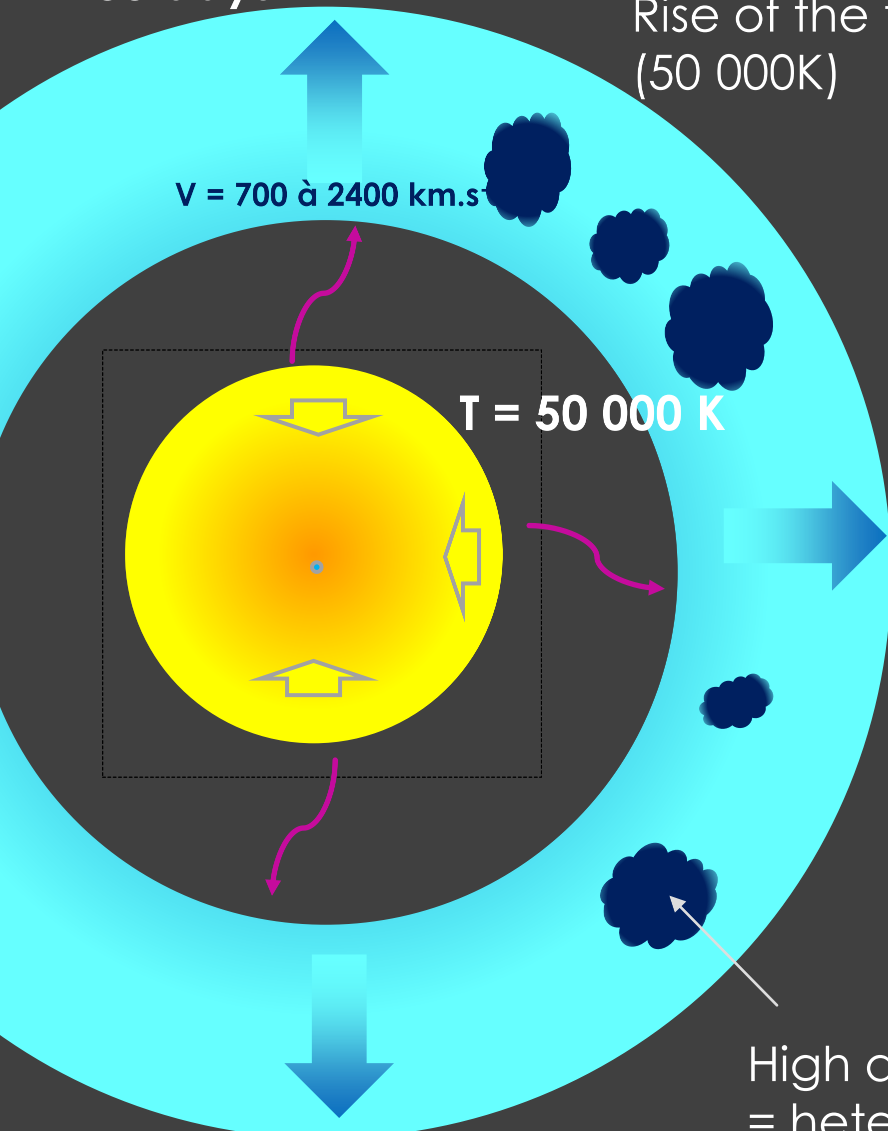
In the ejecta
Recombinaison
$H^{+} + e^{-} \rightarrow H^{0}$

Increase of the emissions



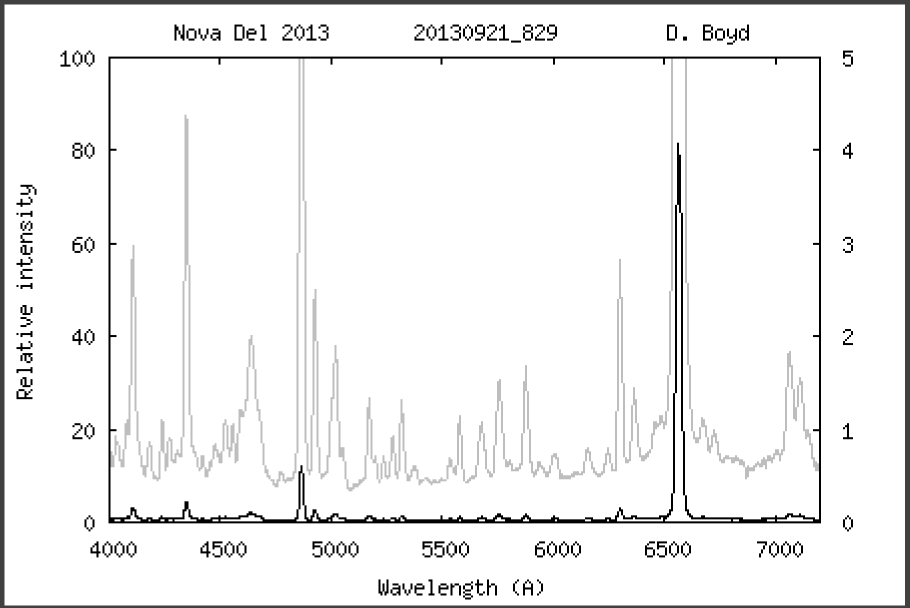
Scale ~ 100 millions de km

T ~ 30 days



Contraction of the remaining envelop
Rise of the temperature
(50 000K)

Shift of the peak of luminosity toward UV
Fading of the continuum in the visible range
Photo-oinisation +++ of the ions in the ejecta

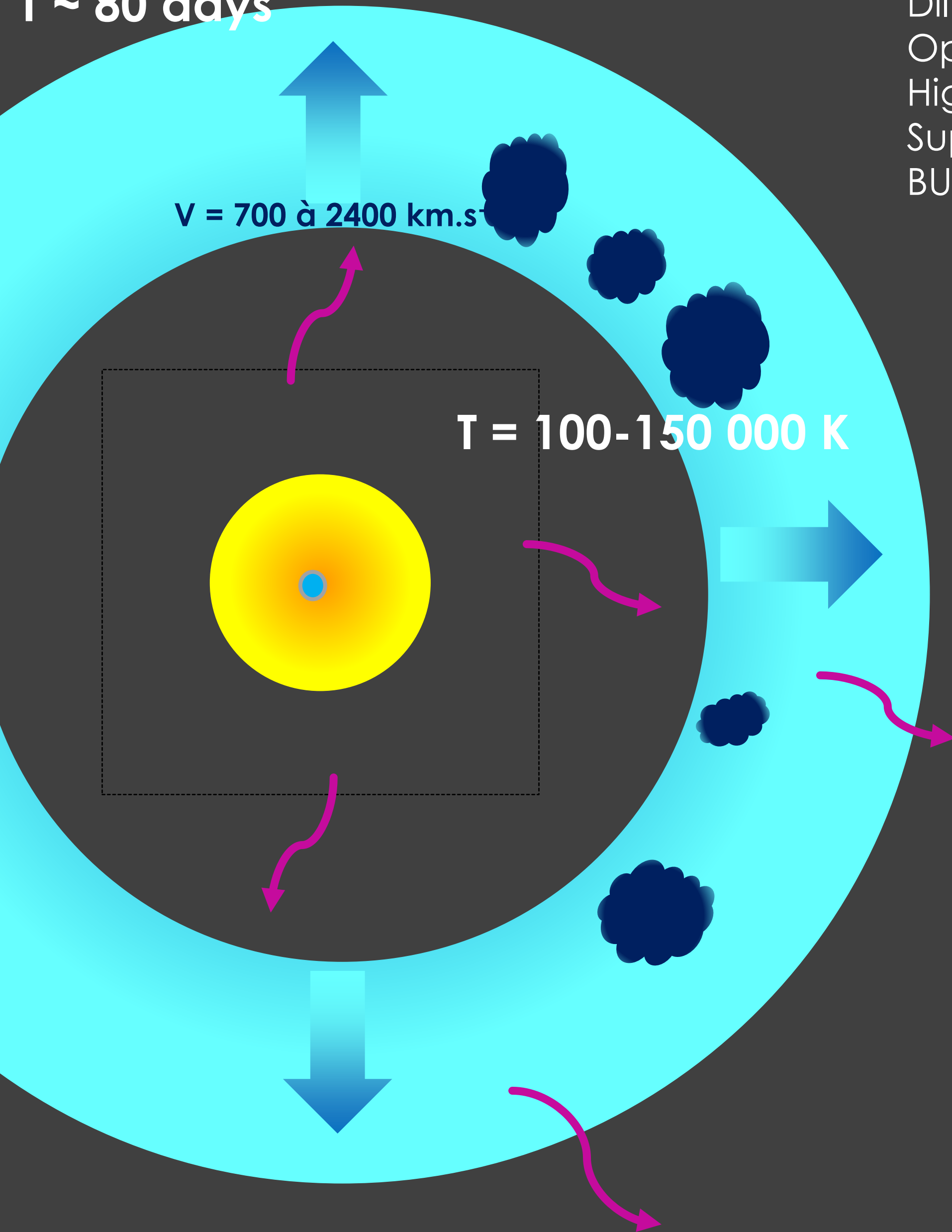


The density of the ejecta decreases
Formation of forbidden lines
(Collisionnally excited lines)

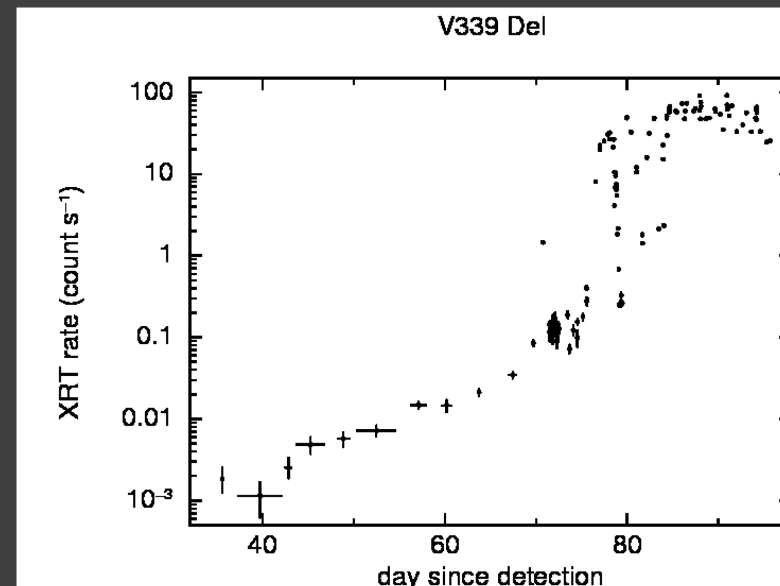
High density zones, blobs
= heterogeneity of the ejecta

Ejecta optically thin

T ~ 80 days



Dilution of the ejecta
Optically thin at all wavelength
High energy level(100eV à 1keV)
Super Soft Source
BUT: Dust can forms in some novae (Dust dip in the LC)



Swift

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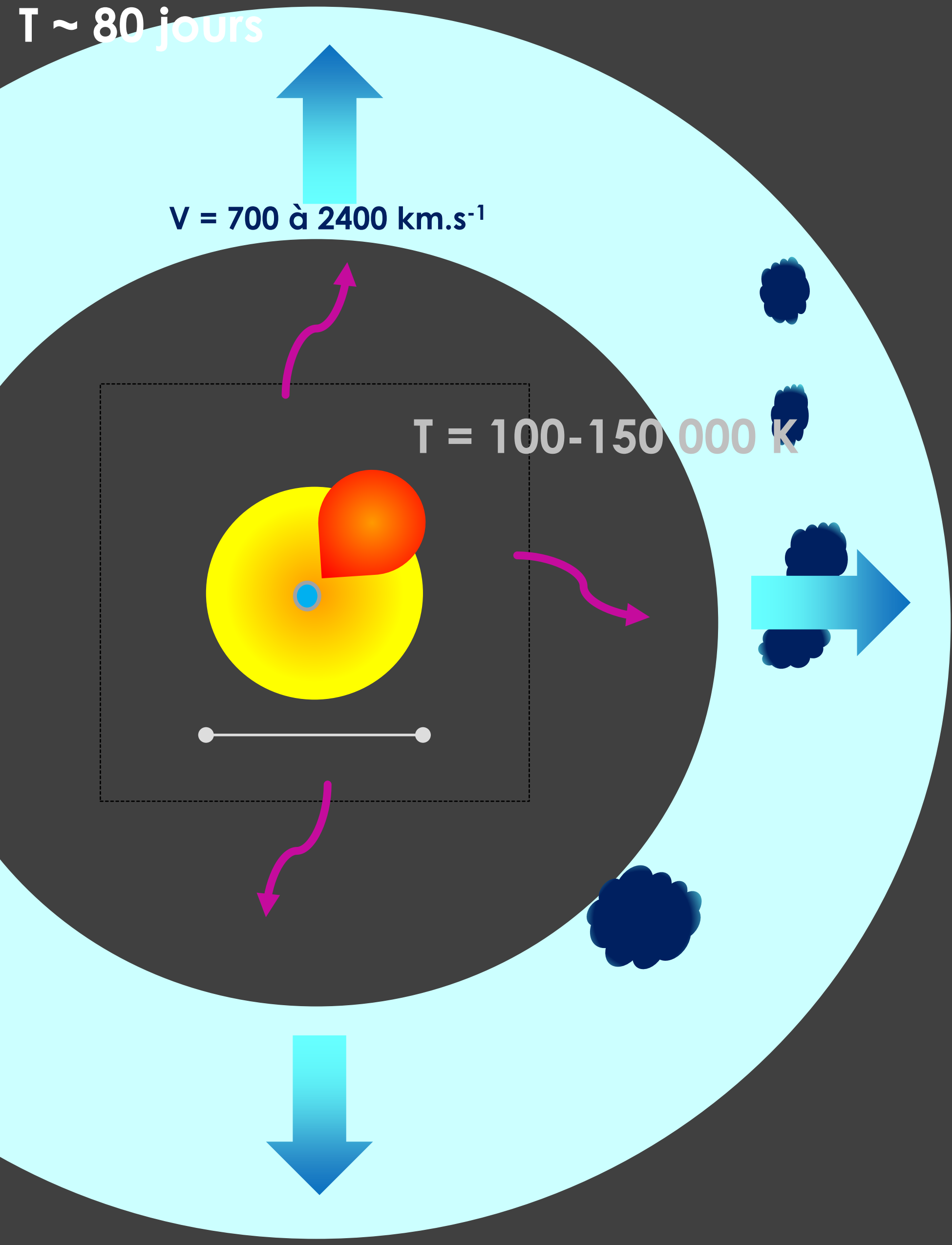
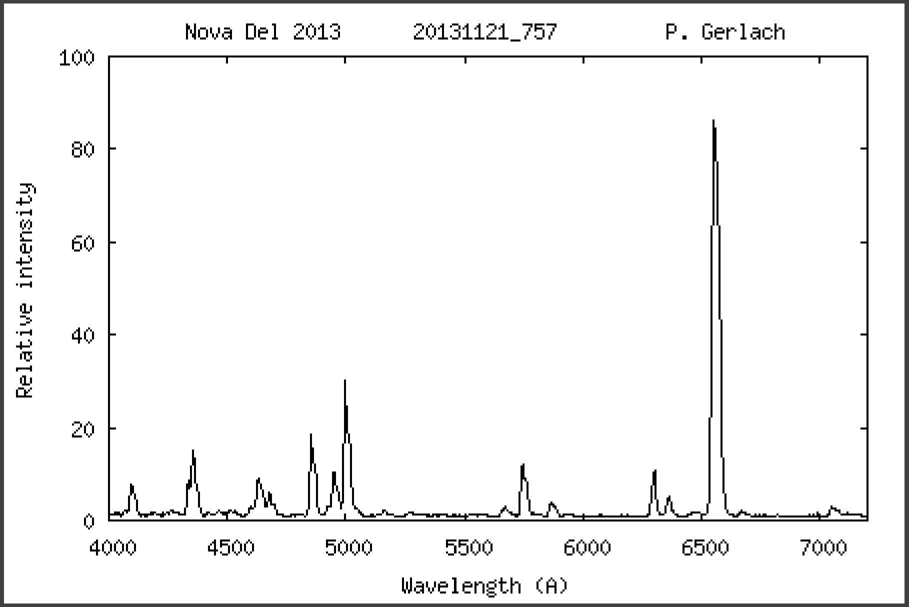
Phase nébulaire

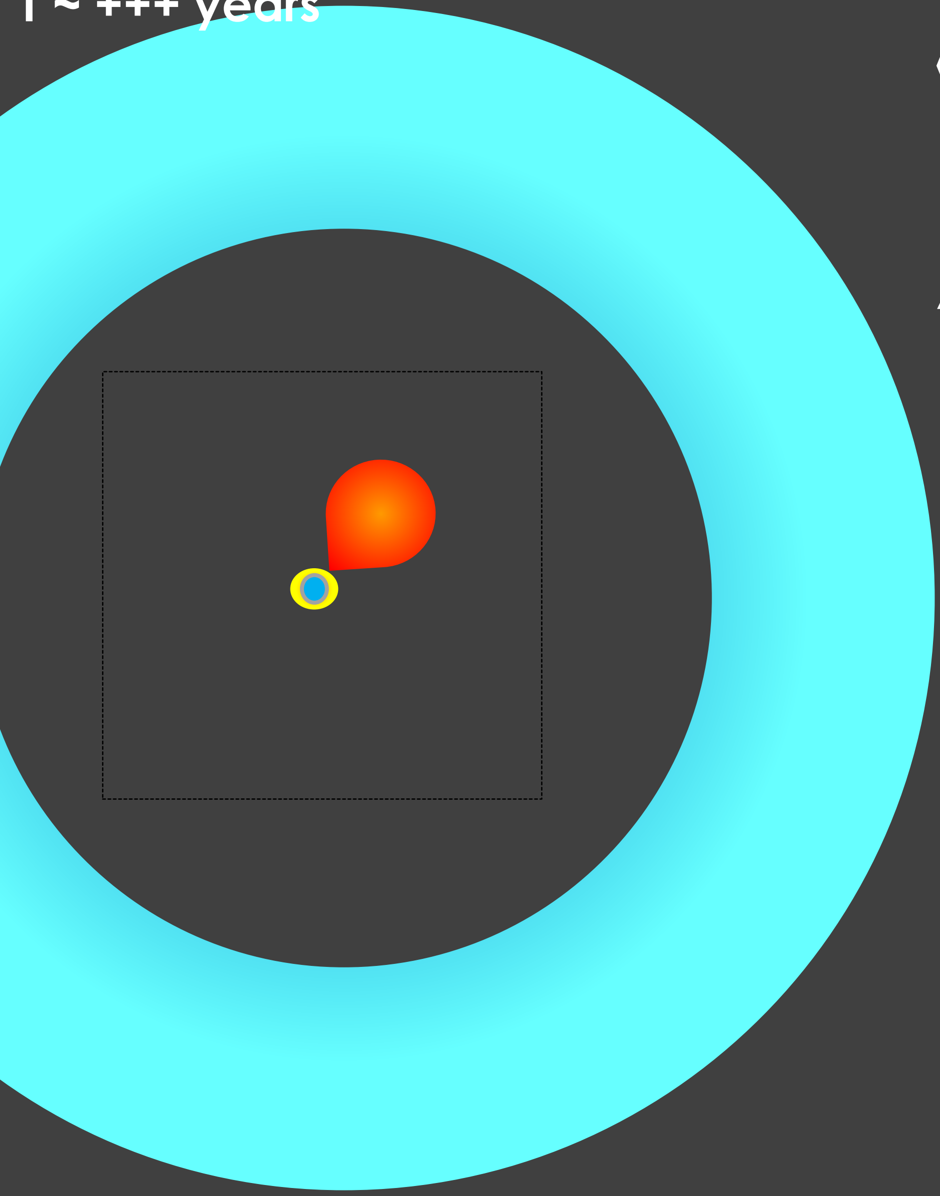


Ejecta optically thin
Heterogene
High ionisation lines
[OIII], He II, Fe VII, Fe X …



Nebular Phase

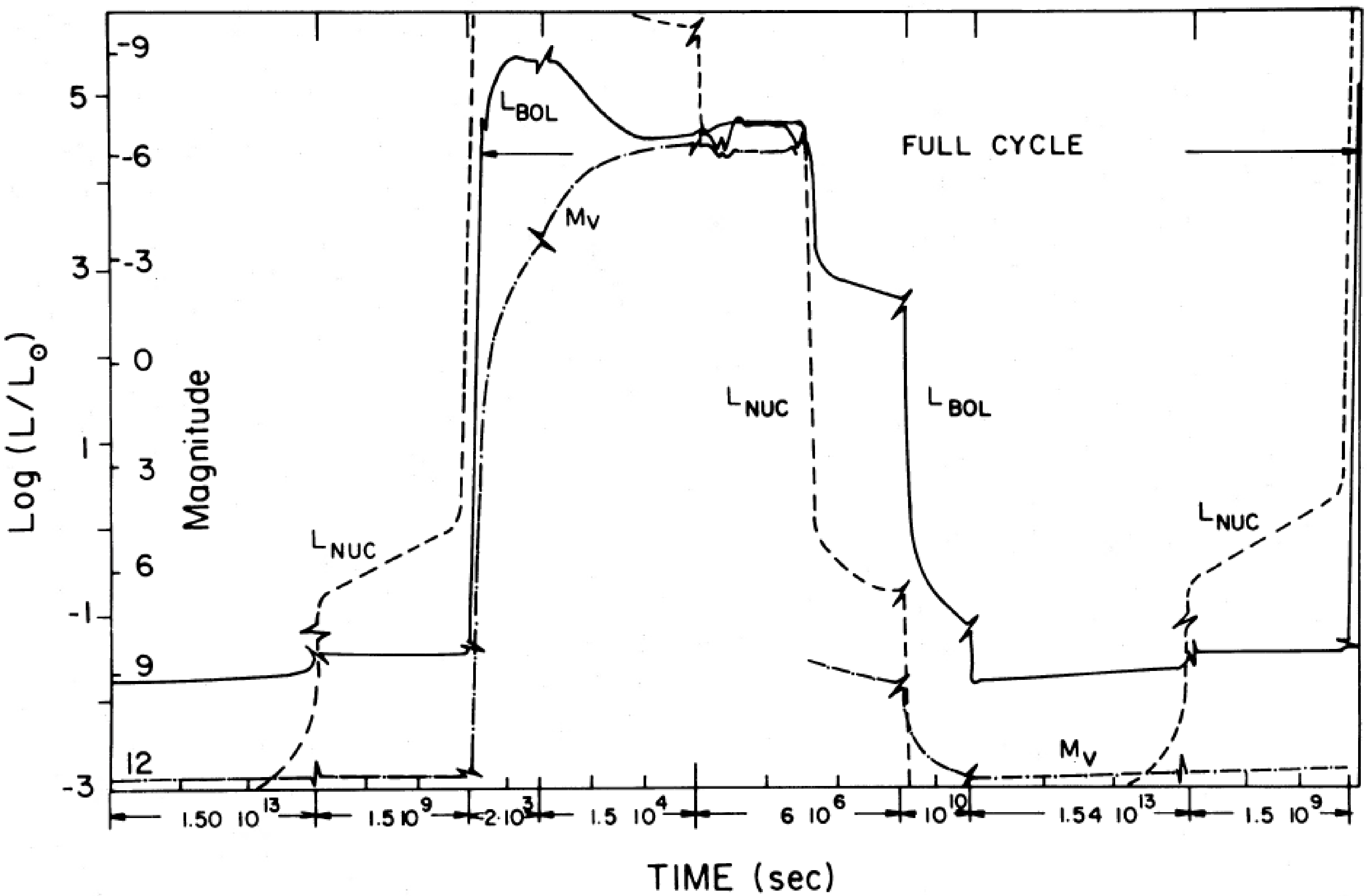
T ~ +++ years

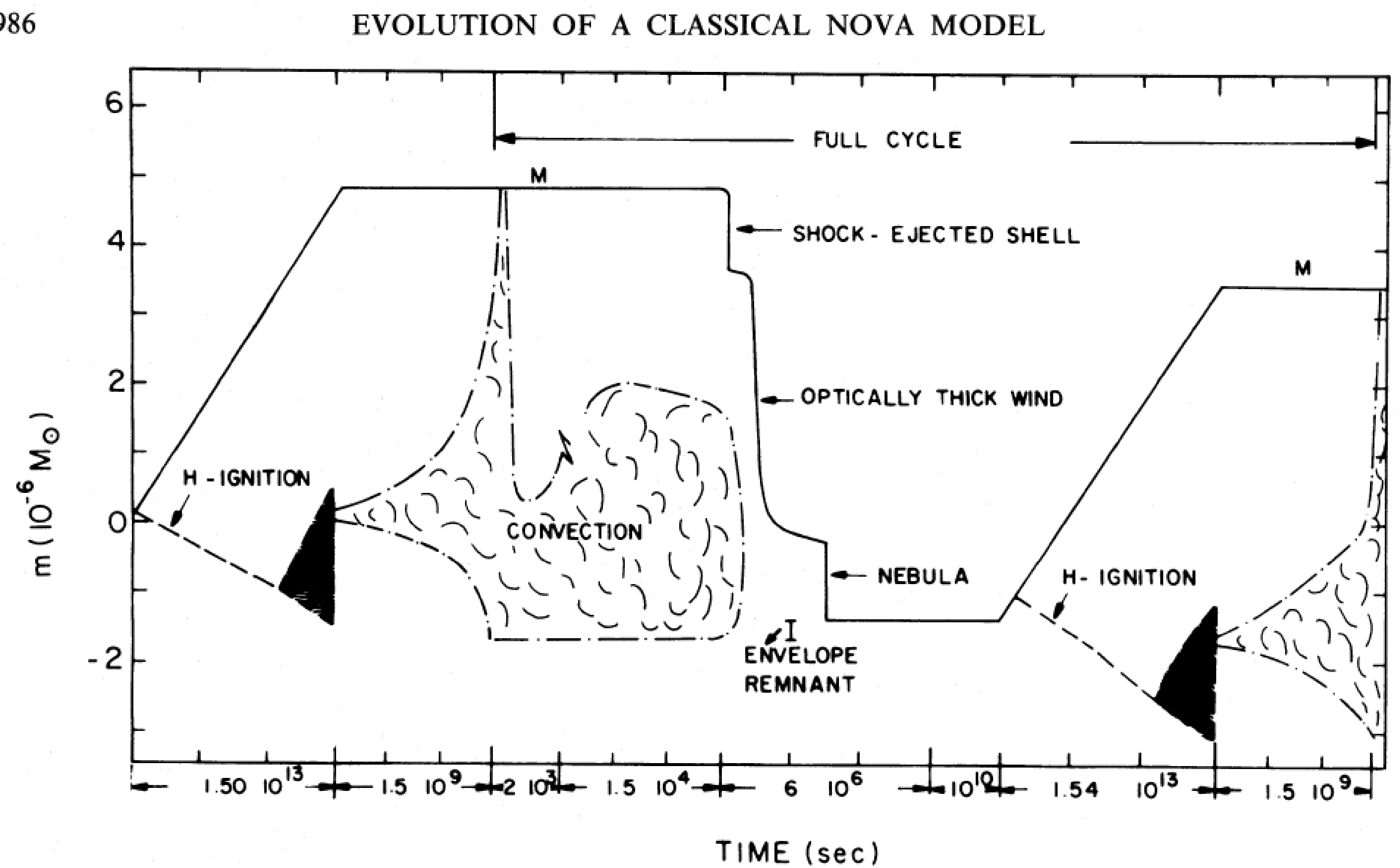


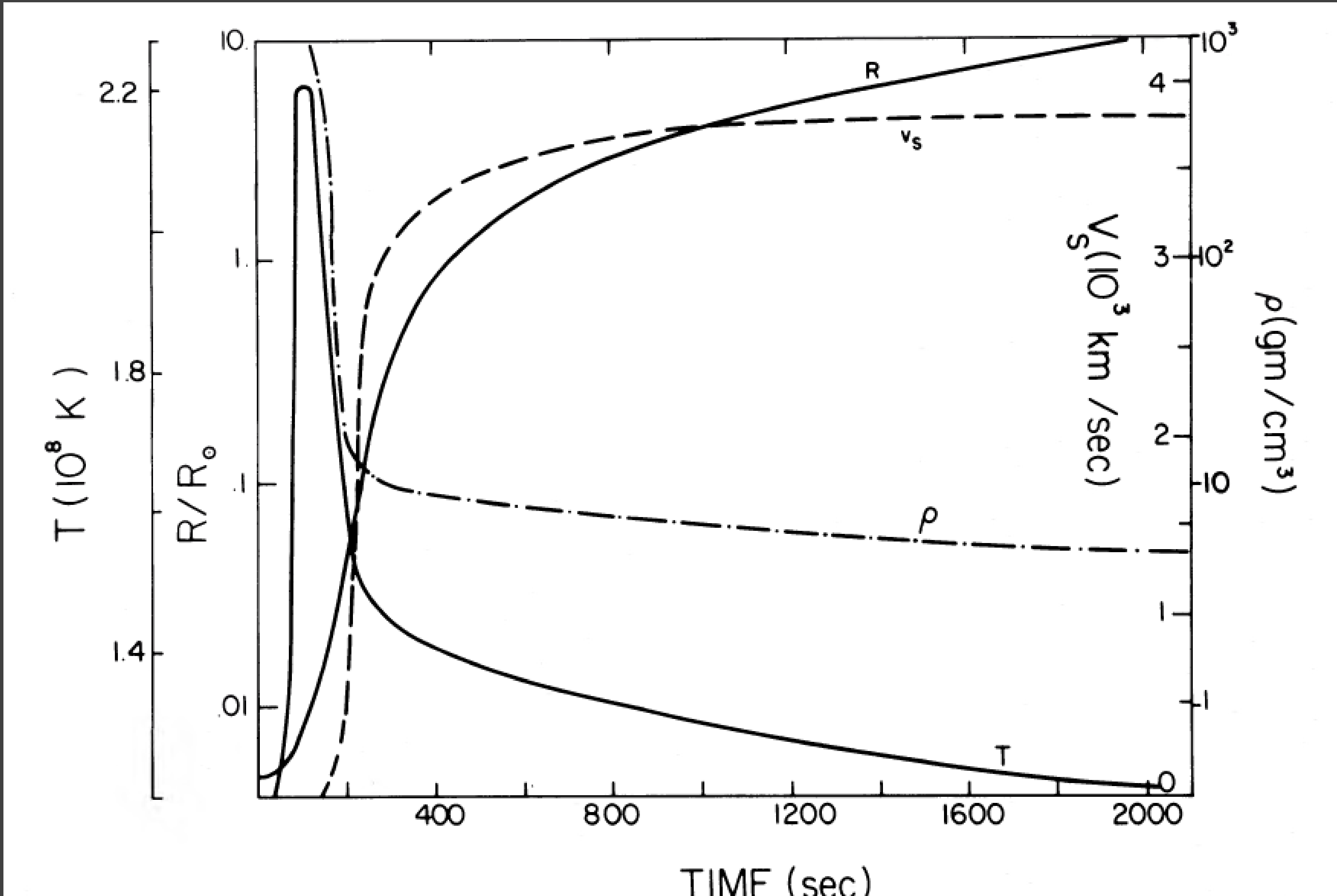
« turn-off »

Hibernation ?

Accretion, outbursts (Dwarf Nova type)
Until the next nova event
(in a few thousands of years)


Log (L/L⊙)
Magnitude
5
3
0
1
-1
-3
-9
-6
-3
0
3
6
9
12
L BOL
M V
L NUC
FULL CYCLE
L NUC
L BOL
L NUC
M V
1.50 10 13
1.5 10 9
2·10 3
1.5 10 4
6 10 6
10 10
1.54 10 13
1.5 10 9
TIME (sec)


986
EVOLUTION OF A CLASSICAL NOVA MODEL
FULL CYCLE
M
SHOCK - EJECTED SHELL
M
OPTICALLY THICK WIND
H - IGNITION
CONVECTION
NEBULA
H- IGNITION
ENVELOPE
REMNANT
6
4
2
0
-2
m (10^{-6} $M_\odot$)
1.50 10^{13}
1.5 10^{9}
2 10^{3}
1.5 10^{4}
6 10^{6}
10^{10}
1.54 10^{13}
1.5 10^{9}
TIME (sec)


T (10⁸ K)
R/R⊙
2.2
1.8
1.4
10.
1.
.1
.01
R
vs
ρ
T
400
800
1200
1600
2000
TIME (sec)
4
3
2
1
0
10³
10²
10
1
Vs (10³ km /sec)
ρ(gm/cm³)

The sort of program I have in mind could not be accomplished by one person, or even one observatory. [...] It would require co-operation between two or more observatories, and would involve the use of six or more intruments
Aside from the direct comparison feature, has not been done before ? The answer is yes it has in an utterly hapzard and unco-ordinated fashion. Each observer has obtained a record of the nova that served his propose very well. But when any attempt was made to synthesize the material, what a hodgepdge ! There has been cooperation, but only after the nova had run its course.
What is required is pooling the effort and ressources during the observing period.
Image that we were sufficiently clairvoyant to know that a bright nova would appear once year hence. I am sure our appoach would be very diffrent from what has caracterized previous observations of novae.

Dean B. Mac Laughlin, Problem in the spectra of novae, 1950, PASP

Observation coordonnée d'une nova classique
dans tous les domaines de longueur d'onde
Gamma, X, UV, Visible, IR, Radio
Following an idea formulated by Mc Laughlin (1950) , mise en œuvre par Steve Shore (2013)

Pise, Juillet 2013

Lyon , Novembre 2013
ARAS observers and Steve Shore (WETAL 2013)

The Astronomer's Telegram

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

ATel #6132; *A. Skopal (Astronomical Institute of the Slovak Academy of Sciences, Tatranska*
gue),M. Slechta
rejov), F. Teyssier, J.
buting participants,

Continuing optical spectroscopy of V339 Del = Nova Del 2013 with the Nordic Optical Telescope and the ARAS Group

ATel #5378; *S. N. Shore (Univ. of Pisa, INFN-Pisa), K. Alton, D. Antao, E. Barbotin, P. Berardi,*
ubs, J.
sen, D.
r, E.
ARAS)

Continuing spectroscopic observations (3600-8800A) of V339 Del = Nova Del 2013 in the early nebular stage with the Nordic Optical Telescope, Ondrejov Observatory and the ARAS group

ATel #5546; *S. N. Shore (Univ. of Pisa, INFN-Pisa); J. Cechura, D. Korcakova, J. Kubat, P.*
Sciences
Berardi,
el, P.
m, D.
J. P.
Thizy, J.-

First high resolution ultraviolet (HST/STIS) and supporting optical spectroscopy of V339 Del = Nova Del 2013

ATel #5409; *S. N. Shore (Univ. of Pisa, INFN-Pisa); G. J. Schwarz (AAS); K. Alton, D. Antao, E.*
Barbotin, P. Berardi, T. Blank, T. Bohlsen, F. Boubault, D. Boyd, J. Briol, C. Buil, S.
ham, D.
Buchet, J.
N. Terry,
-U Ness
F. Bode

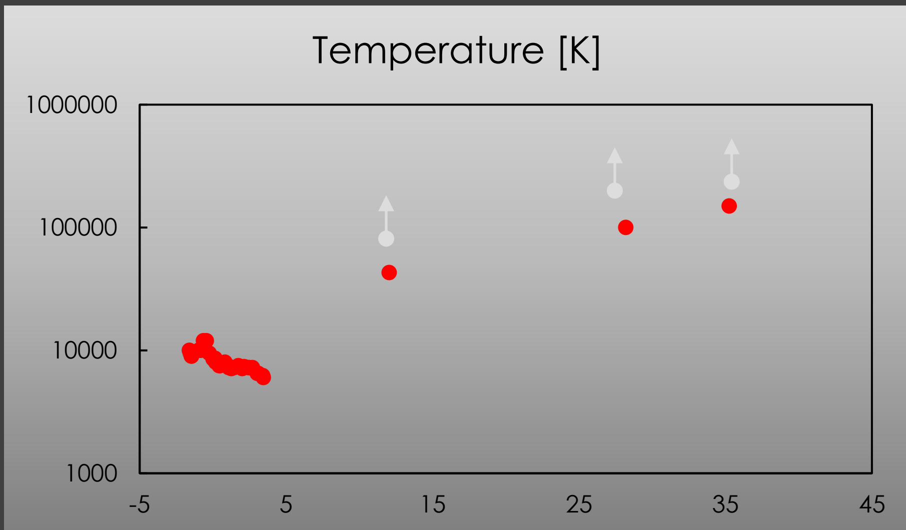
Continuing spectroscopic observations (3500-8800A) of Nova Del 2013 with the Ondrejov Observatory and the ARAS group

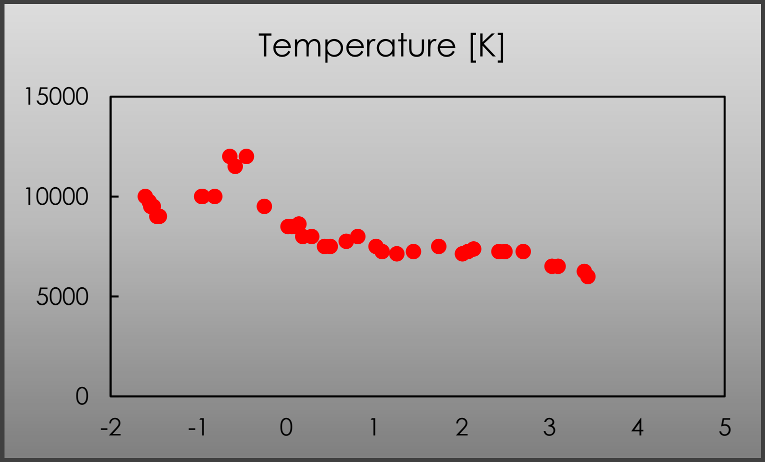
ATel #5312; *S. N. Shore (Univ. of Pisa, INFN-Pisa); P. Skoda, D. Korcakova, P. Koubsky R. K?Ä?ek, P. Rutsch, M. Slechta ((Astronomical Institute, Academy of Sciences of the Czech Republic- Ondrejov, Czech Republic); O. Garde, O. Thizy , T. de France, D. Antao, J. Edlin, K. Graham, J. Guarro, F. Teyssier, P. Berard, i T. Bohlsen, E. Pollmann, T. Lemoult, A. Favaro, J.-N. Terry, E. Barbotin, F. Boubault, J. P. Masviel, R. Leadbeater, C. Buil, B. Mauclaire (contributing participants, ARAS)*
on 23 Aug 2013; 01:15 UT

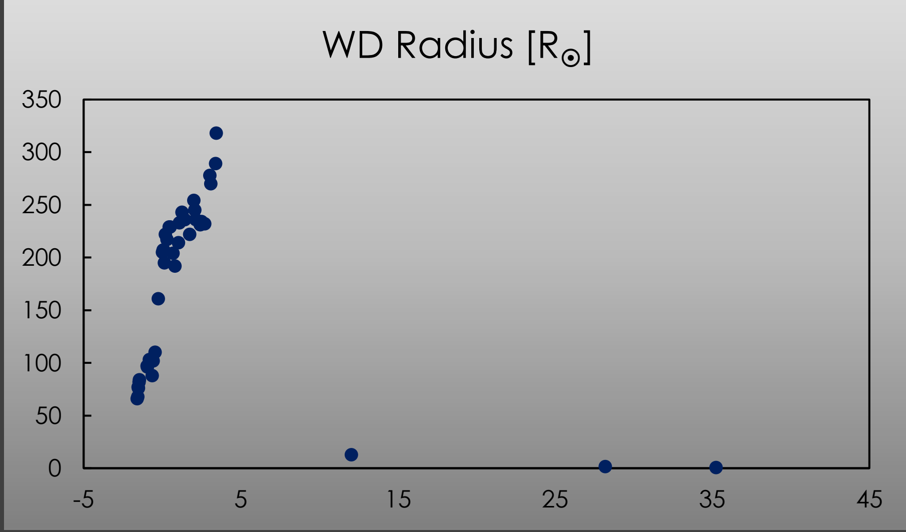
Astronomy & Astrophysics

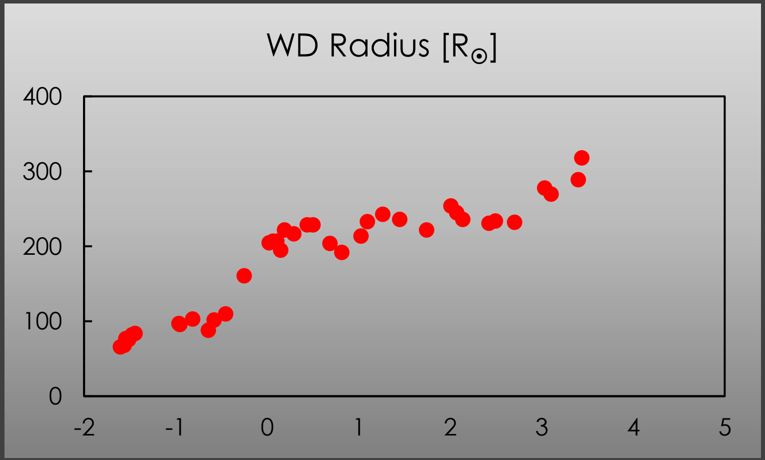
Early evolution of the extraordinary Nova Del 2013 (V339 Del) *

A. Skopal[1]**, H. Drechsel[2], T. Tarasova[3], T. Kato[4], M. Fujii[5], F. Teyssier[6], O. Garde[7], J. Guarro[8], J. Edlin[9], C. Buil[10], D. Antao[11], J.-N. Terry[12], T. Lemoult[13], S. Charbonnel[14], T. Bohlsen[15], A. Favaro[16], and K. Graham[17]

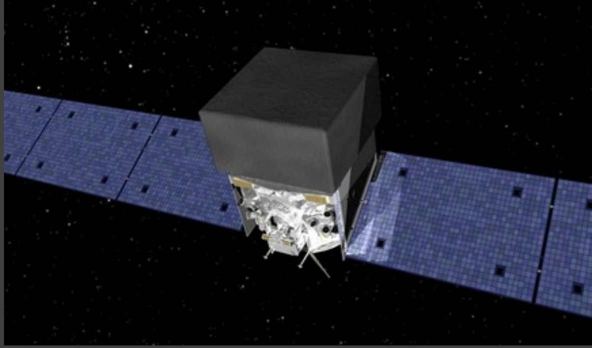






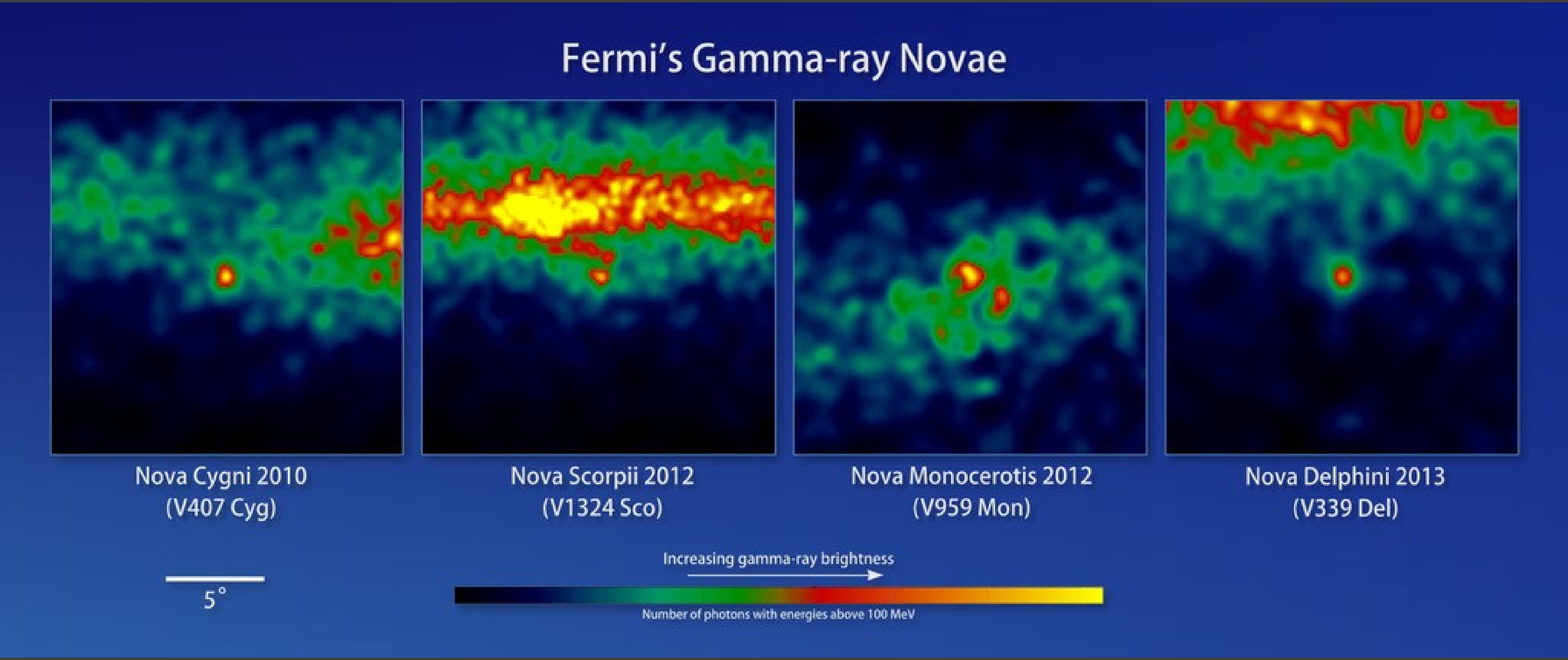


F. Teyssier January 2021



Nova Del 2013

Forth nova observed in Gamma-rays, Second Classical Nova

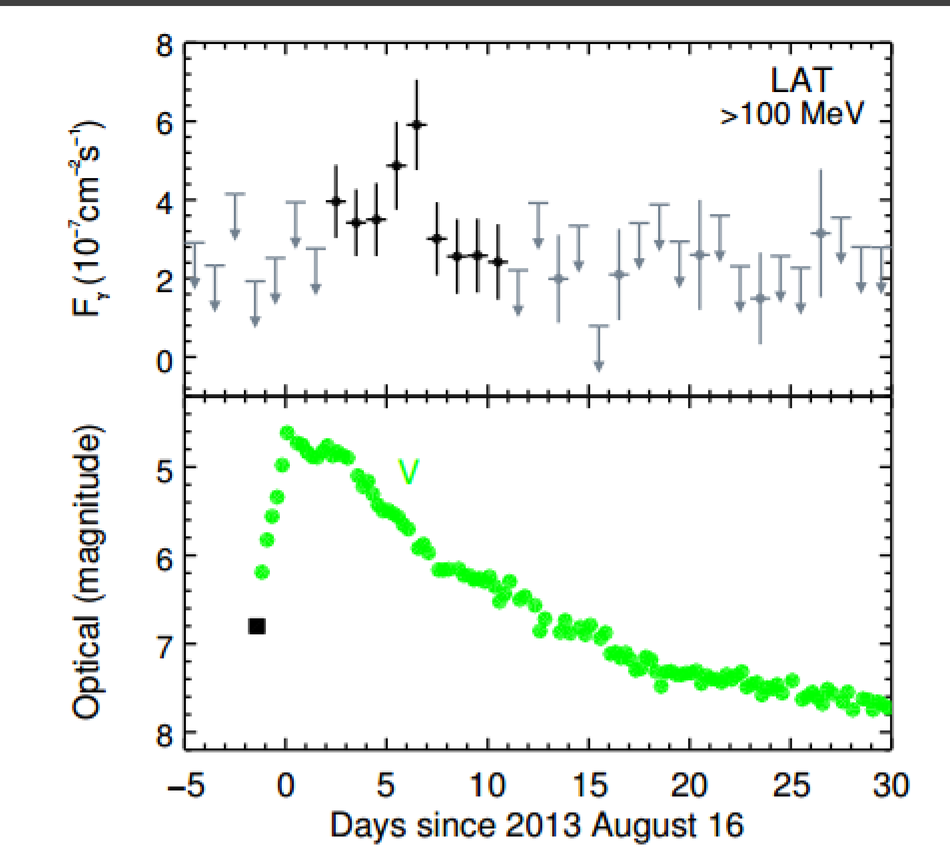


Credit: NASA/DOE/Fermi LAT Collaboration

Science
AAAS

Fermi establishes classical novae as a distinct class of gamma-ray sources

Science, Volume 345, Issue 6196, pp. 554-558 (2014)

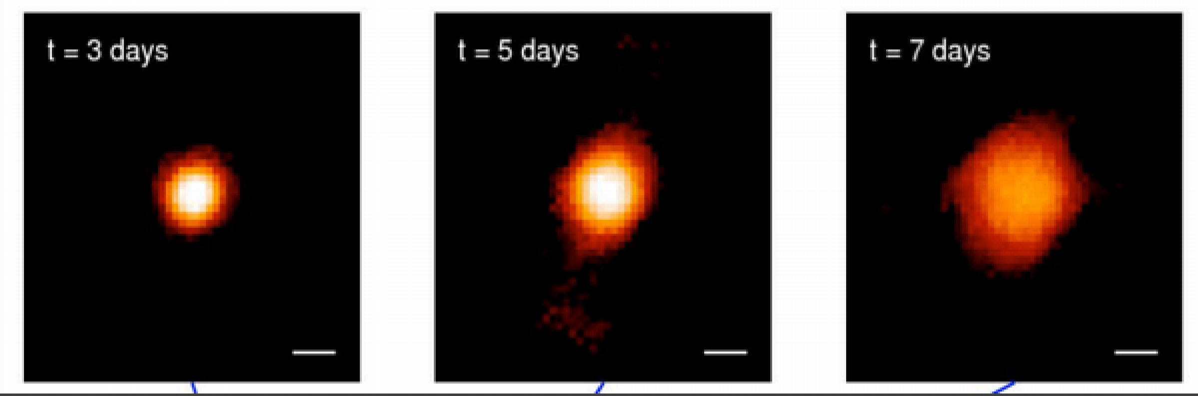


Gamma Emission V339 Del

49. We acknowledge with thanks the variable star observations from the AAVSO International Database contributed by observers worldwide and used in this research, and the dedicated observers of the Astronomical Ring for Access to Spectroscopy (ARAS) group for their tireless and selfless efforts.

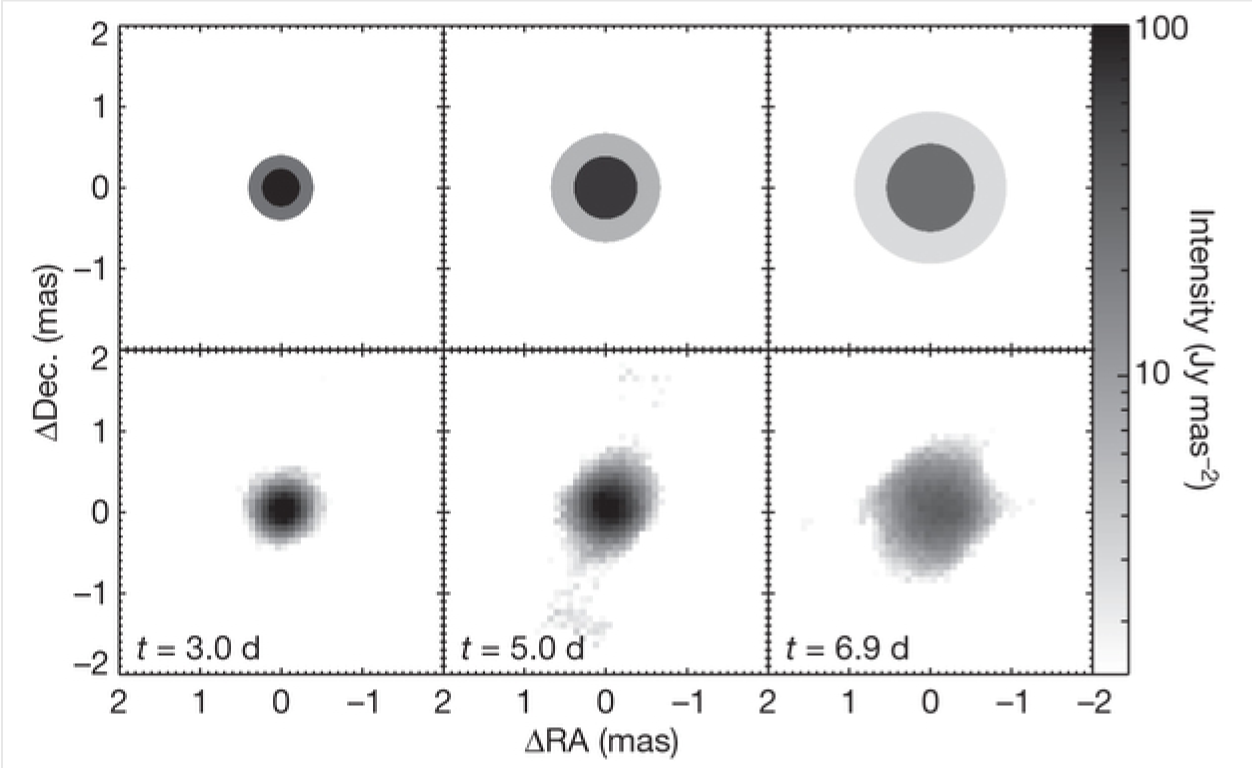
Tireless and selfless efforts

nature International weekly journal of science



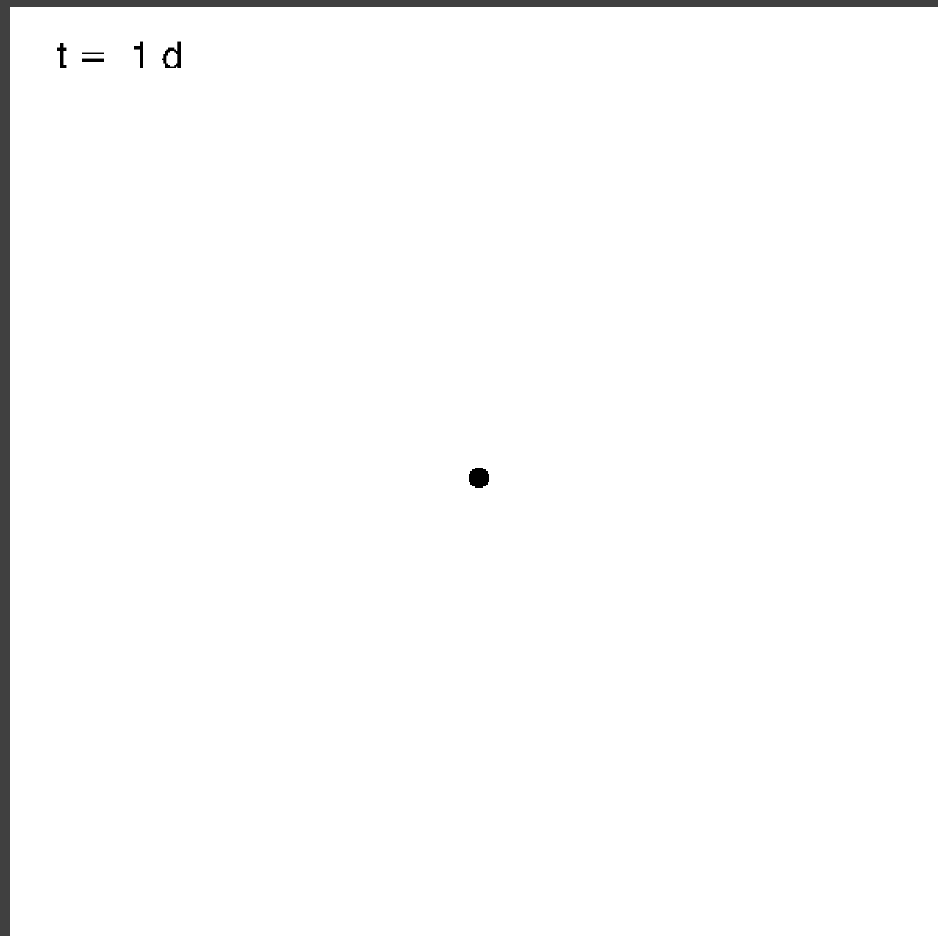
The expanding fireball of Nova Delphini 2013
G.H. Shaefer & al.
26 octobre 2014

Figure 4: Model and reconstructed images of Nova Del 2013.



nature International weekly journal of science

The expanding fireball of Nova Delphini 2013
G.H. Shaefer & al.
26 octobre 2014



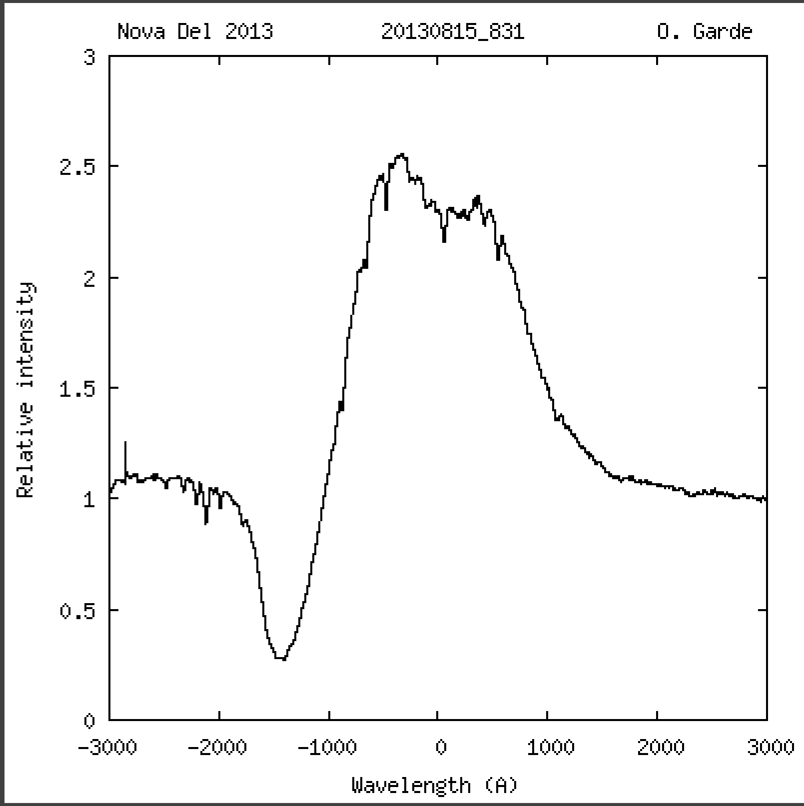
nature International weekly journal of science

The expanding fireball of Nova Delphini 2013

G.H. Shaefer & al.

26 octobre 2014

From an analysis of spectra downloaded from the archive of the Astronomical Ring for Access to Spectroscopy[17], we estimated the outflow speed near the continuum-forming layer to be $V_{ejection} = 613 \pm 79$ km s^{-1}



17 Shore, S. N. *et al.* Continuing spectroscopic observations (3500–8800A) of Nova Del 2013 with the Ondrejov Observatory and the ARAS group. *Astron. Telegr.* **5312**, 1 (2013)

We thank O. Garde and other members of the Astronomical Ring for Access to Spectroscopy for use of their archive of Nova Del 2013 spectra.

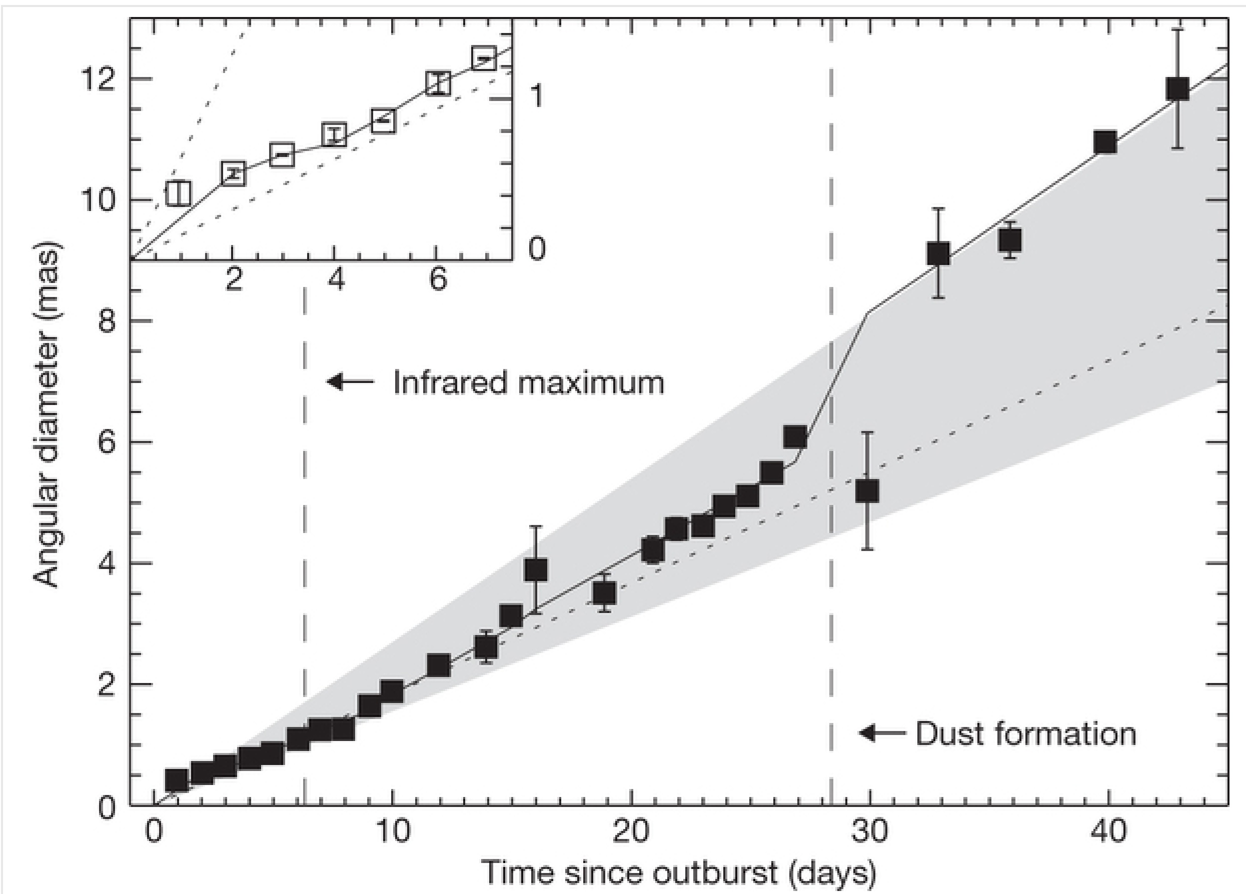
nature International weekly journal of science

The expanding fireball of Nova Delphini 2013

G.H. Shaefer & al.

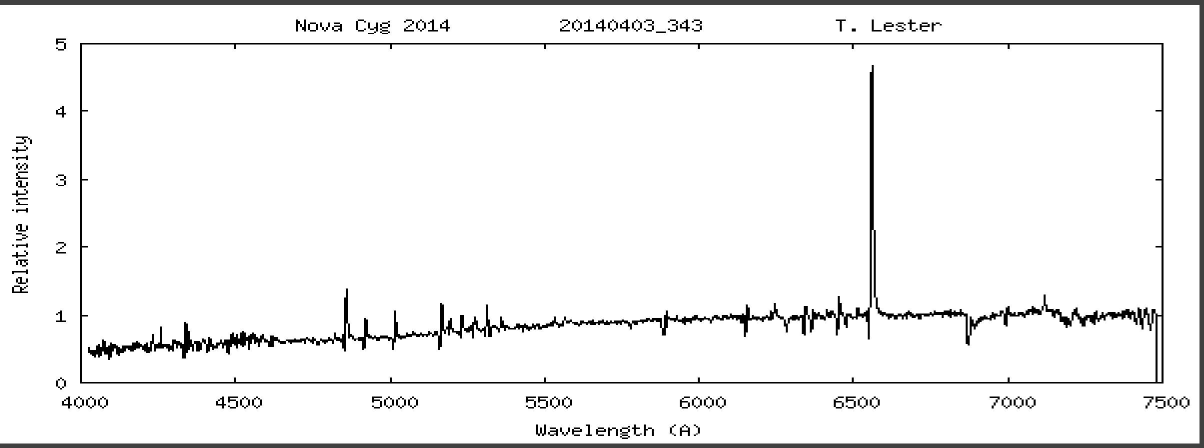
26 octobre 2014

Figure 1: Expansion curve of Nova Del 2013.



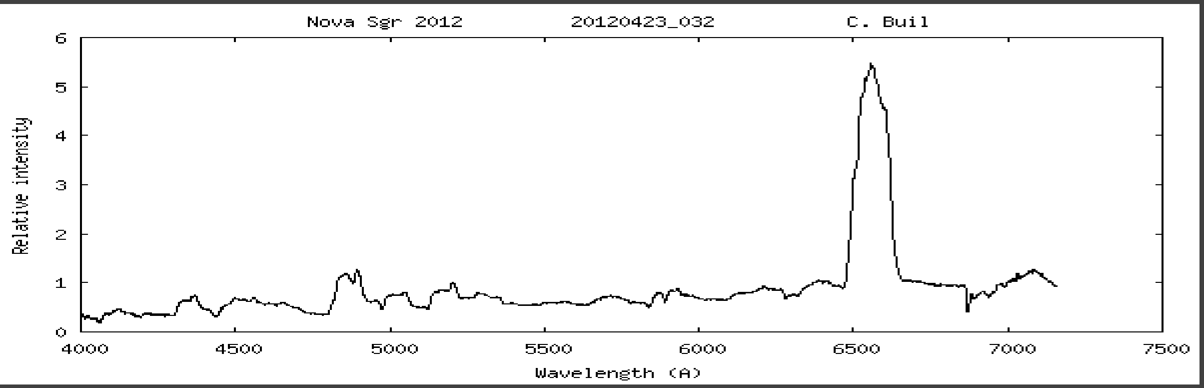
distance to the nova of
4.54 ± 0.59 kiloparsecs from the Sun

Williams, 1991,1994 **Two Spectral types**



Fe II

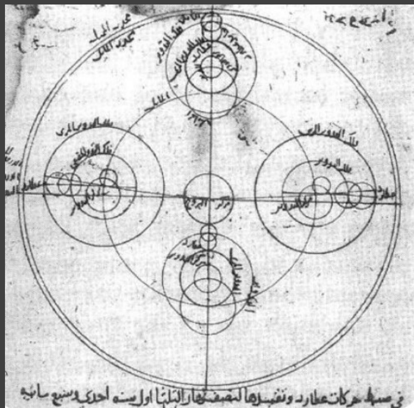
Lines– 700 à 2500 km.s^{-1}
Fe II
Profils P Cygni
Slow Novae



He/N

Broad lines> 2000 km.s^{-1}
He N
Fast Nova

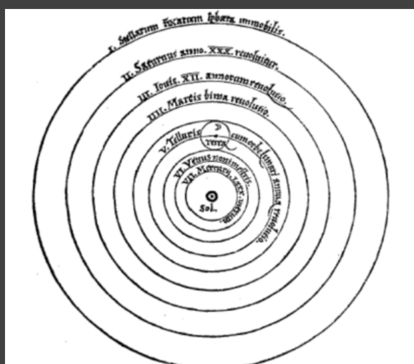
1. **Taxonomic classifications**
2. **Model of the ejecta '**



Ptolemee

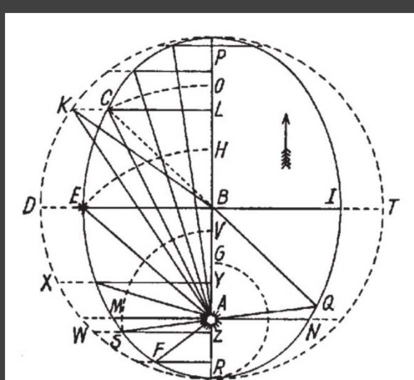
A model — SIMPLE: Rising Sun in the East
Physicaly Wrong
JUSTE (with +++ Eplicycles)

Imagine: ‘we « true » in the model AND have Modern Computers’
How many « epicycles » could we build?



Copernic

A model — COMPLEX to understand
Physicaly Right
peu JUSTE



Kepler

A model — COMPLEXE
Physicaly Right
JUSTE

*« The ‘**essential**’ Revolution is Keplian » (FMT, 2021)*

Newton: Theory + Computation (2 Bodies)
Einstein: A little bit more complex …
Future: ? (Mond ….)

Thèse(s)

Winds

1 ejecta + Wind(s)

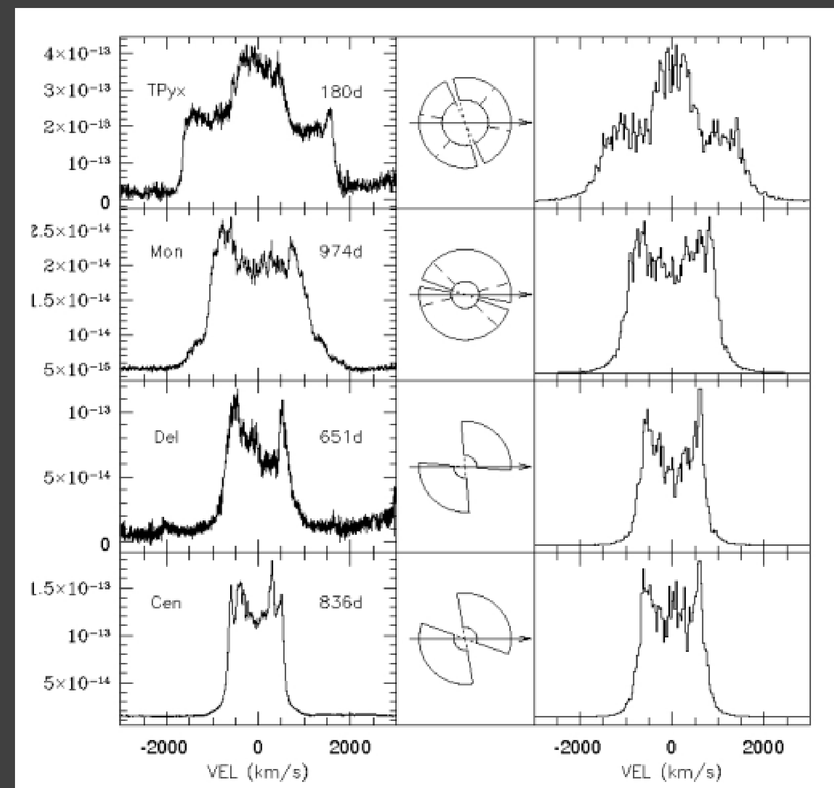
Several ejecta (equatorial, tropical, polar)+ Winds(s) or no

Chocks …

Antithèse (Uniformed model):

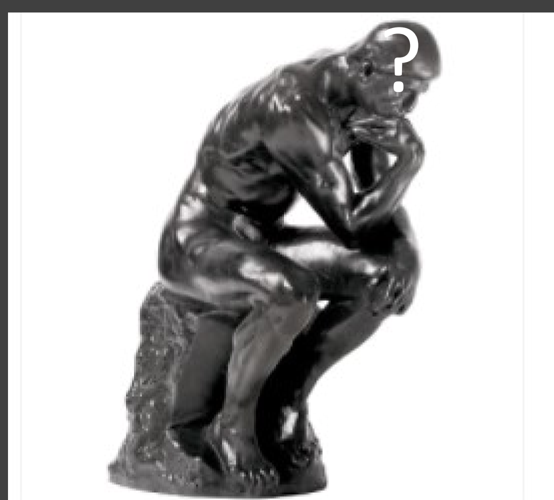
1 ejecta

Opacité + Ionization stages



Masson+,2018

Synthèse:



Classification of Novae

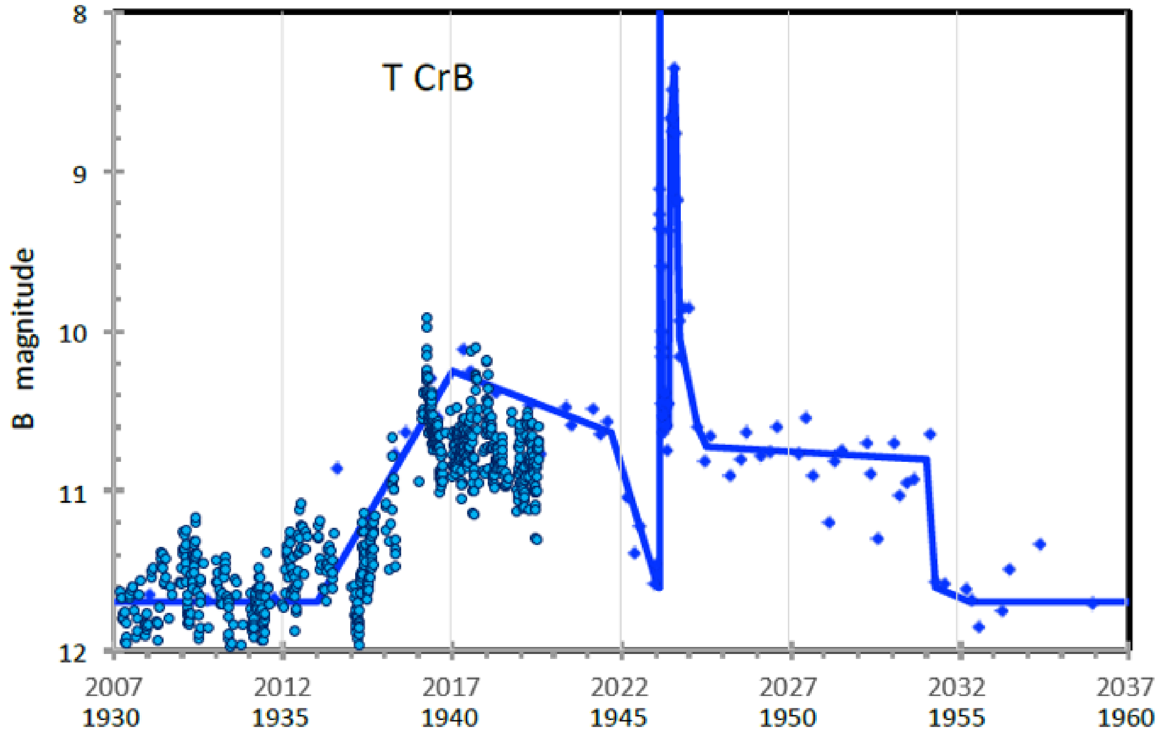
NOVAE

- Classical NOVAE (N = +++100)
  - NOVAE Fast to slow
  - Symbiotic NOVAE Very Slow
    - S Type (Red Giant): AG Peg, RT Ser, V1329 Cyg, PU Vul
    - D Type (Mira): RR Tel, V2110 Oph, V1016 Cyg, HM Sge, RX Pup, V407 Cyg, CN Cha
- Recurrent NOVAE (N = 10)
  - U Sco type
  - T Pyx type
  - T CrB type Symbiotic: T CRB, RS Oph, V745 Sco, V3980 Sgr

References Allen 1980
Mürset & Nussbaumer 1994
Munari 1997
Mikolajewska 201

Symbiotiques : T CrB RS Oph

Pre-nova outburst monitoring



Adapted from Brad Shaeffer

Diamonds : 1946 Brad Shaefer data

Dots : AAVSO B band - 1 day mean

Outburst predicted : 2023.6 +/-1

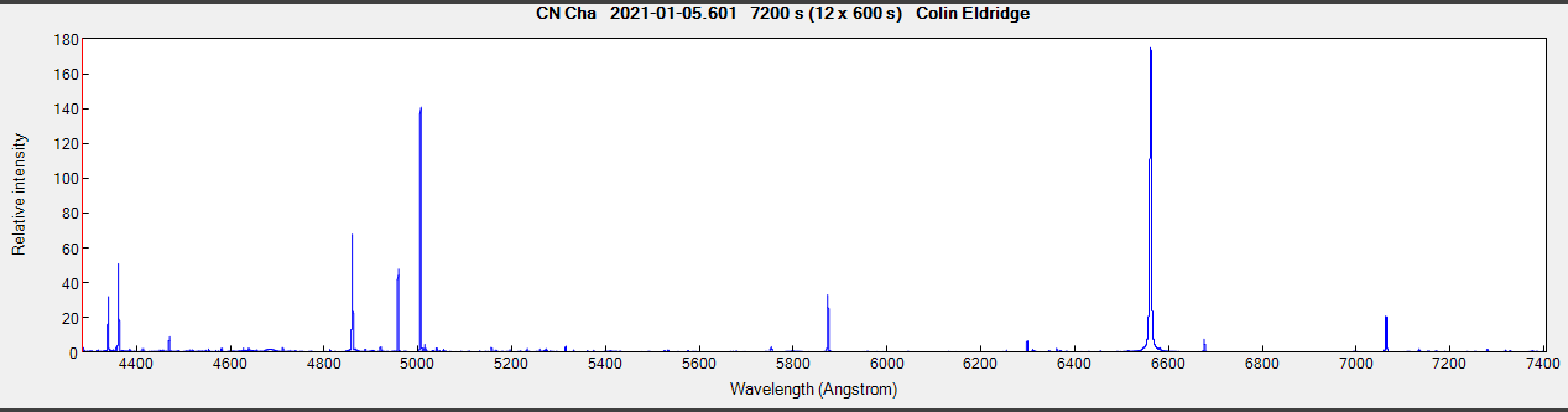
Other monitoring of a recurrent nova: RS Oph

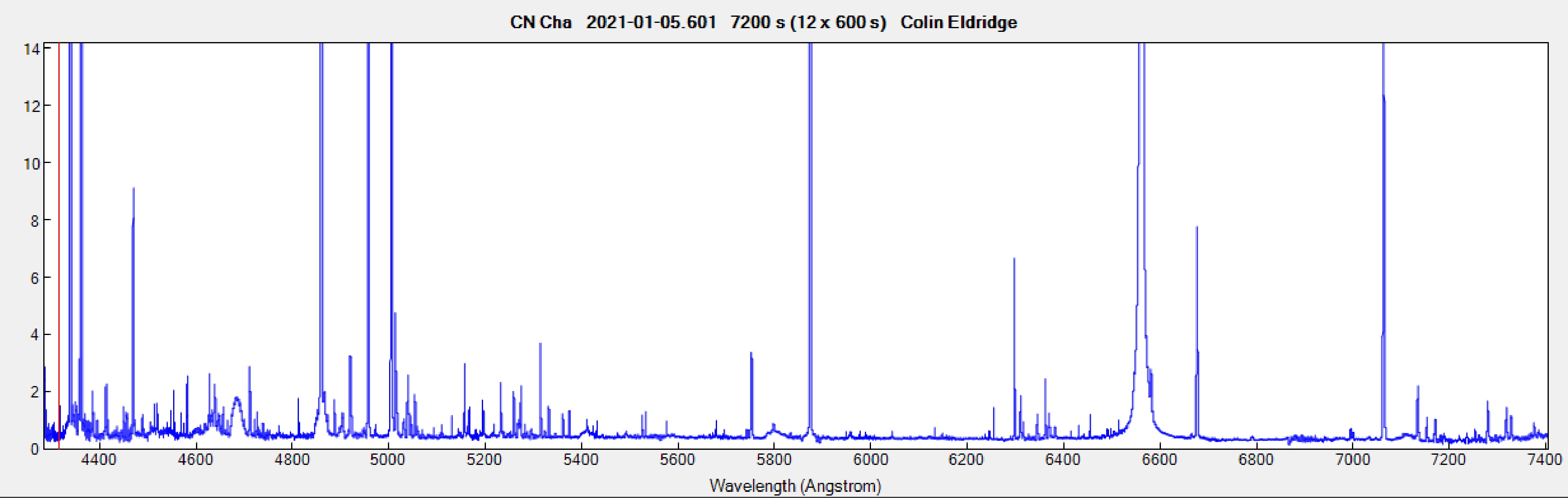
In collaboration with Natalia Shagatova and Augustin Skopal

Novae symbiotiques

CN Cha

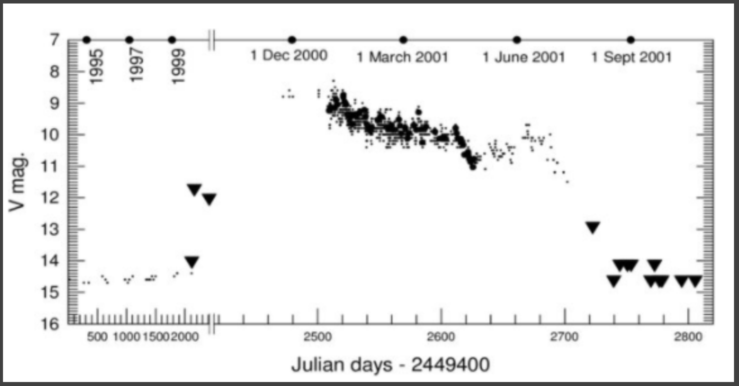
My Christmas gift ☺

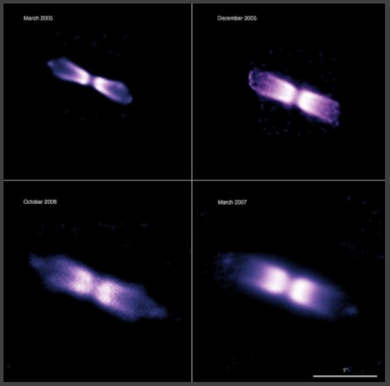


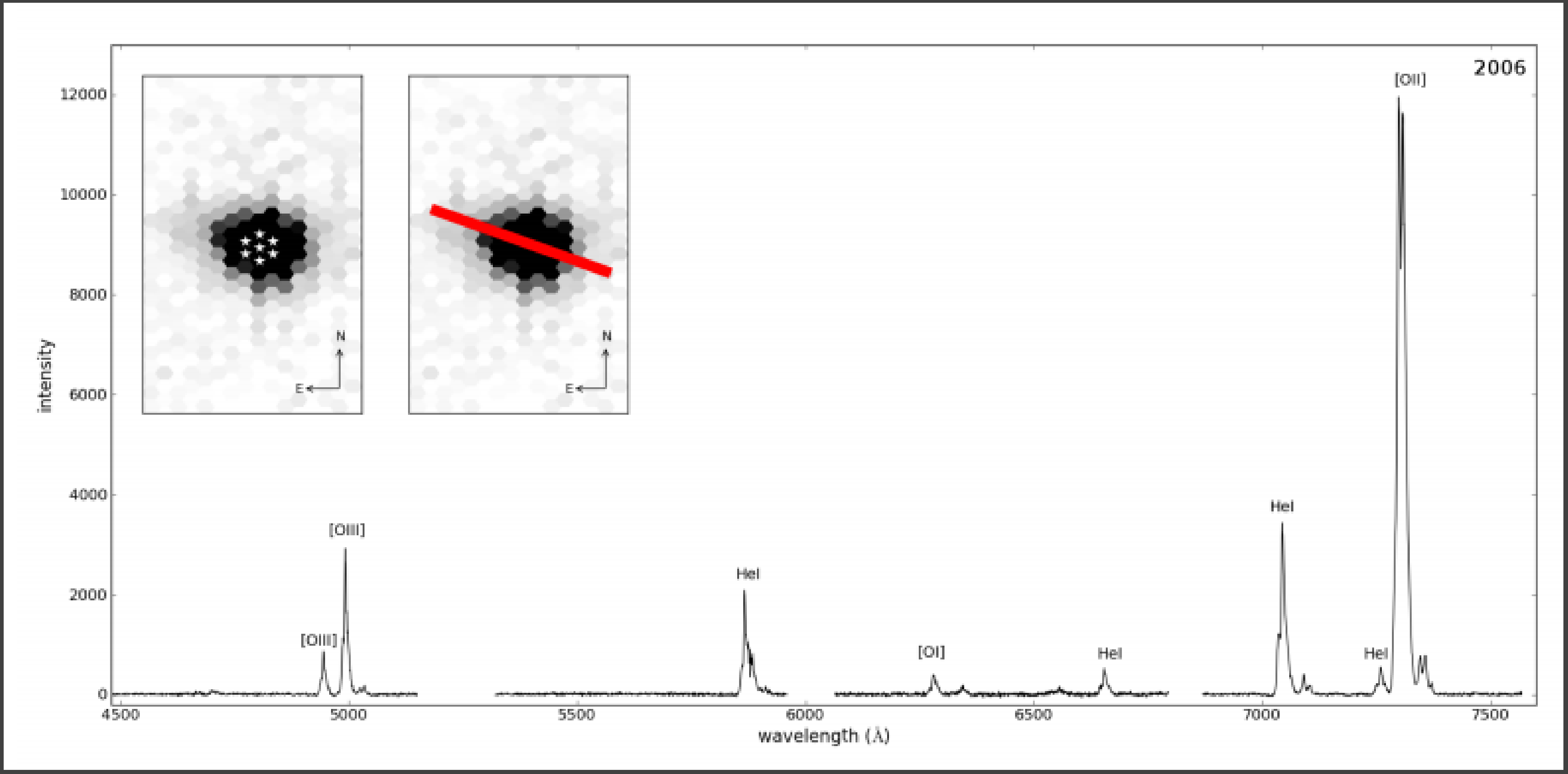


Helium Nova

V445 Pup



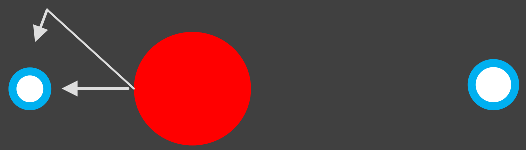




F. Teyssier January 2021

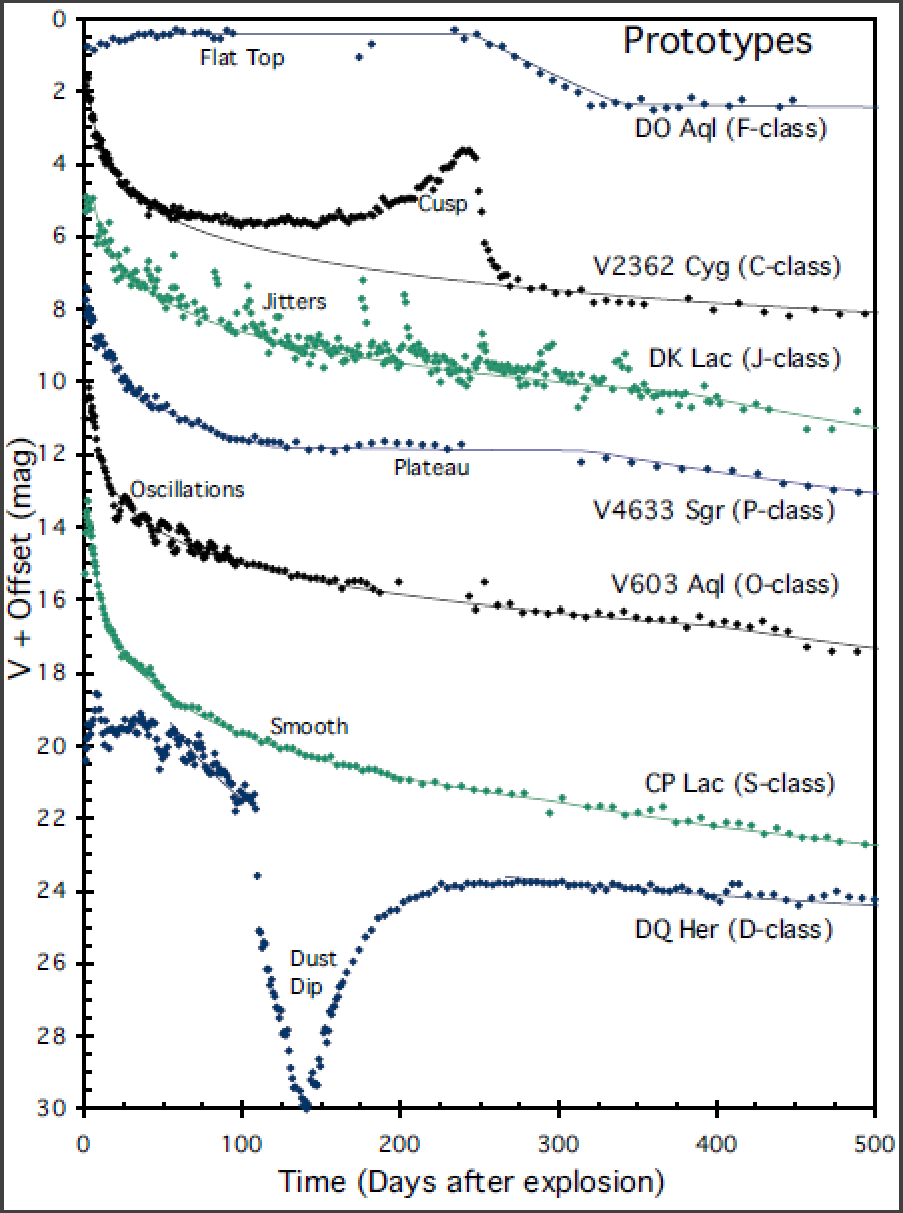
Novae | Références

White Dwarf
Masse
Température
Luminosité
Composition He →CO→ Ne
Homégénéité
Magnétisme



Enveloppe
Masse
Taux accrétion
Densité
Pression
Composition Matière accrétée + mixing
Géométrie
Rotation White Dwarf
Régime accrétion
Zone accrétion
Migration de la matière accrétée

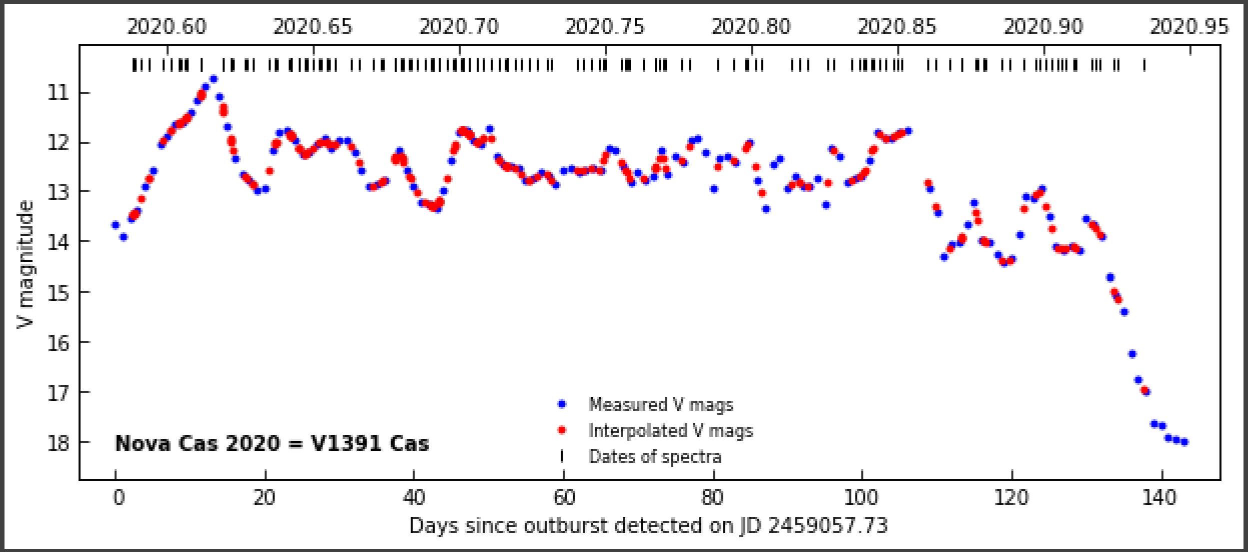
Variations

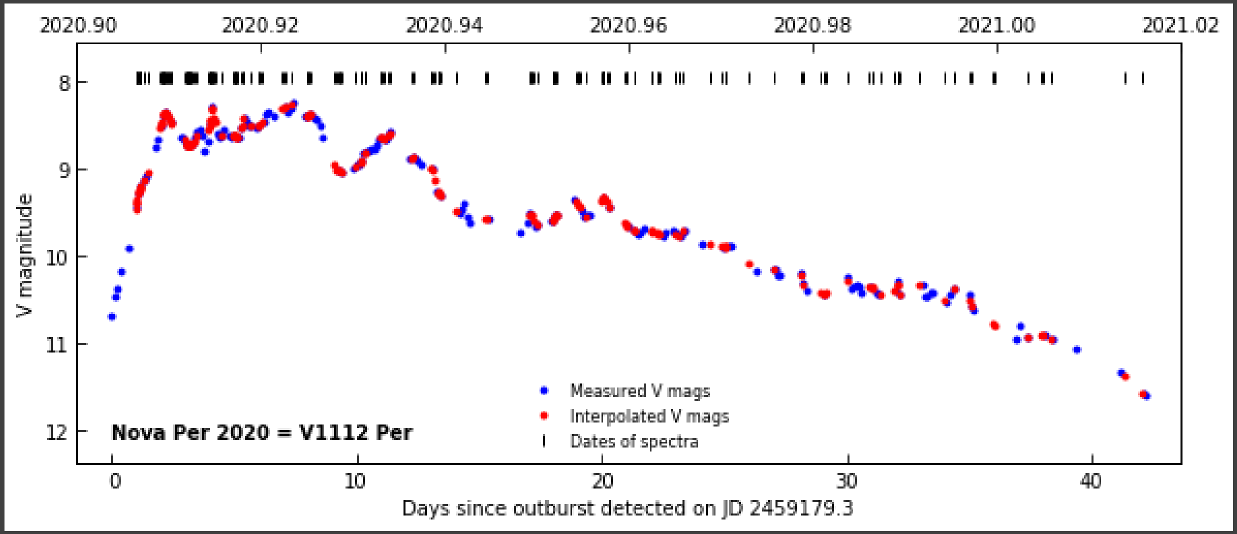


Strope, Shaeffer, Henden, 2010
Catalog of 93 Nova Light Curves: Classification and Properties

Two novae with oscillations at maximum

Luminosity curves: selected and interpollated AAVSO data by David Boyd



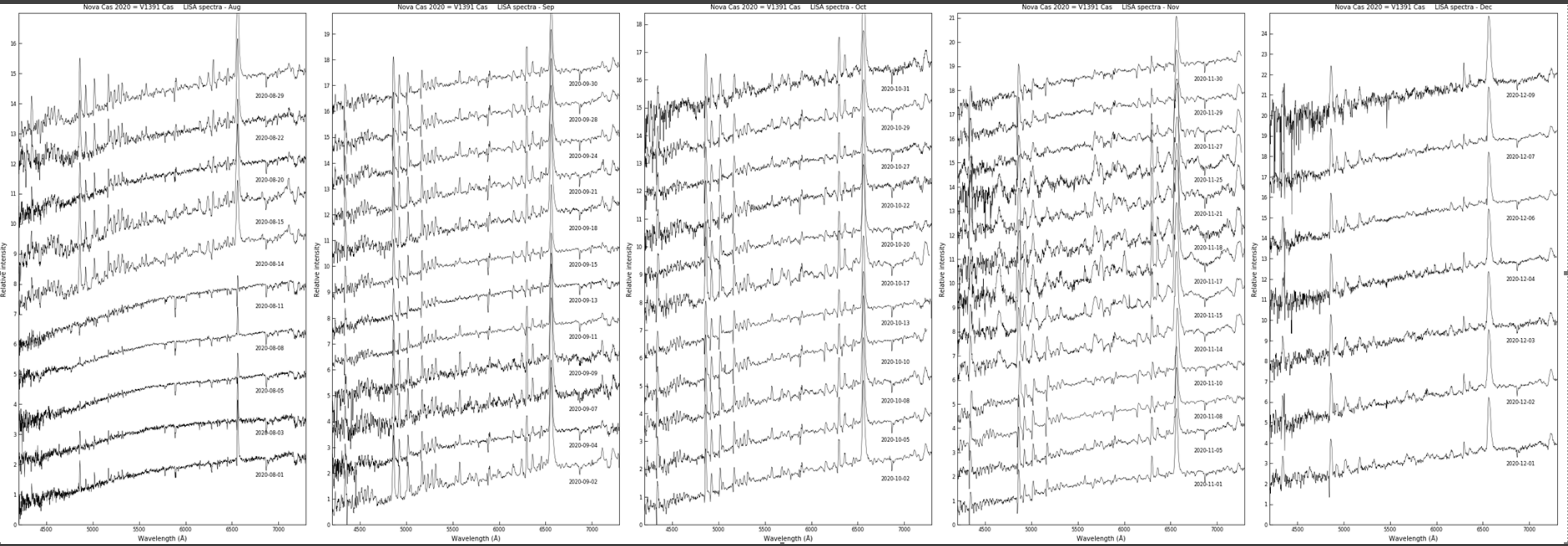


"It's somewhere between a nova and a supernova ... probably a pretty good nova."

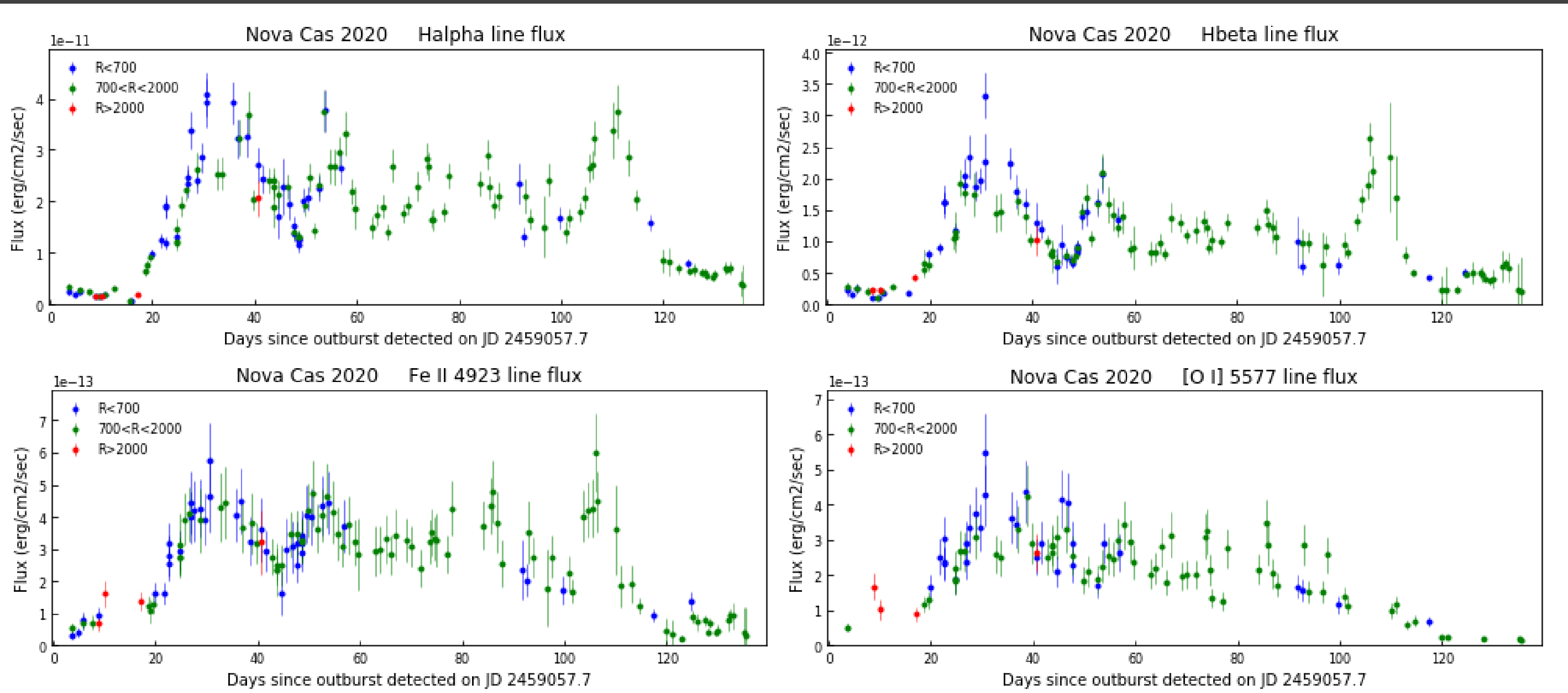
''It's somewhere between a nova and something else ... probably a pretty bad nova.''

A classic
(RS Oph Conference, 1985)
adapted by
François Teyssier
Nova Cas 2020
Nova Per 2020

"All right then, I'll go to hell!"
Mark Twain
Private Message ;-)

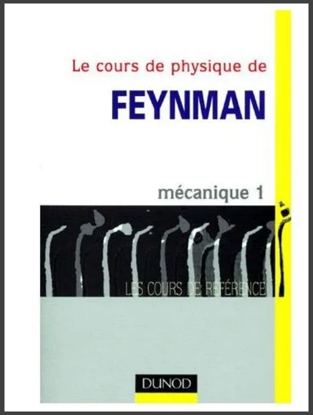


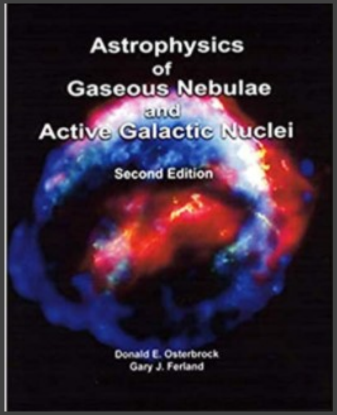
Nova Cas 2020
Low Resolution Spectra
Study: David Boyd

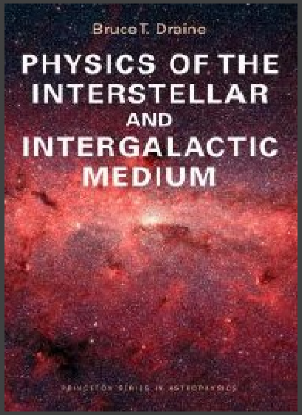


Nova Cas 2020
Intensity of the flux of a few lines on flux calibrated spectra
Study: David Boyd

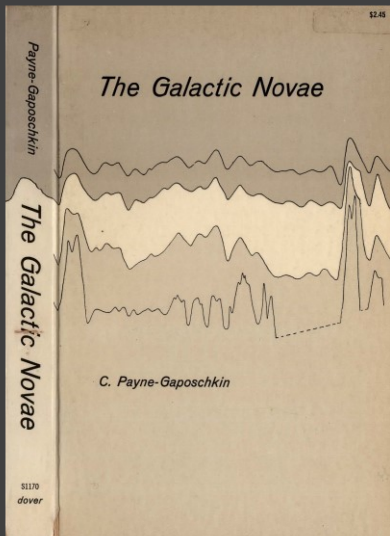
Basis. A few of my favourite lectures



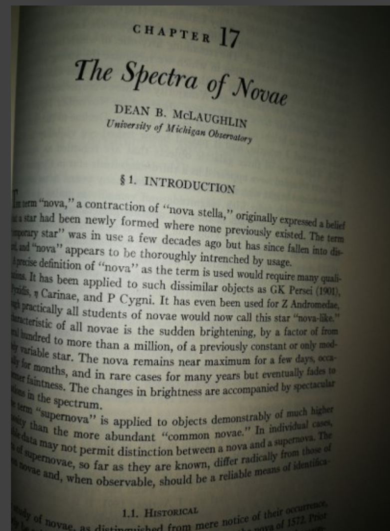




+ Read the « old » publications (1930 à 1950)



1956


CHAPTER 17

The Spectra of Novae

DEAN B. McLAUGHLIN
University of Michigan Observatory

§ 1. INTRODUCTION

term "nova," a contraction of "nova stella," originally expressed a belief
a star had been newly formed where none previously existed. The term
porary star" was in use a few decades ago but has since fallen into dis-
and "nova" appears to be thoroughly intrenched by usage.
precise definition of "nova" as the term is used would require many quali-
It has been applied to such dissimilar objects as GK Persei (1901),
η Carinae, and P Cygni. It has even been used for Z Andromedae,
practically all students of novae would now call this star "nova-like."
racteristic of all novae is the sudden brightening, by a factor of from
hundred to more than a million, of a previously constant or only mod-
variable star. The nova remains near maximum for a few days, occa-
for months, and in rare cases for many years but eventually fades to
faintness. The changes in brightness are accompanied by spectacular
in the spectrum.
term "supernova" is applied to objects demonstrably of much higher
than the more abundant "common novae." In individual cases,
data may not permit distinction between a nova and a supernova. The
of supernovae, so far as they are known, differ radically from those of
novae and, when observable, should be a reliable means of identifica-

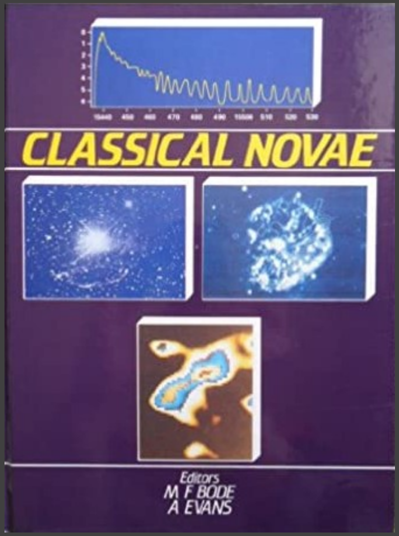
1.1. HISTORICAL

of novae, as distinguished from mere notice of their occurrence,

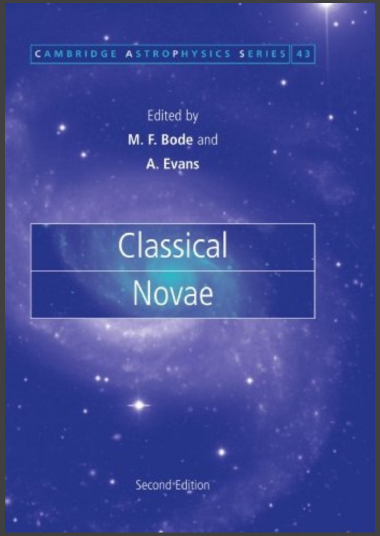
1960

Download:

http://www.astronomie-amateur.fr/Novae/Publications.html



1989



2008

Novae | Références

- Reviews