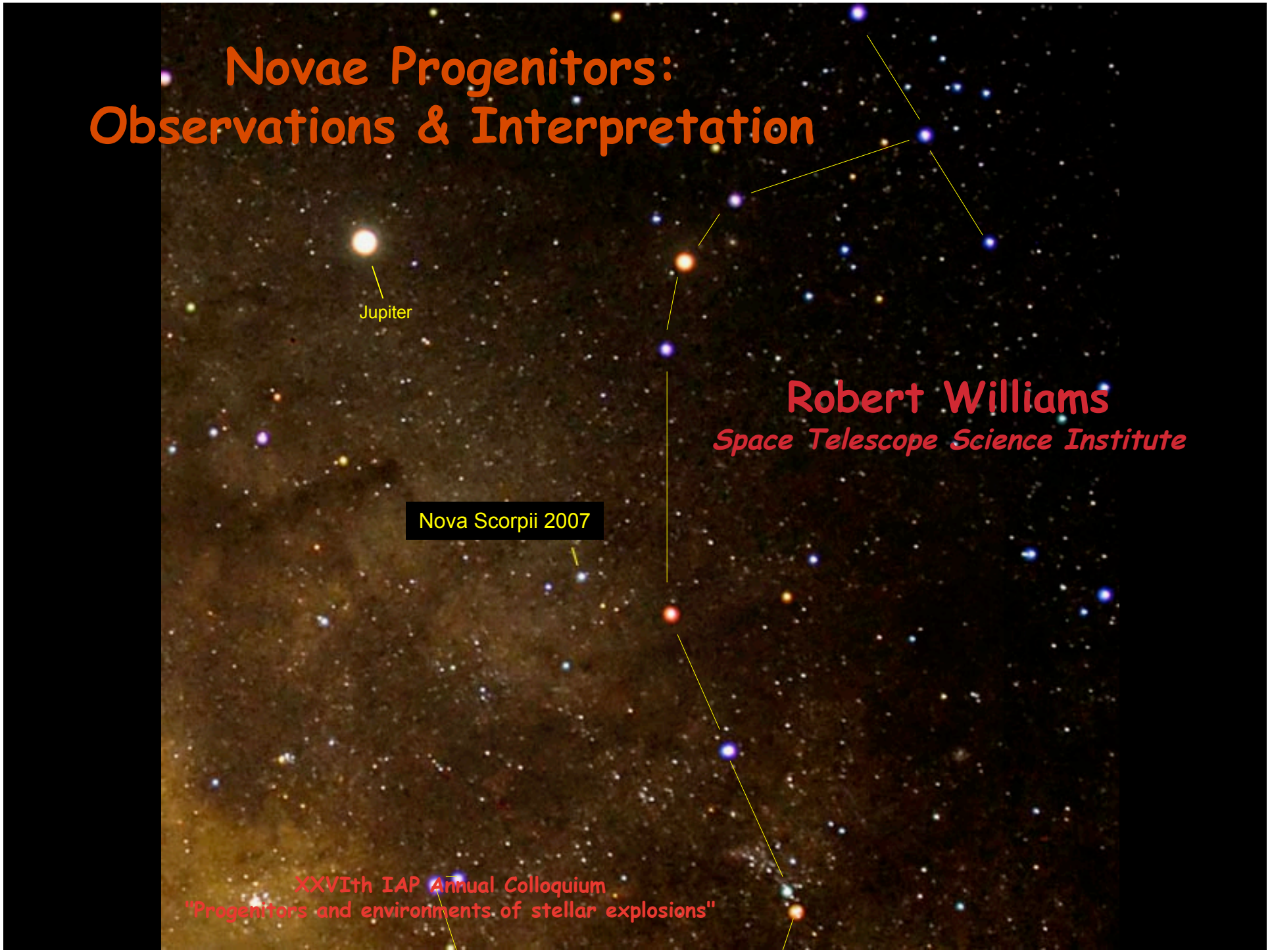
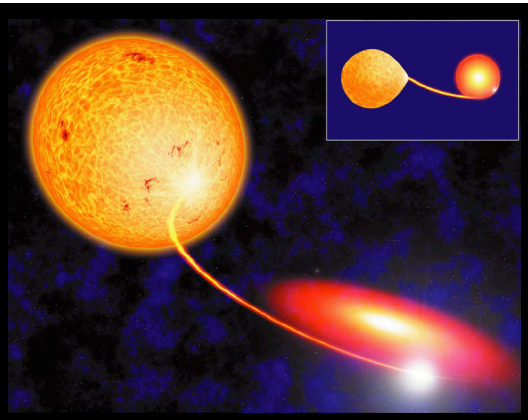
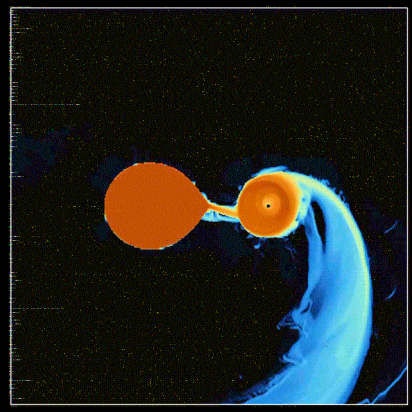
Novae Progenitors: Observations & Interpretation

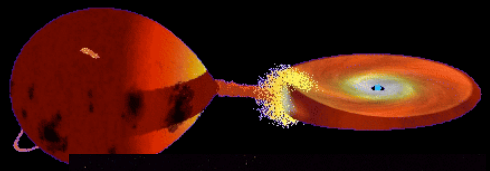


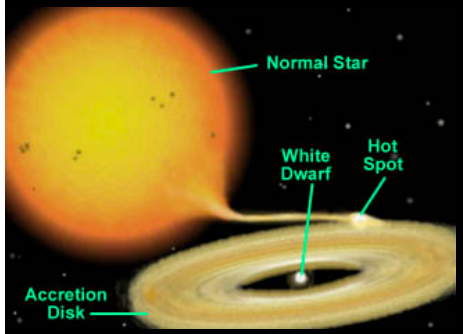
Robert Williams
Space Telescope Science Institute

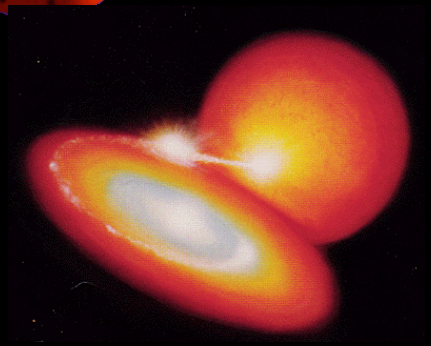
XXVIth IAP Annual Colloquium
"Progenitors and environments of stellar explosions"

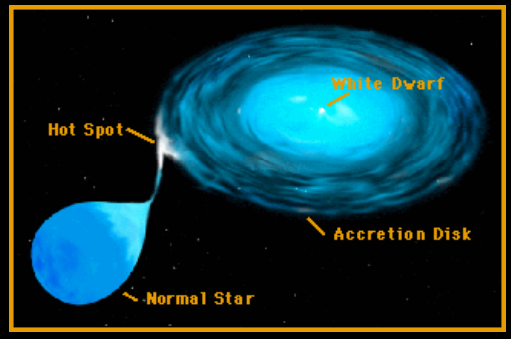


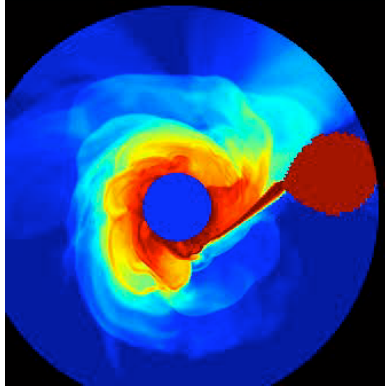


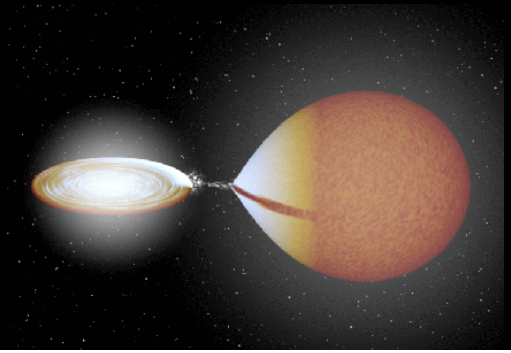


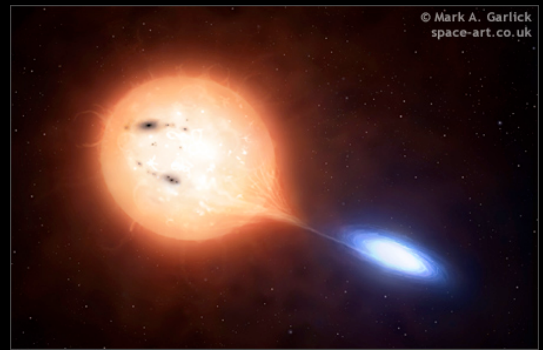








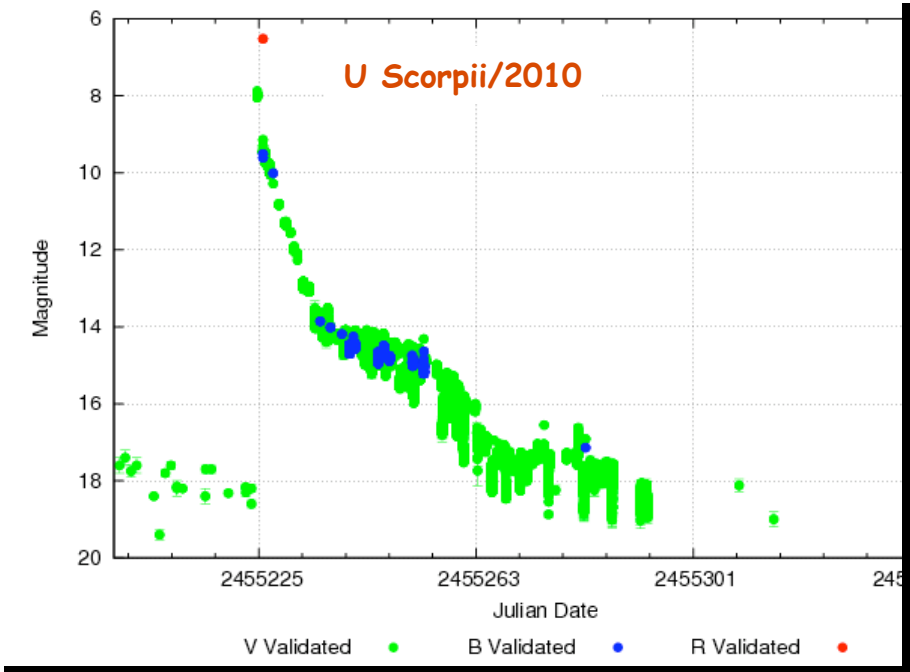


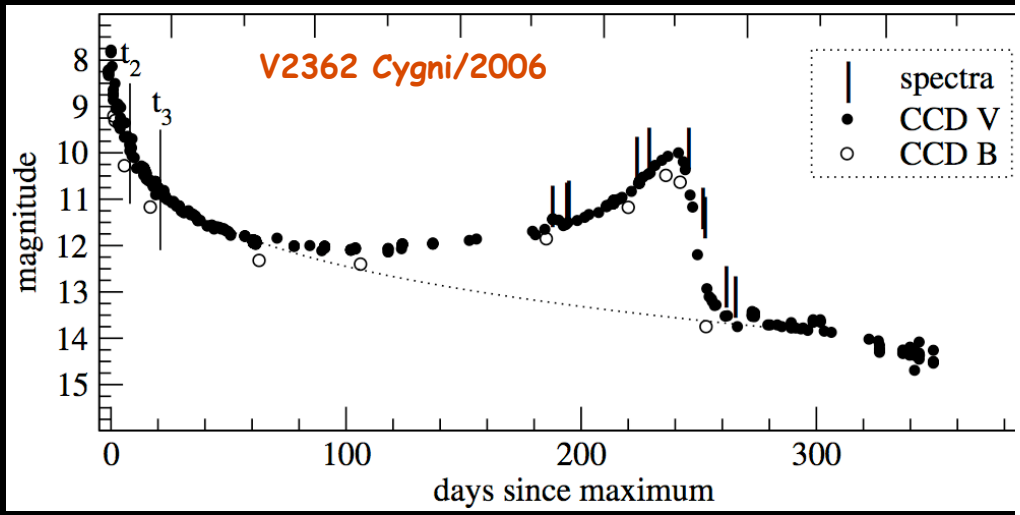


Google Images:
'Mass Transfer Binaries'

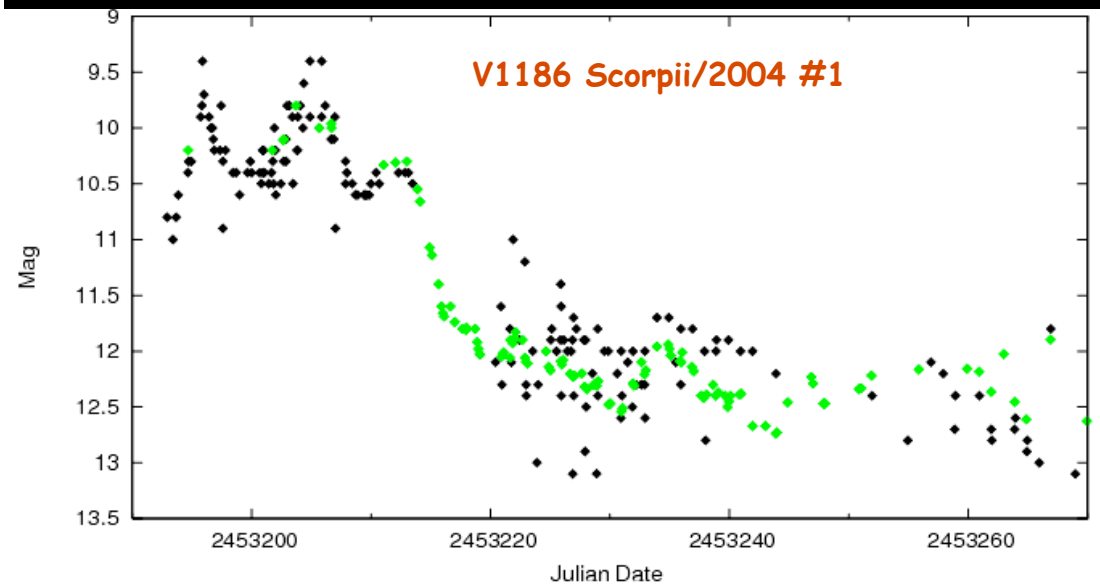
AAVSO

Novae: Light Curves



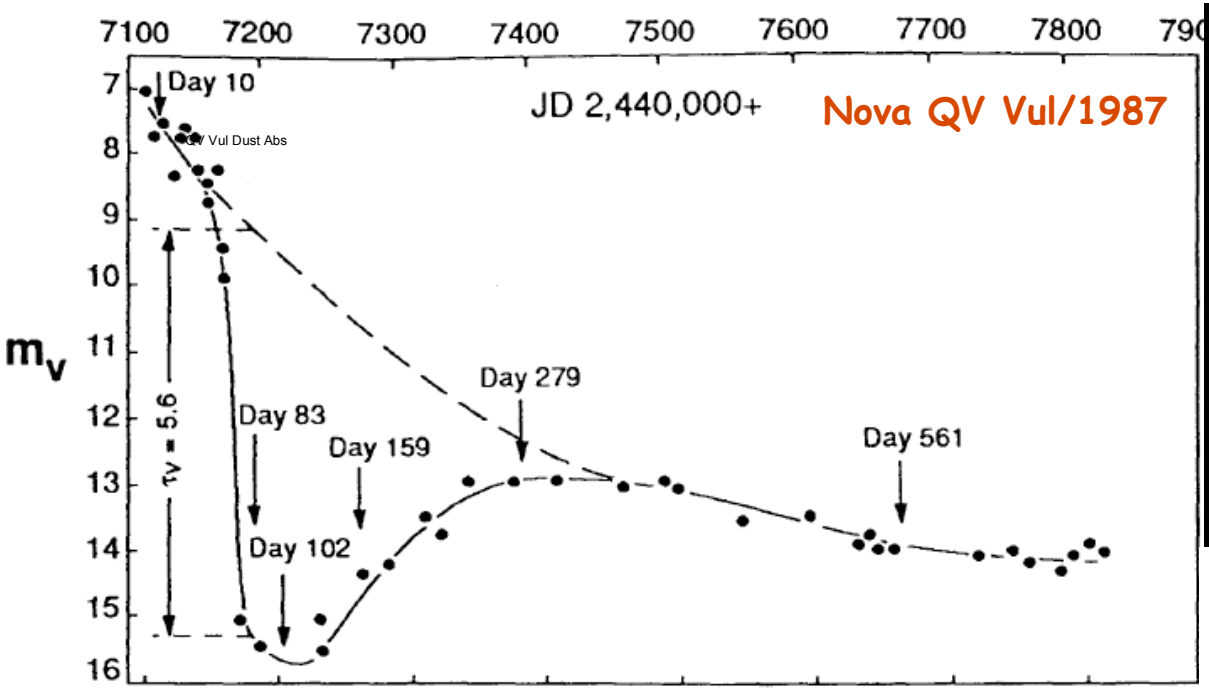


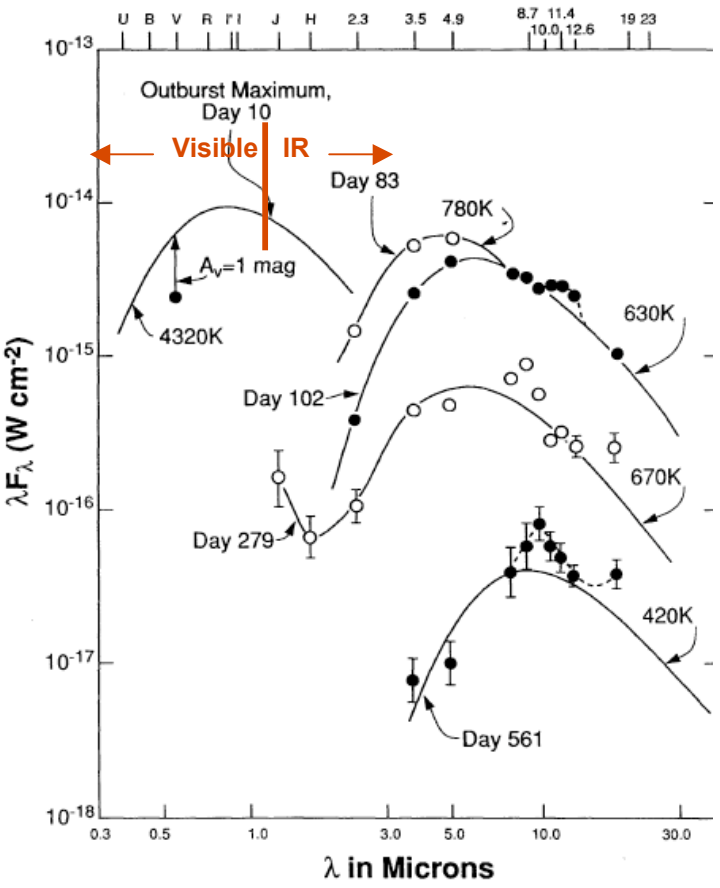
Kimeswenger et al. 2008, A&A, **471**, L51



AAVSO

Optical Extinction & IR Emission: Dust Formation

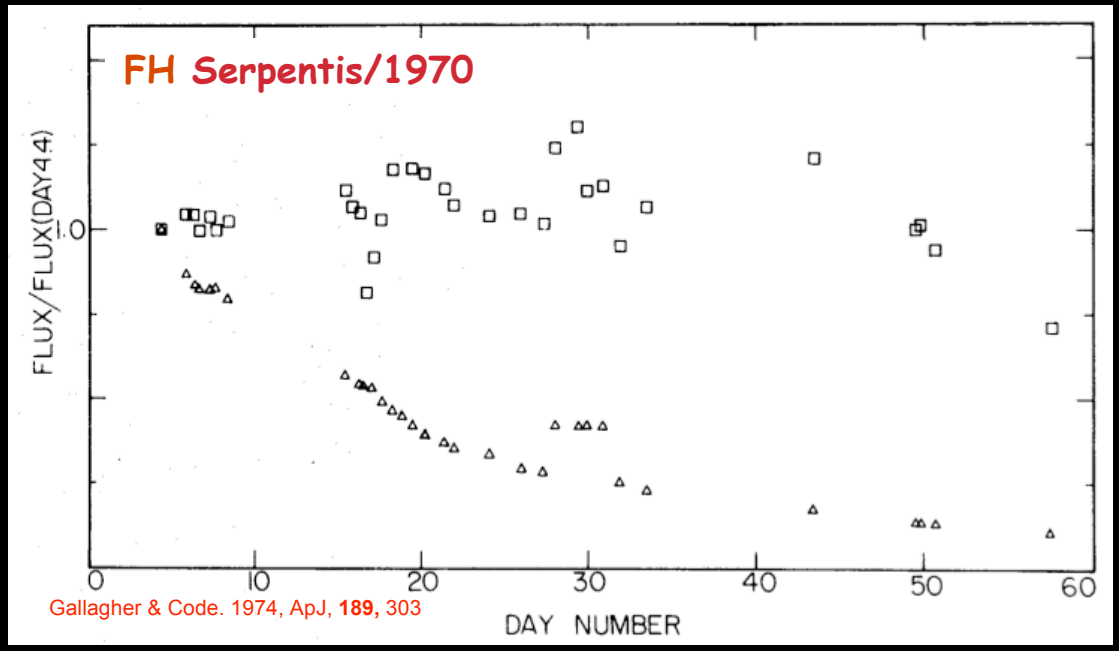




Gehrz et al. 1992, ApJ, **400**, 671

Novae:

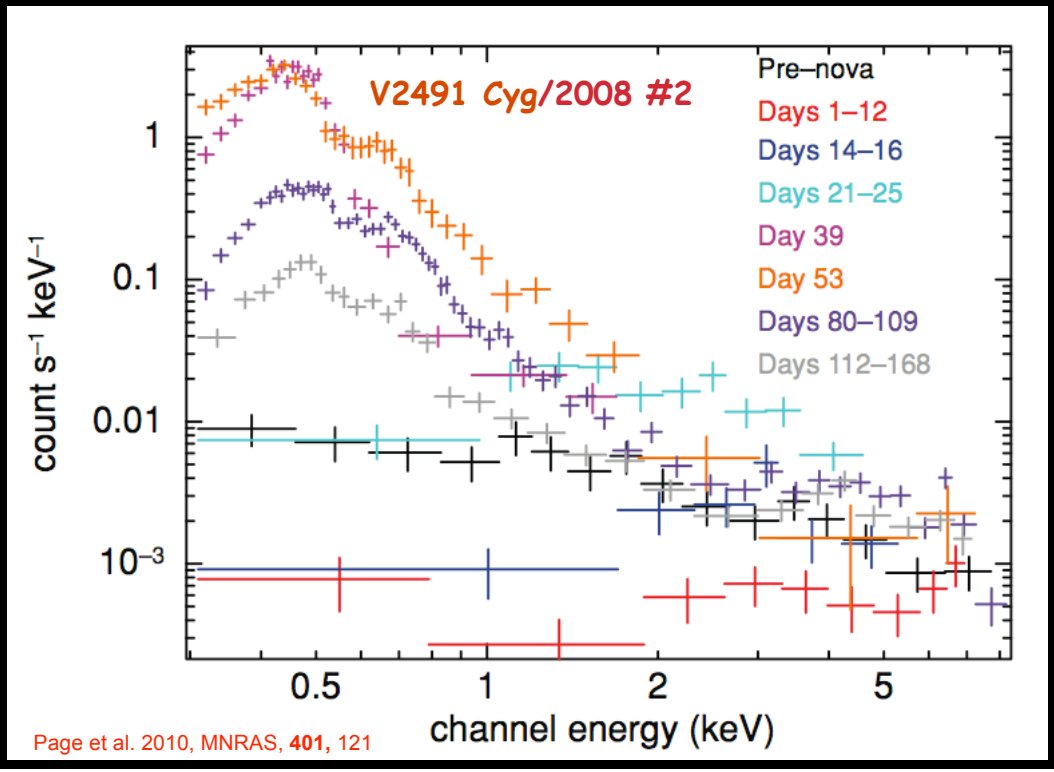
UV



Gallagher & Code. 1974, ApJ, **189,** 303

* Many novae remain at L_{edd} for weeks & months

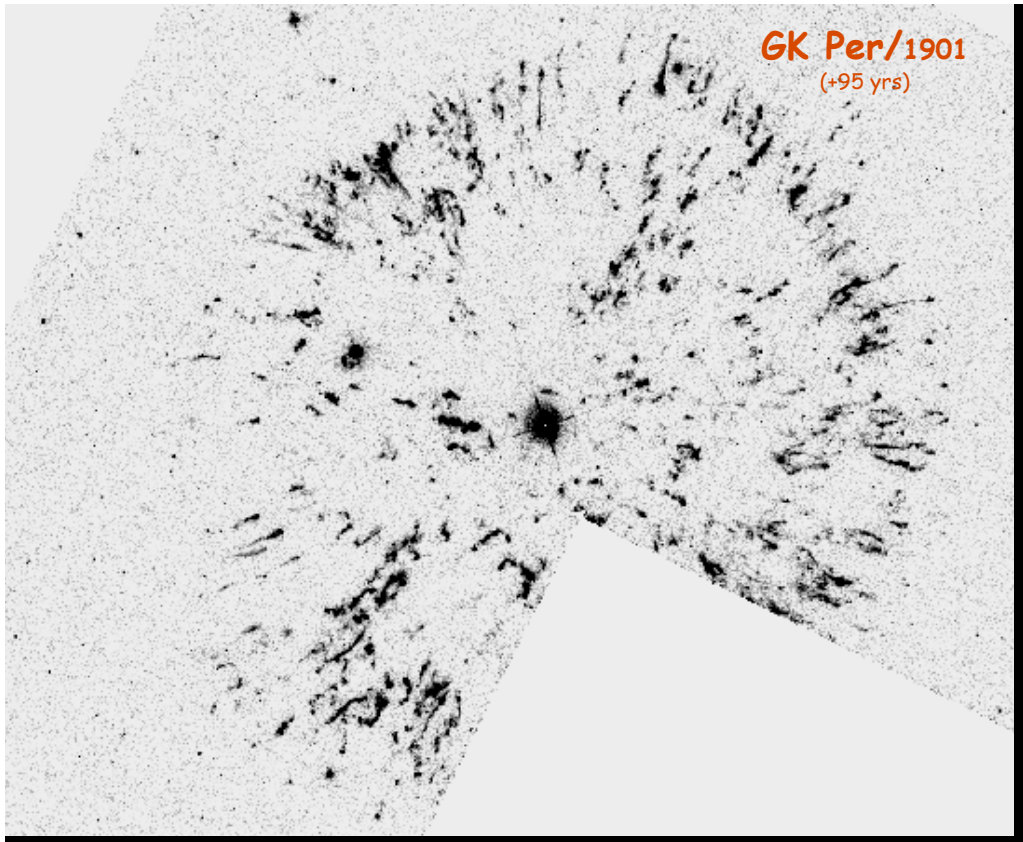
X-ray

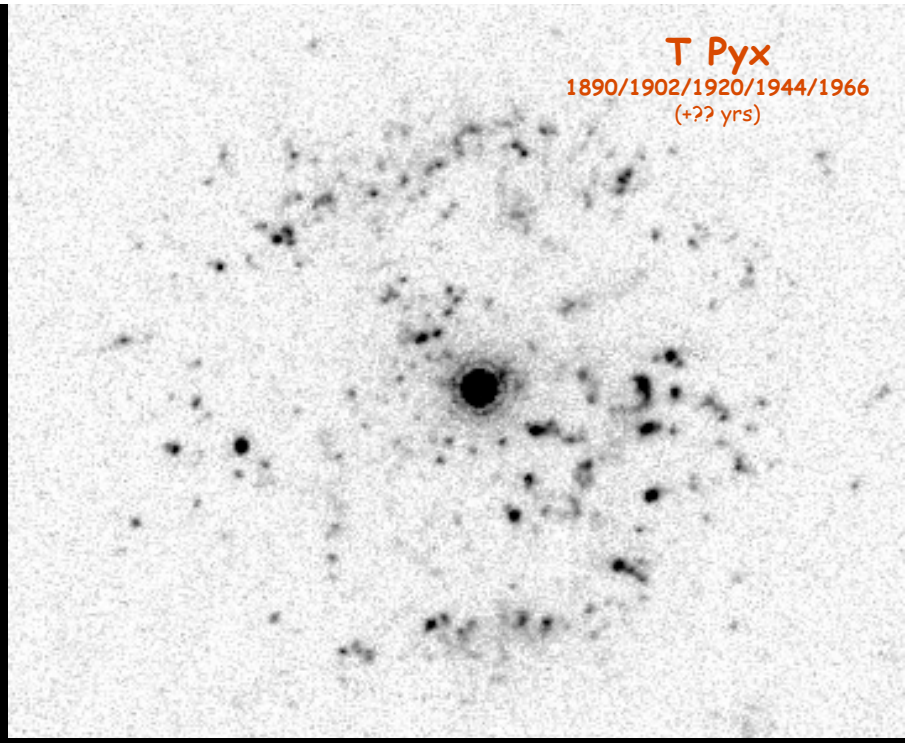


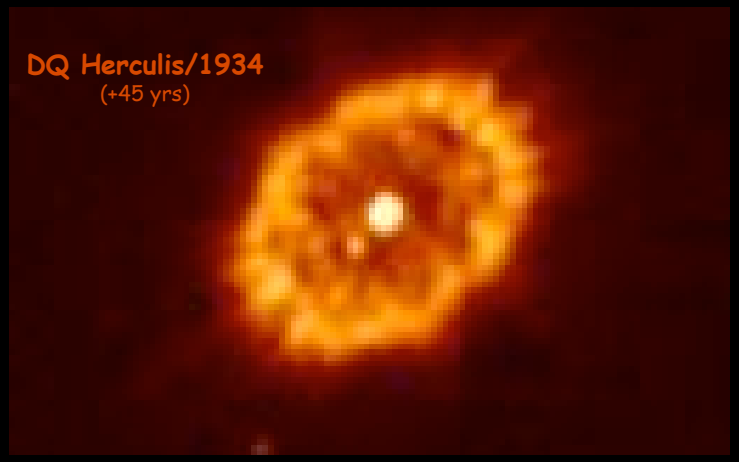
Page et al. 2010, MNRAS, **401,** 121

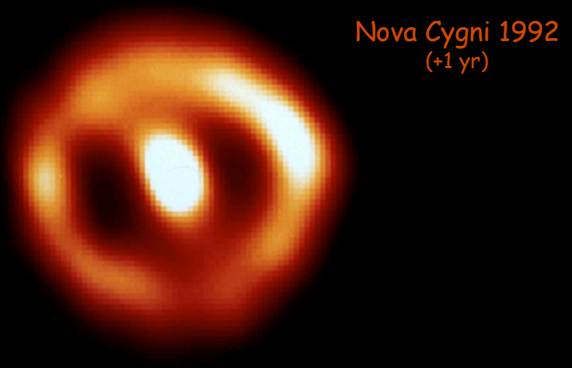
* <20% of novae show 'super soft' x-rays (<1 keV) in first weeks of outburst. Attributed to hot WD.
* >50% of novae show hard x-rays (>10 keV) months after outburst. Attributed to collisions between ejecta components.

Novae: Resolved Shells

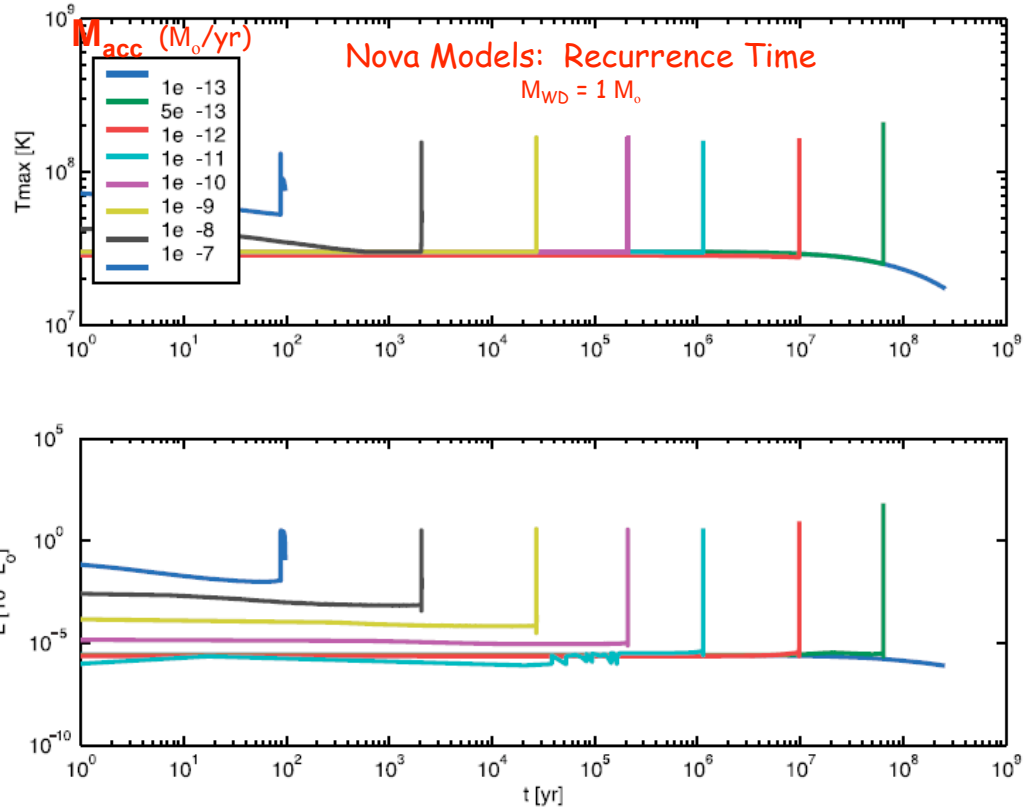




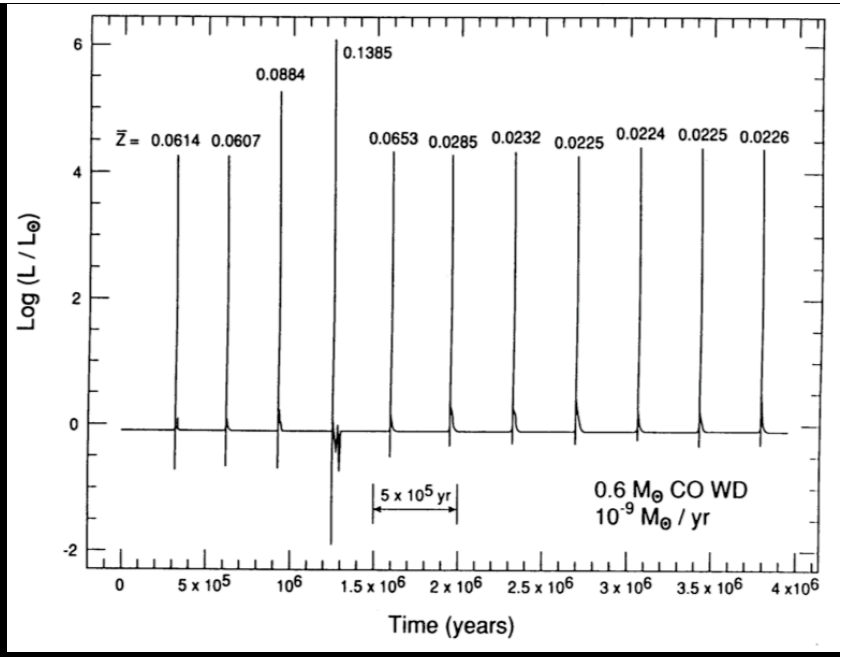


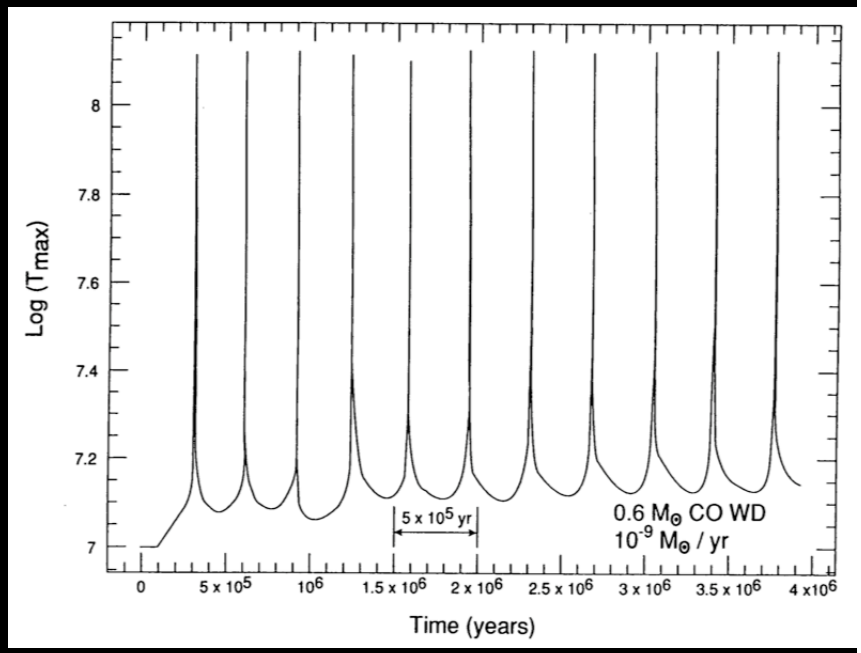


Multi-Cycle Nova Models

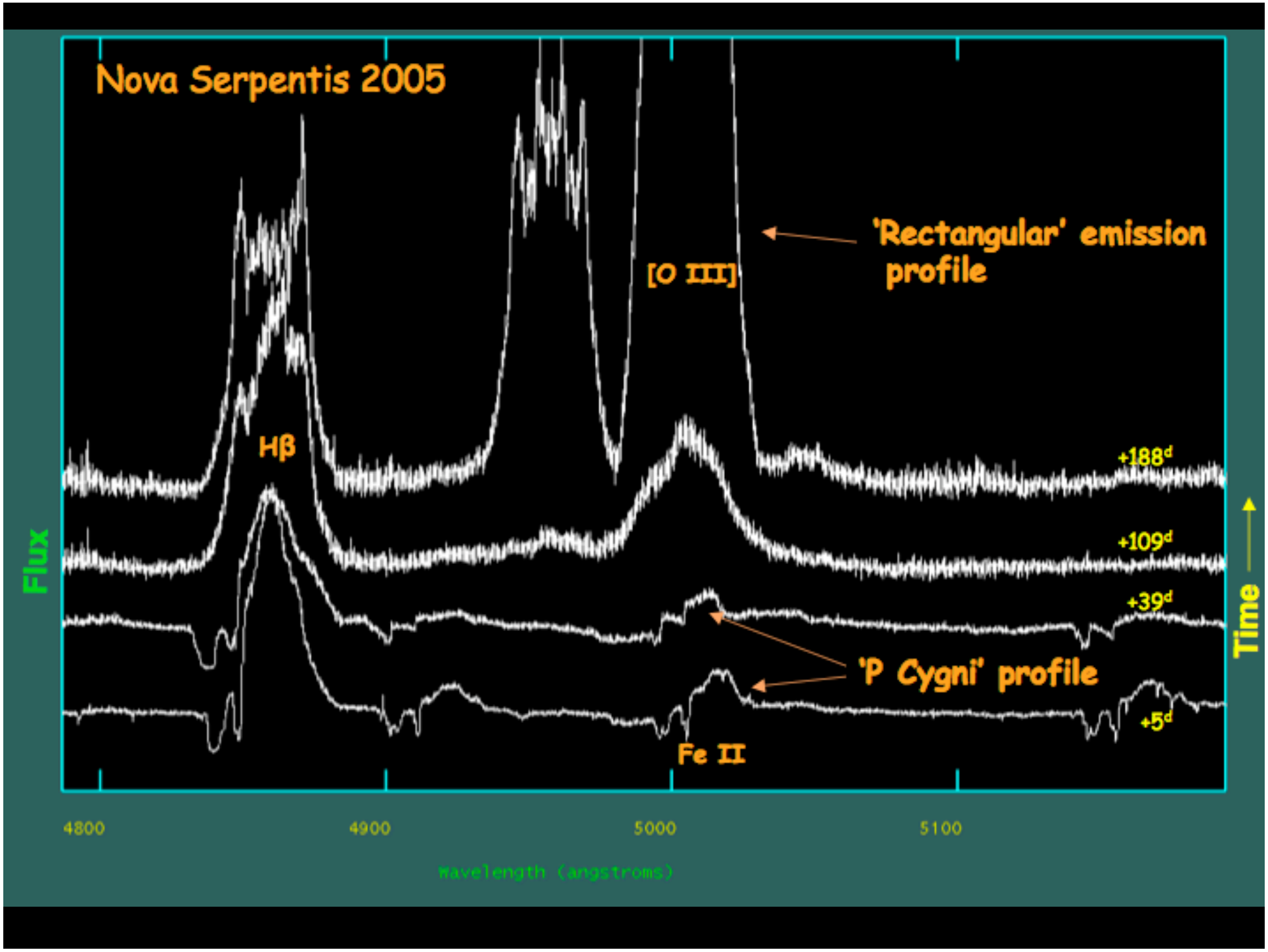


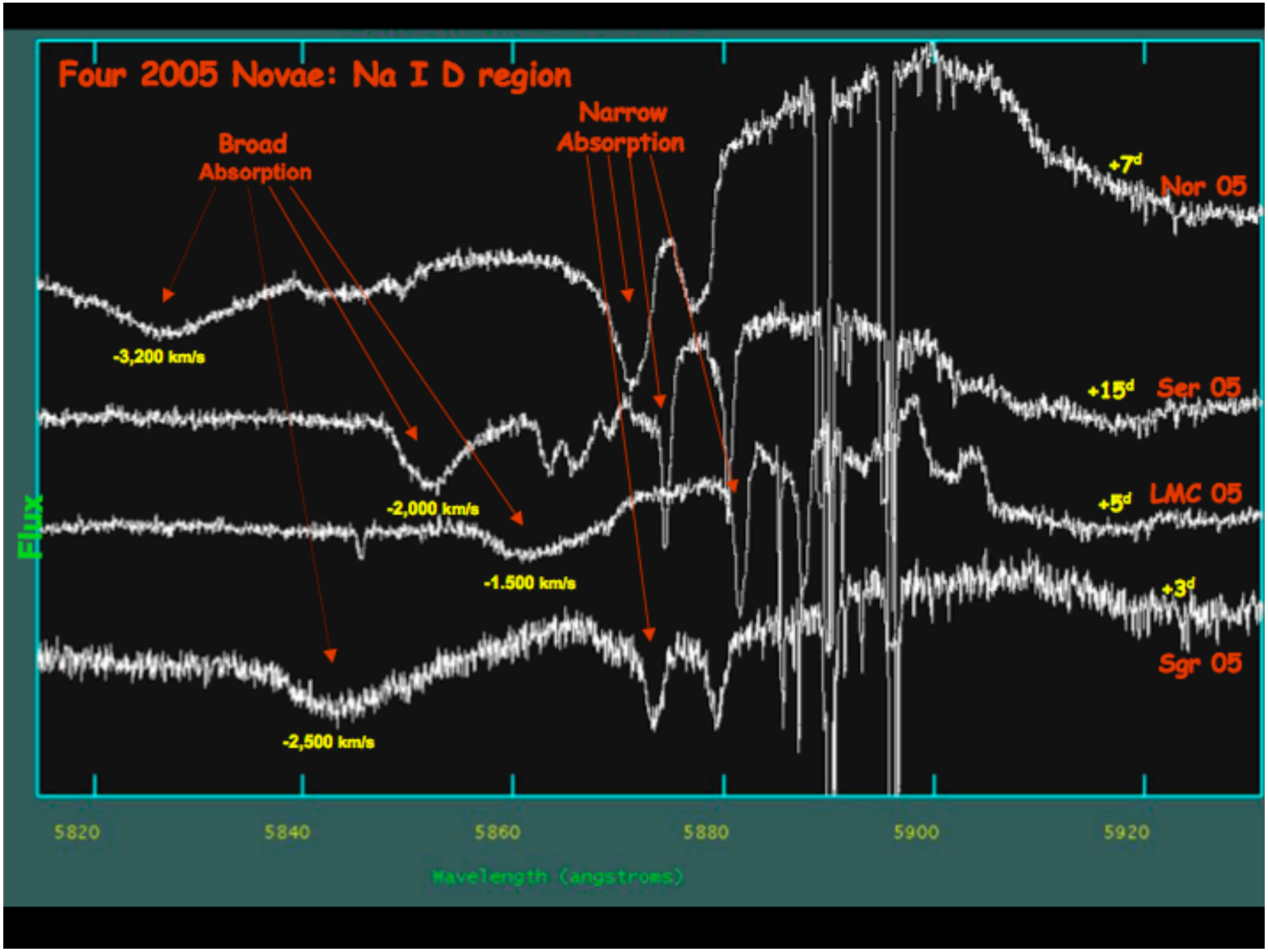
Yaron, O. et al. 2005, ApJ, **623**, 398

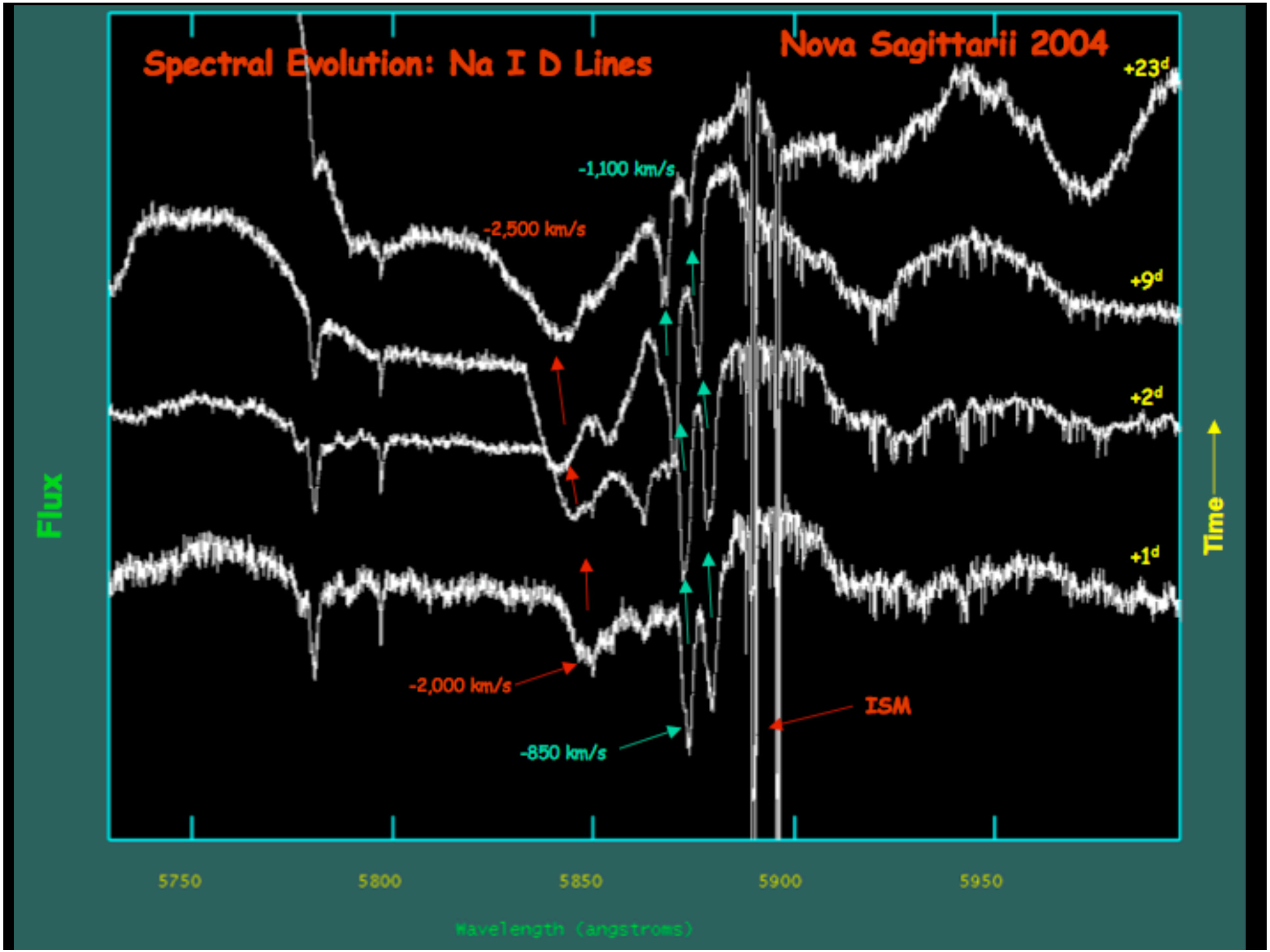


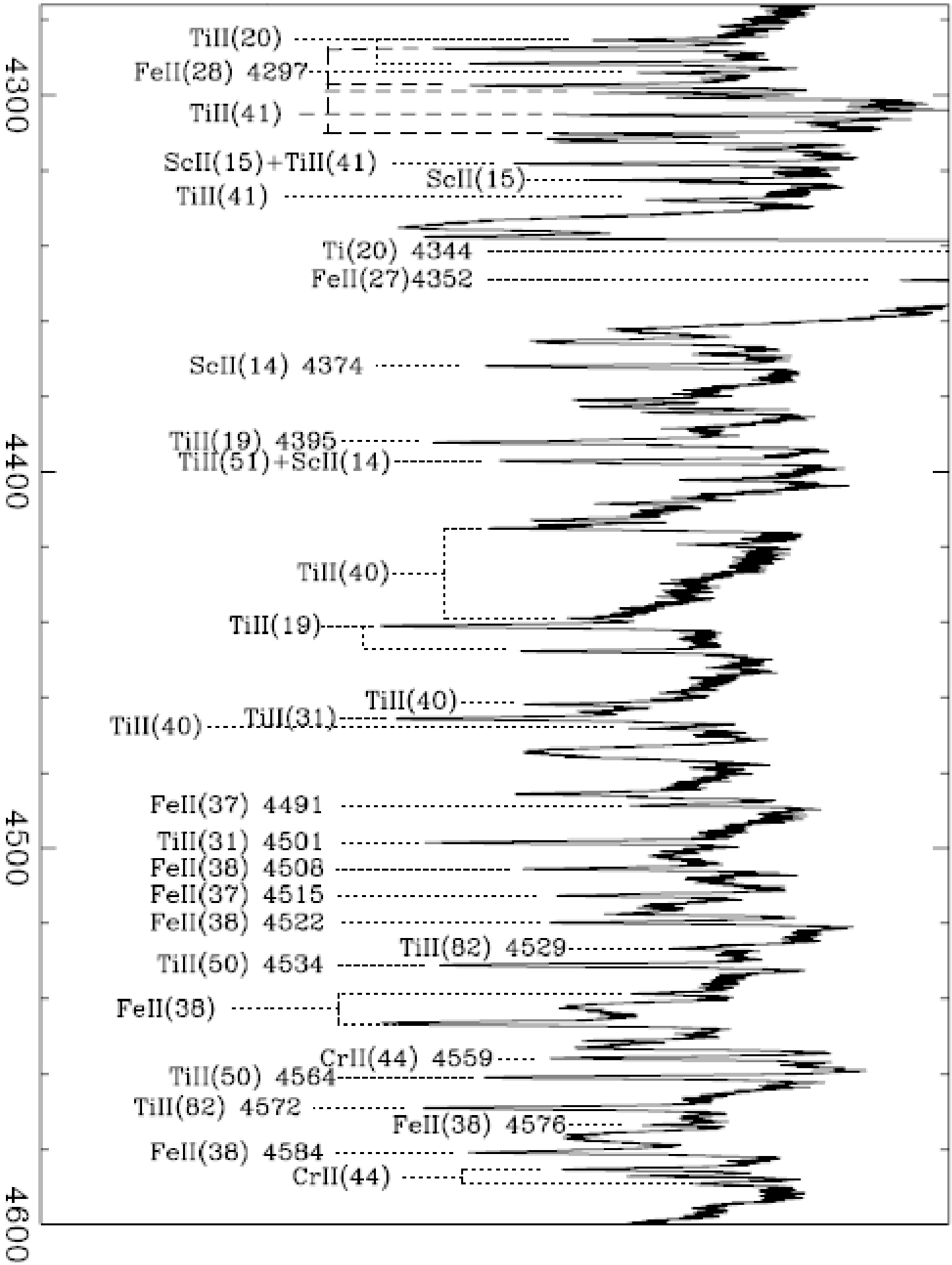


Shara, M. et al. 1993, ApJ, **623**, 398

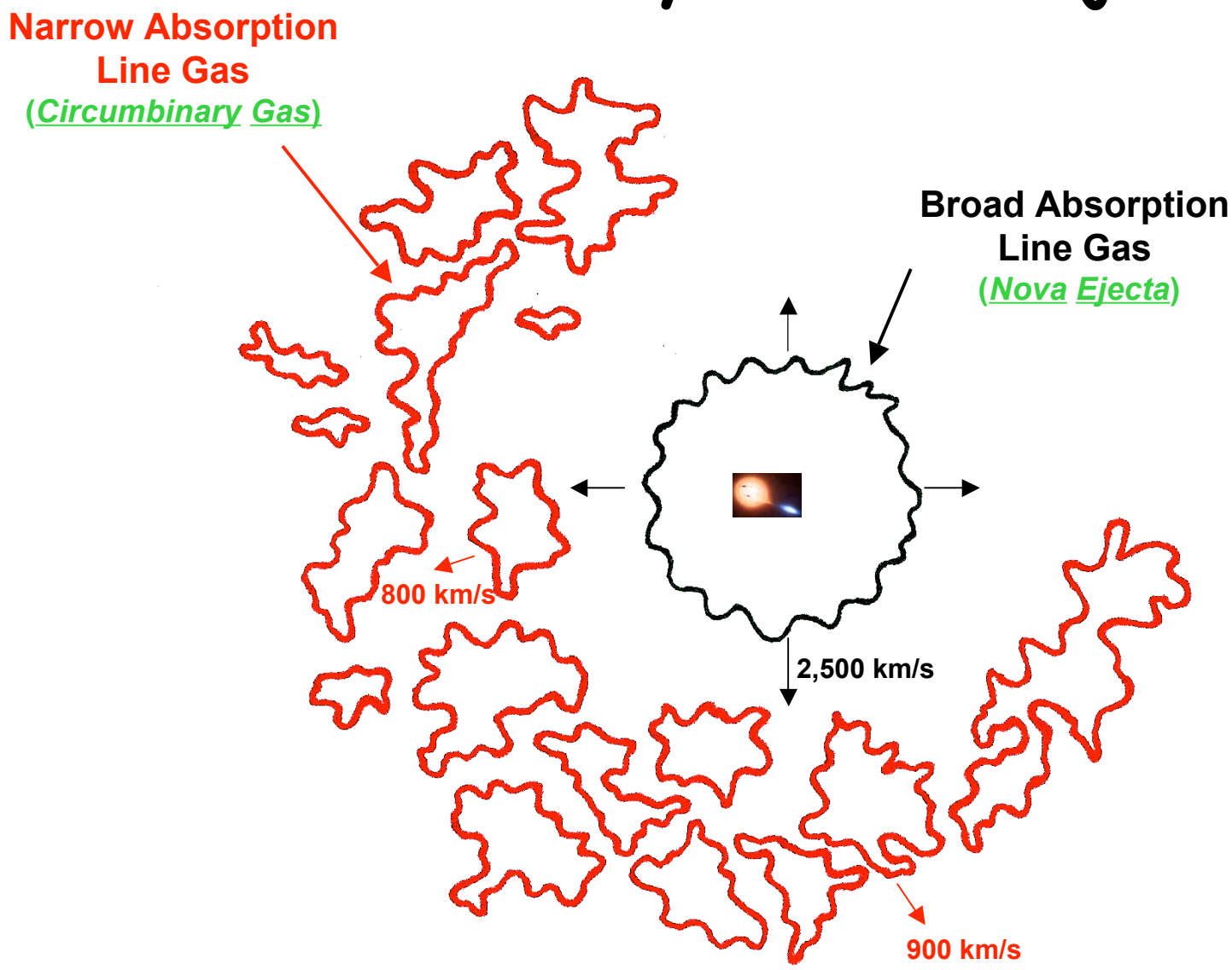

Nova Serpentis 2005
'Rectangular' emission profile
[O III]
Hβ
+188d
+109d
+39d
'P Cygni' profile
+5d
Fe II
Flux
Time
4800
4900
5000
5100
Wavelength (angstroms)


Four 2005 Novae: Na I D region
Broad Absorption
Narrow Absorption
-3,200 km/s
-2,000 km/s
-1.500 km/s
-2,500 km/s
+7d
Nor 05
+15d
Ser 05
+5d
LMC 05
+3d
Sgr 05
Flux
5820
5840
5860
5880
5900
5920
Wavelength (angstroms)

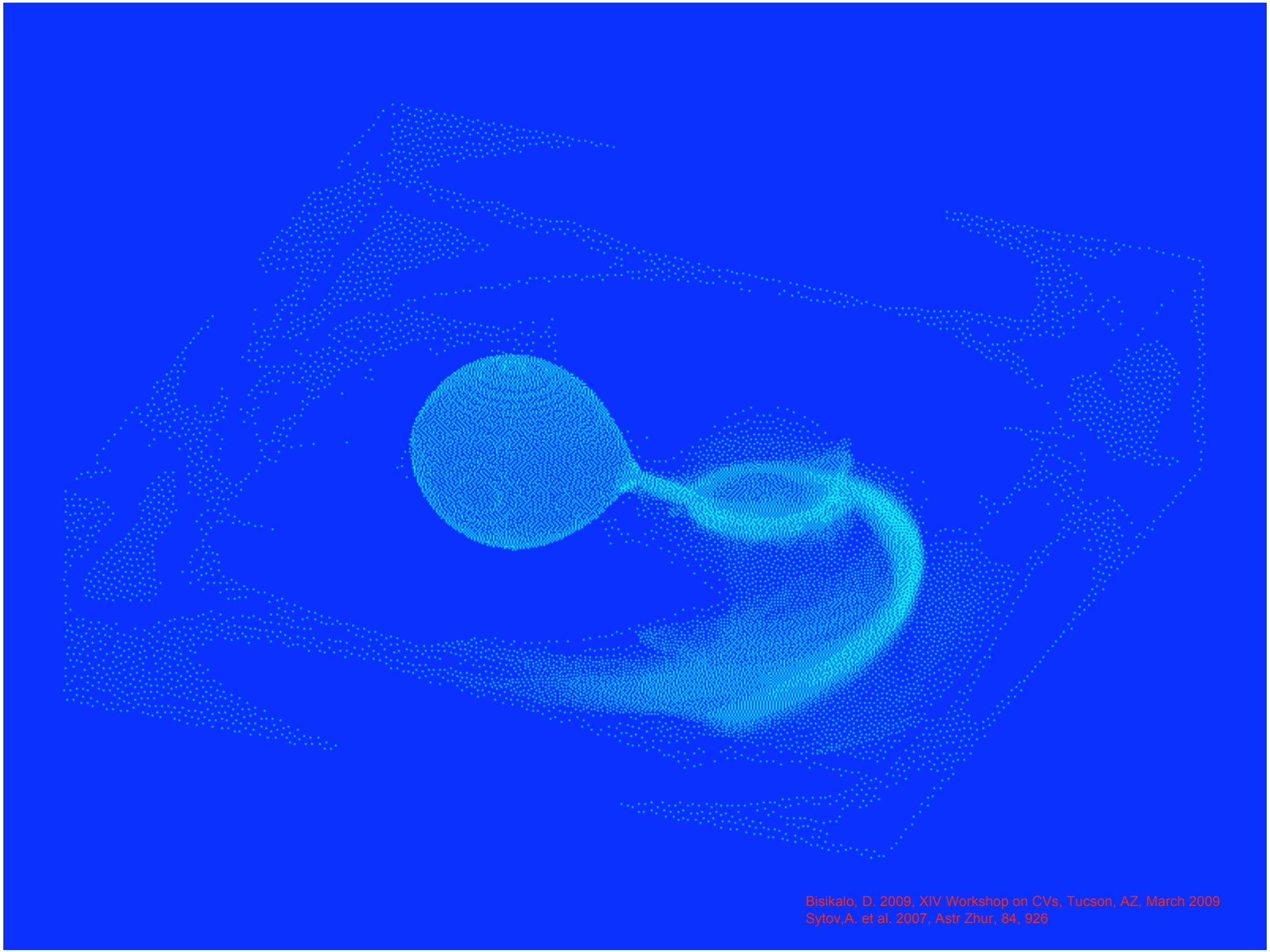

Spectral Evolution: Na I D Lines
Nova Sagittarii 2004
+23d
-1,100 km/s
-2,500 km/s
+9d
+2d
+1d
-2,000 km/s
ISM
-850 km/s
Flux
Time
5750
5800
5850
5900
5950
Wavelength (angstroms)


4300
4400
4500
4600
TiII(20)
FeII(28) 4297
TiII(41)
ScII(15)+TiII(41)
ScII(15)
TiII(41)
Ti(20) 4344
FeII(27)4352
ScII(14) 4374
TiII(19) 4395
TiII(51)+ScII(14)
TiII(40)
TiII(19)
TiII(40)
TiII(40)
TiII(31)
FeII(37) 4491
TiII(31) 4501
FeII(38) 4508
FeII(37) 4515
FeII(38) 4522
TiII(82) 4529
TiII(50) 4534
FeII(38)
CrII(44) 4559
TiII(50) 4564
TiII(82) 4572
FeII(38) 4576
FeII(38) 4584
CrII(44)

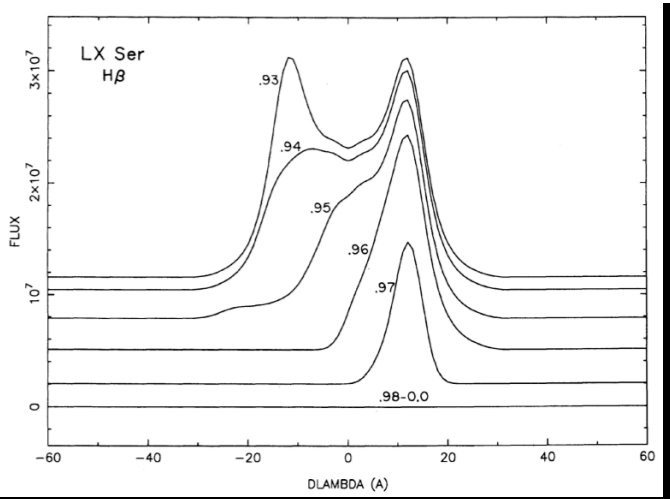
Geometry of Nova Ejecta



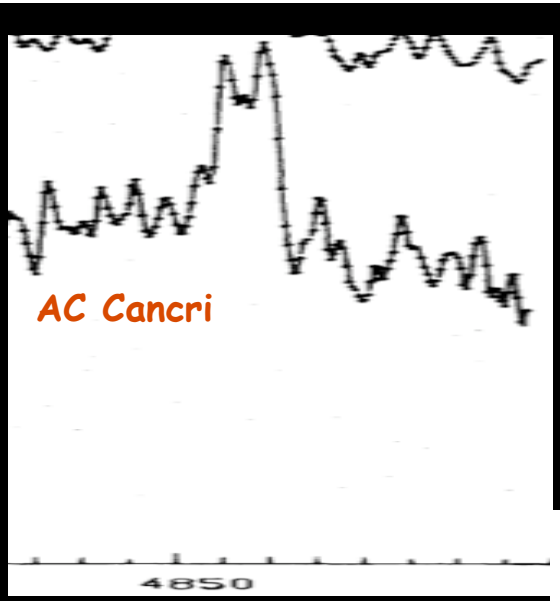
RW & Mason. 2010, Ap&SS, **327**, 207



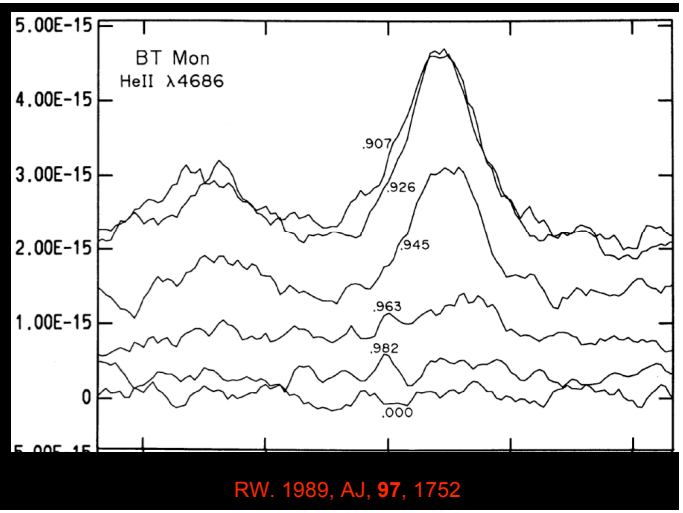
Bisikalo, D. 2009, XIV Workshop on CVs, Tucson, AZ, March 2009
Sytov A. et al. 2007, Astr Zhur, 84, 926



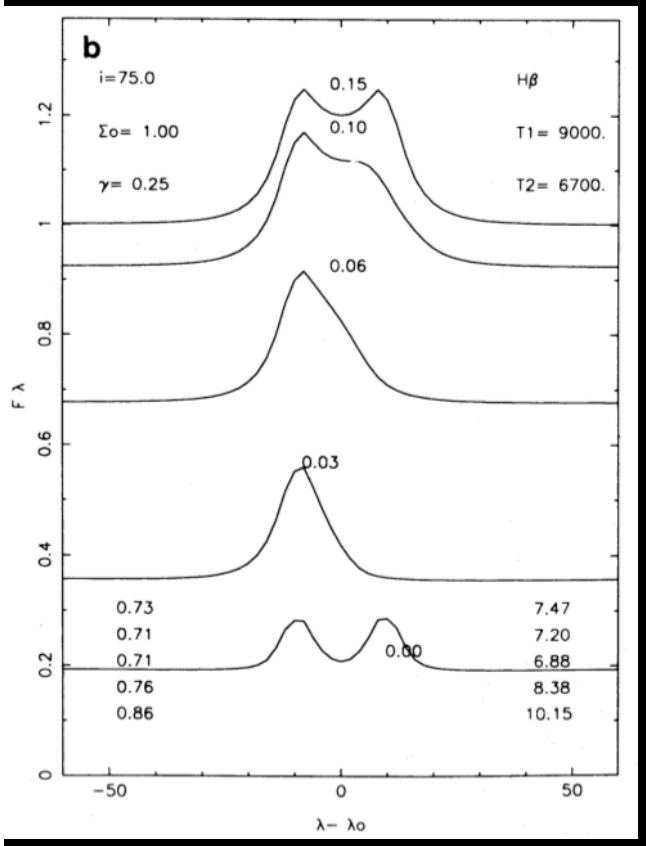
Lin, D. et al. 1988, ApJ, **327**, 234

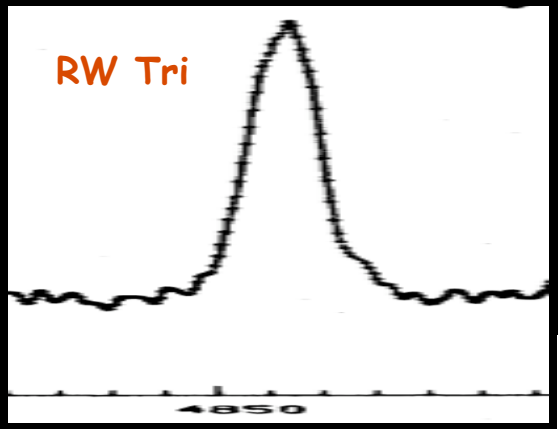


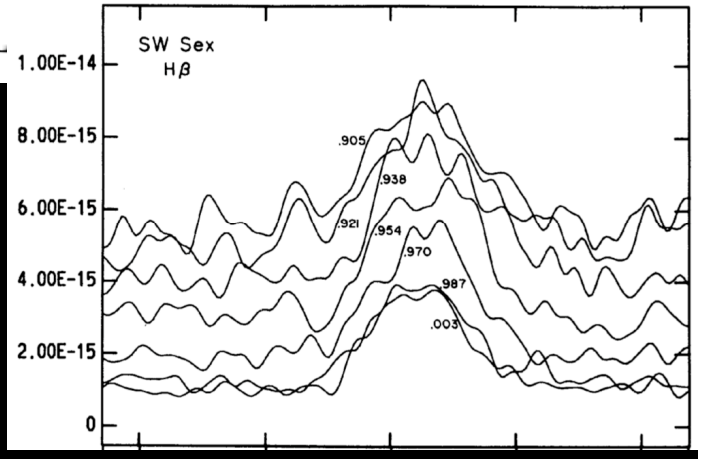
Kaitchuck, R. et al. 1983, ApJ, **267**, 239

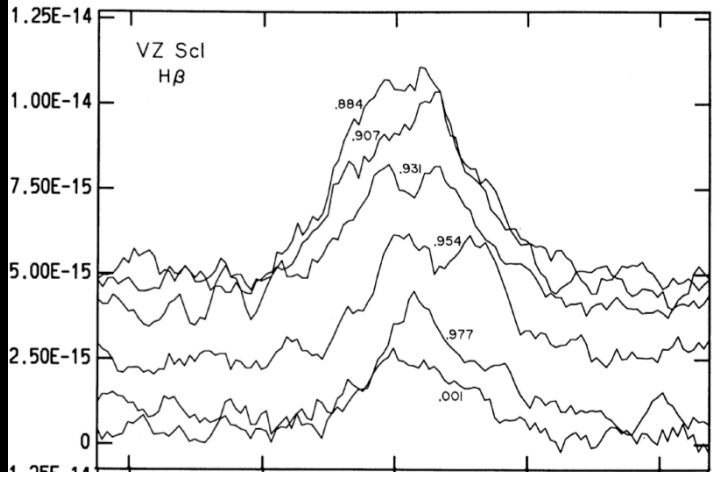


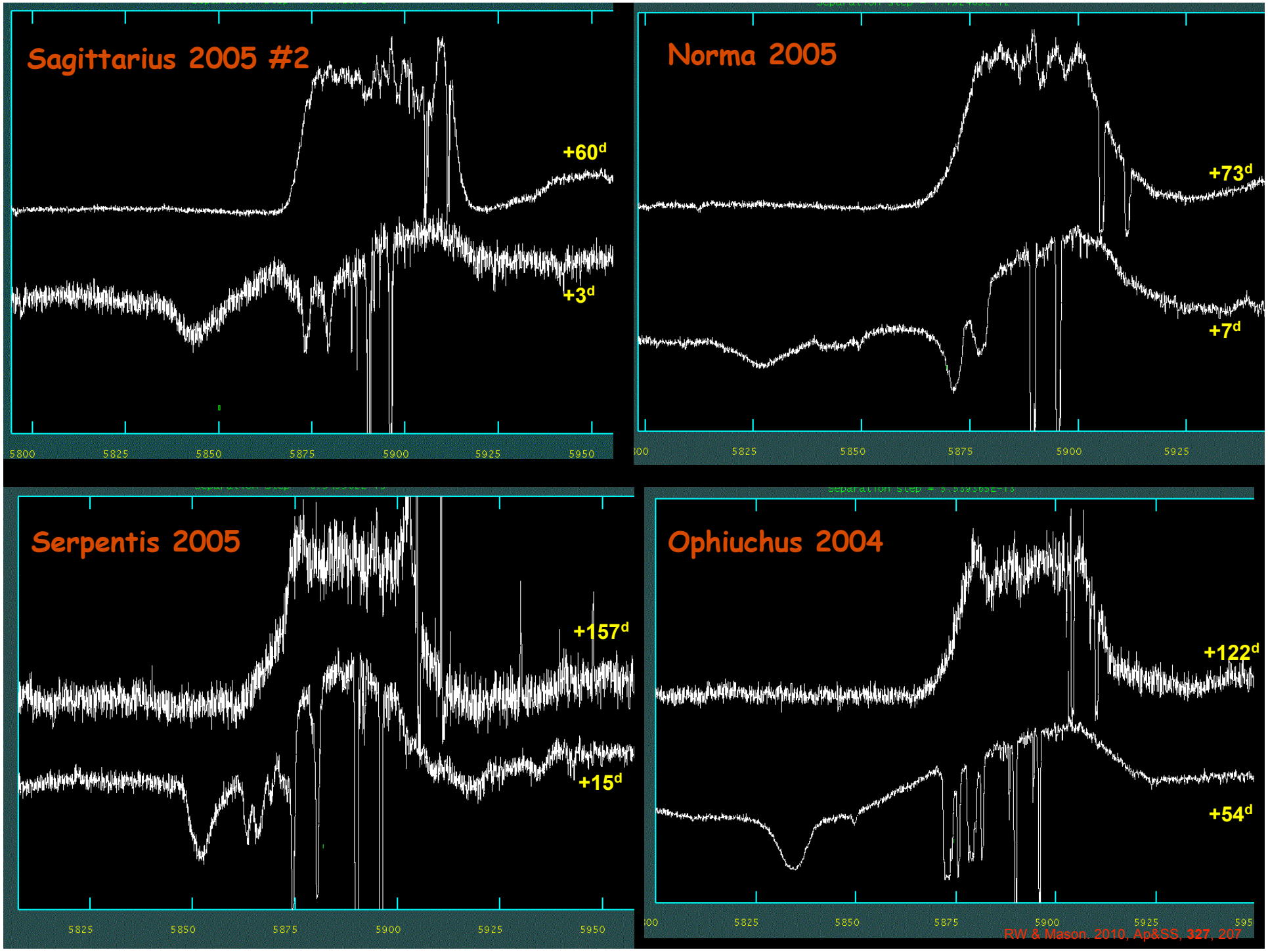
RW. 1989, AJ, **97**, 1752









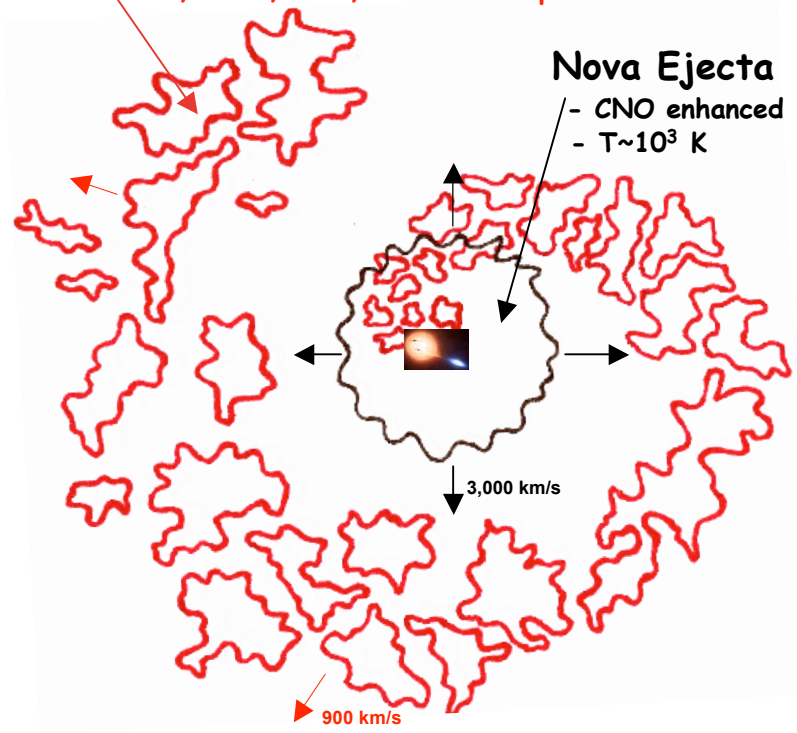

Sagittarius 2005 #2
+60d
+3d
5800
5825
5850
5875
5900
5925
5950
Norma 2005
+73d
+7d
5825
5850
5875
5900
5925
Serpentis 2005
+157d
+15d
5825
5850
5875
5900
5925
5950
Ophiuchus 2004
+122d
+54d
5825
5850
5875
5900
5925
RW & Mason, 2010, Ap&SS, 327, 207

Evolution of Nova Ejecta

I. Early Phase *(0-1 month)*

Circumbinary Shell
- Solar abundances:
- $T \sim 10^4$ K
- Sc II, Ti II, Y II, Sr II. absorption

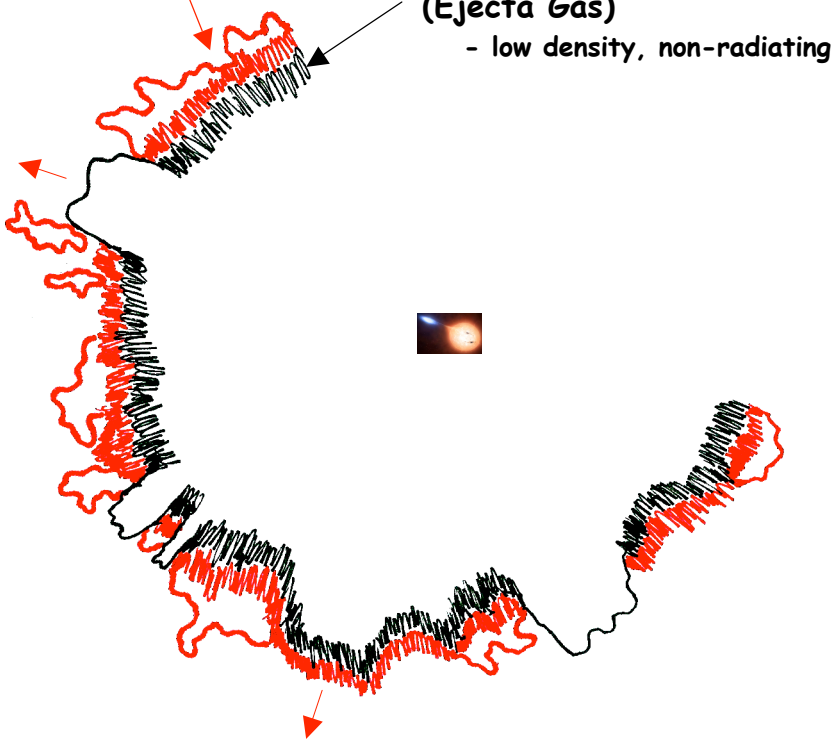
Nova Ejecta
- CNO enhanced
- $T \sim 10^3$ K



II. Emission-Line Phase *(>2 months)*

Forward Shock
(Circumbinary Gas)
- moderate density, radiating
- $T \sim 10^6 \rightarrow 10^4$ K

Reverse Shock
(Ejecta Gas)
- low density, non-radiating



RW & Mason. 2010, Ap&SS, **327**, 207

In Summary ……

- The progenitors of novae are surrounded by a significant mass of circumbinary gas at the time of outburst. It almost certainly originates in the secondary star.

  (*Note: creation of the large CB reservoir requires more energy than the total nova outburst. The most plausible source of energy is the orbital kinetic energy of the binary.*)

- Many (most?) novae show no observational evidence for accretion disks.

- The existence of the large reservoir of circumbinary gas at the time of discovery suggests that some novae outbursts may be triggered by collapse of circumbinary gas onto the WD

- (*……which would have implications for novae systems as SNe Ia progenitors*).