# Disk Accretion at High Mass Transfer Rates in Two Recent Novae


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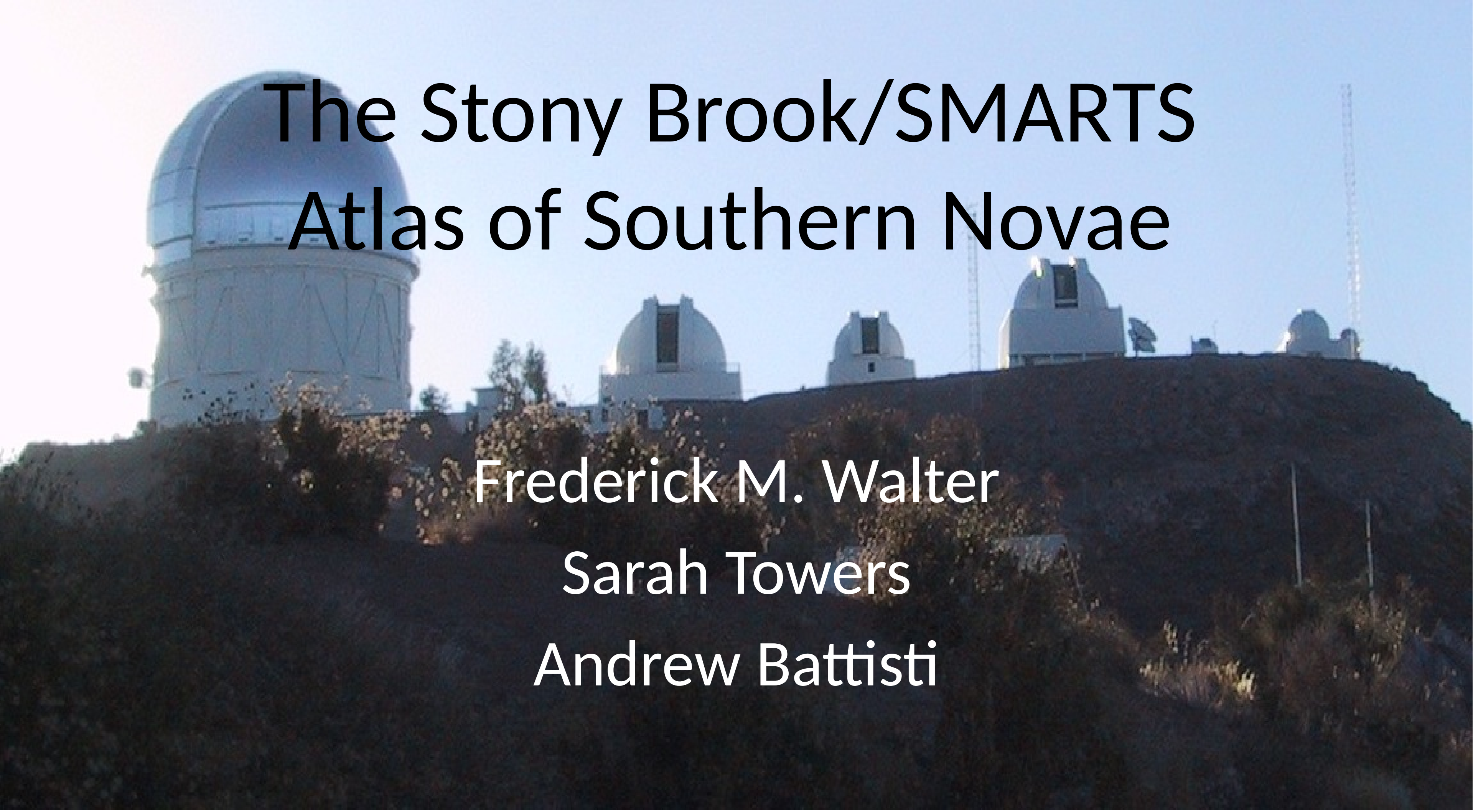
# Novae – Consequences of Accretion

- **Novae**: thermonuclear runaways on the surfaces of white dwarf stars
- **Progenitors**: mass-accreting white dwarfs
- **Mechanisms**:
  – Roche-lobe overflow in cataclysmic variables
  – Wind accretion in symbiotic systems

# Motivational Questions

- What is mass accretion rate prior to nova?
  - Generally unobservable
- Does the nova disrupt the disk?
  - Probably, but…
- How soon does the disk reform?



# The Stony Brook/SMARTS Atlas of Southern Novae

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Sarah Towers

Andrew Battisti

http://www.astro.sunysb.edu/fwalter/SMARTS/NovaAtlas/

Walter *et al.* 2012 PASP **124**, 1057

On-line: 105 novae observed for up to 15 years

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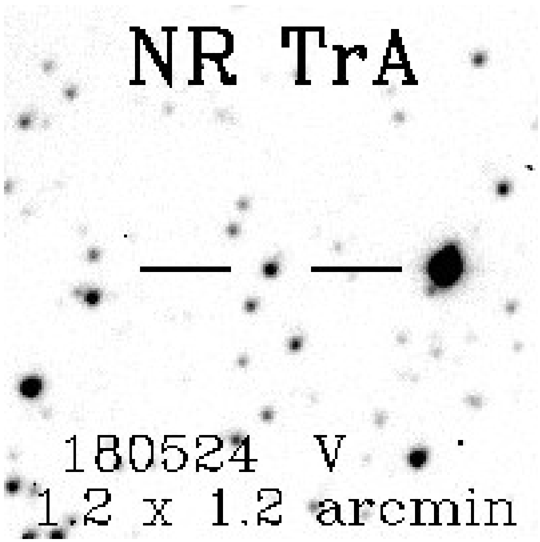
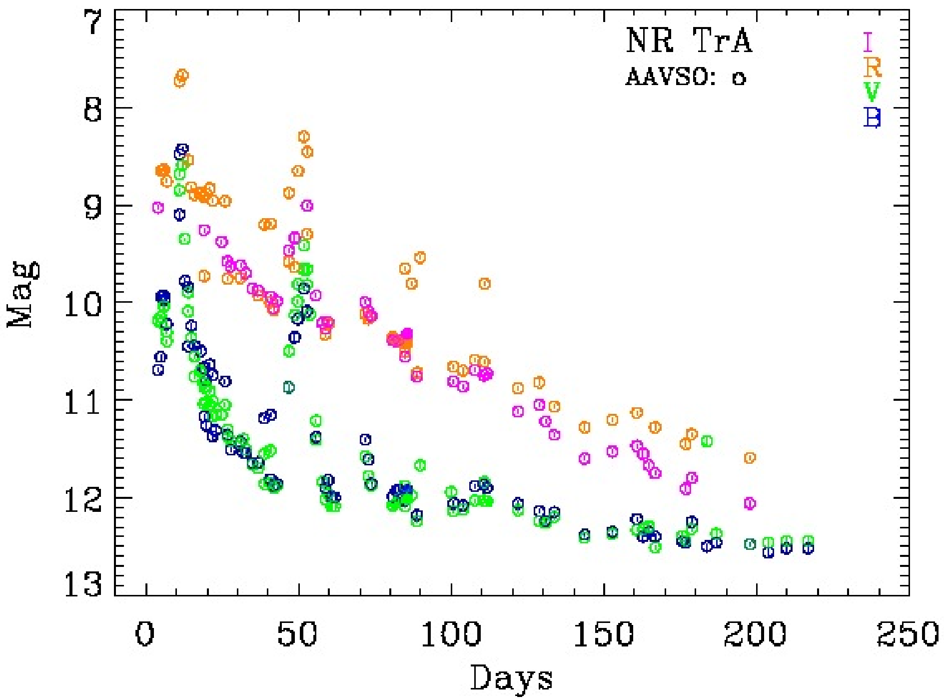
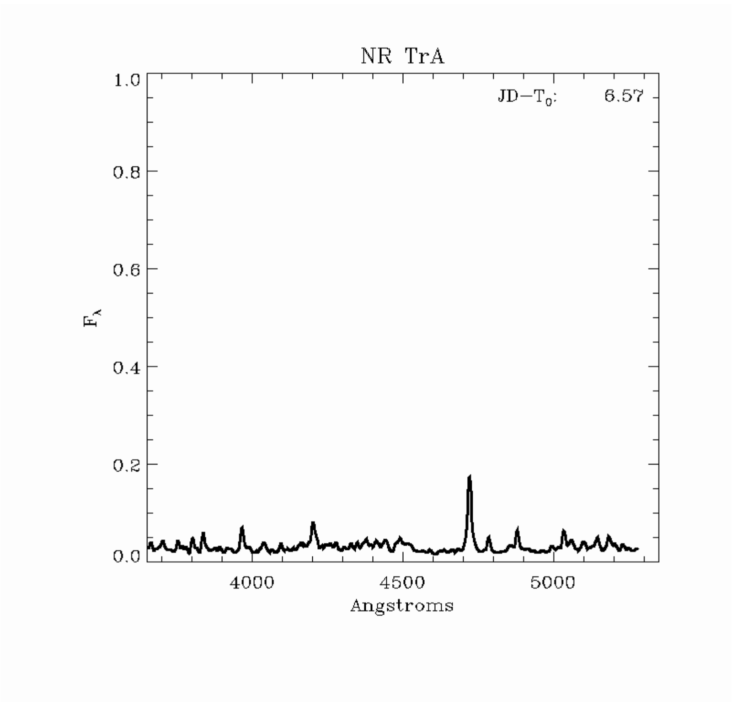
# NR TrA (Nova TrA 2008)

- Fe II (optically-thick) nova
- J-type light curve (jitters)

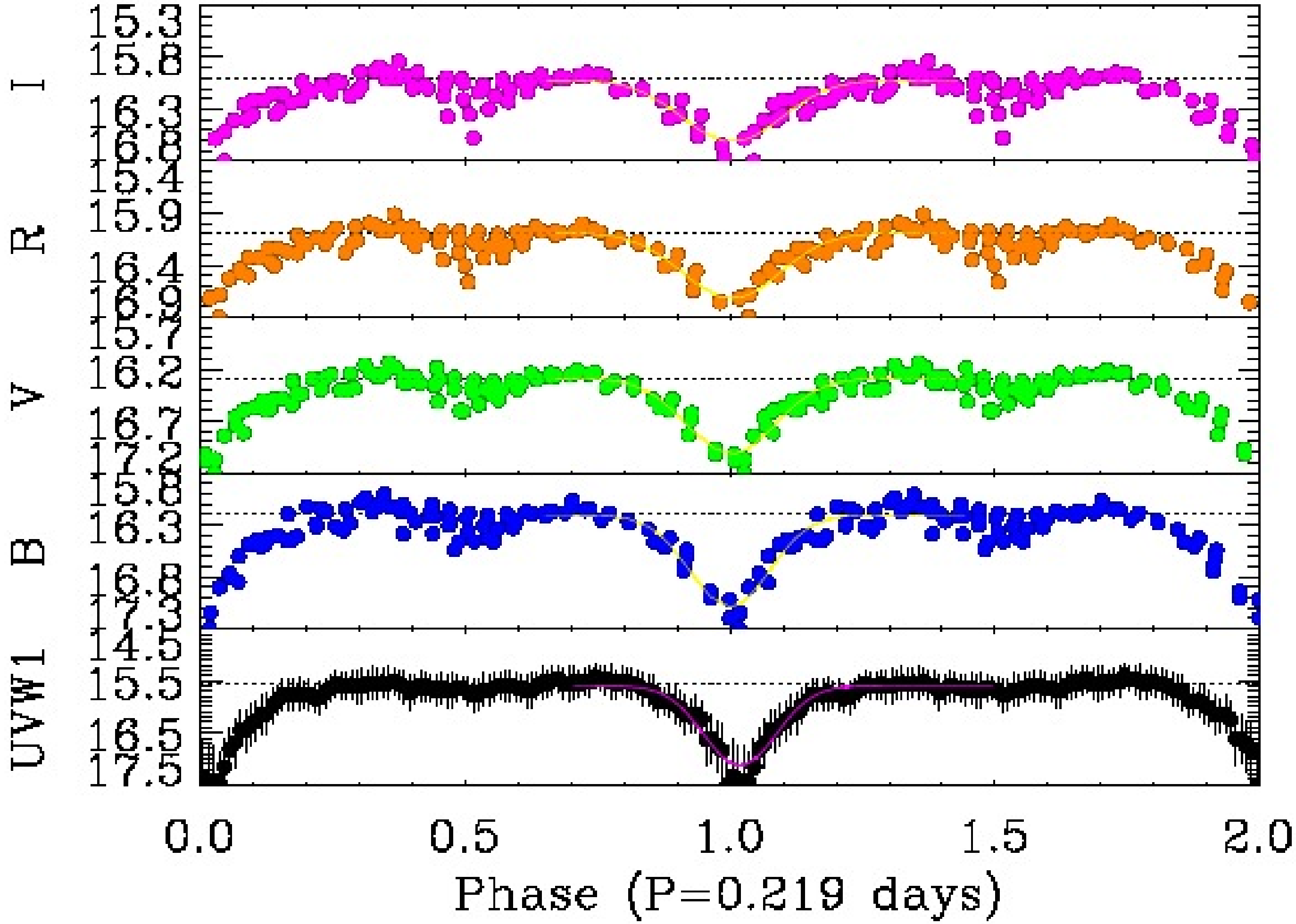


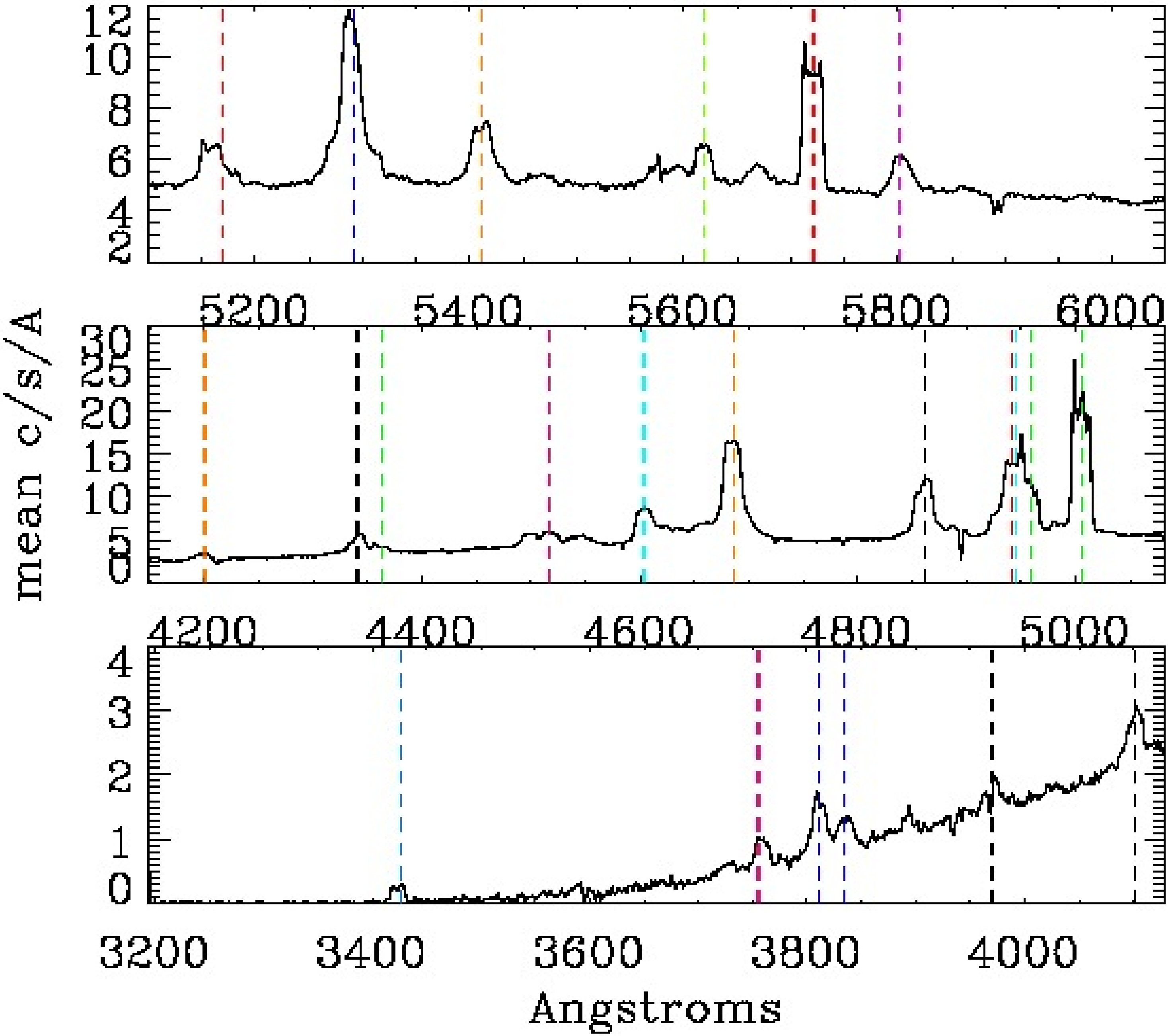
# NR TrA

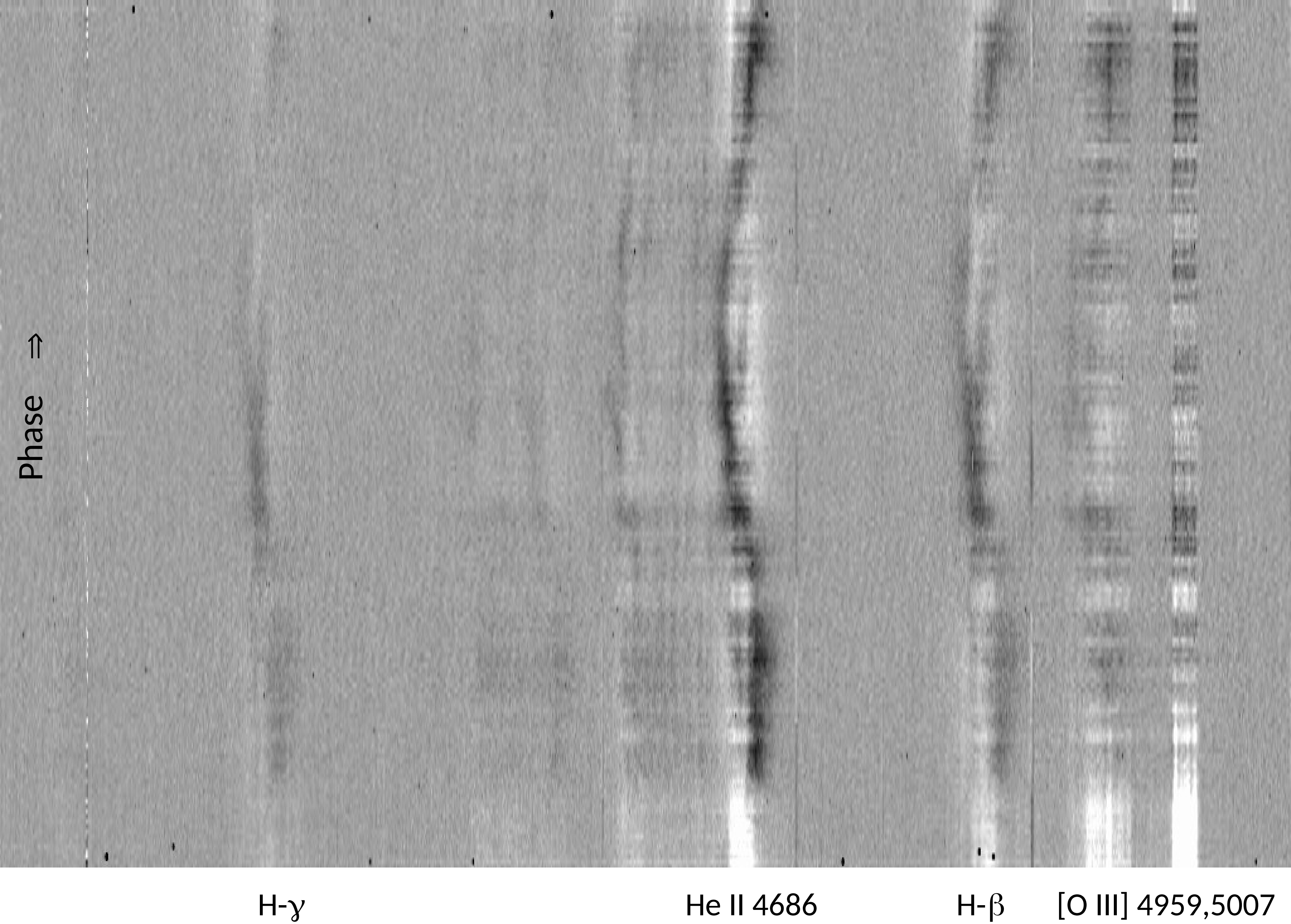
- Eclipses noted beginning day 1258
- Eclipses are deeper and wider at short wavelengths

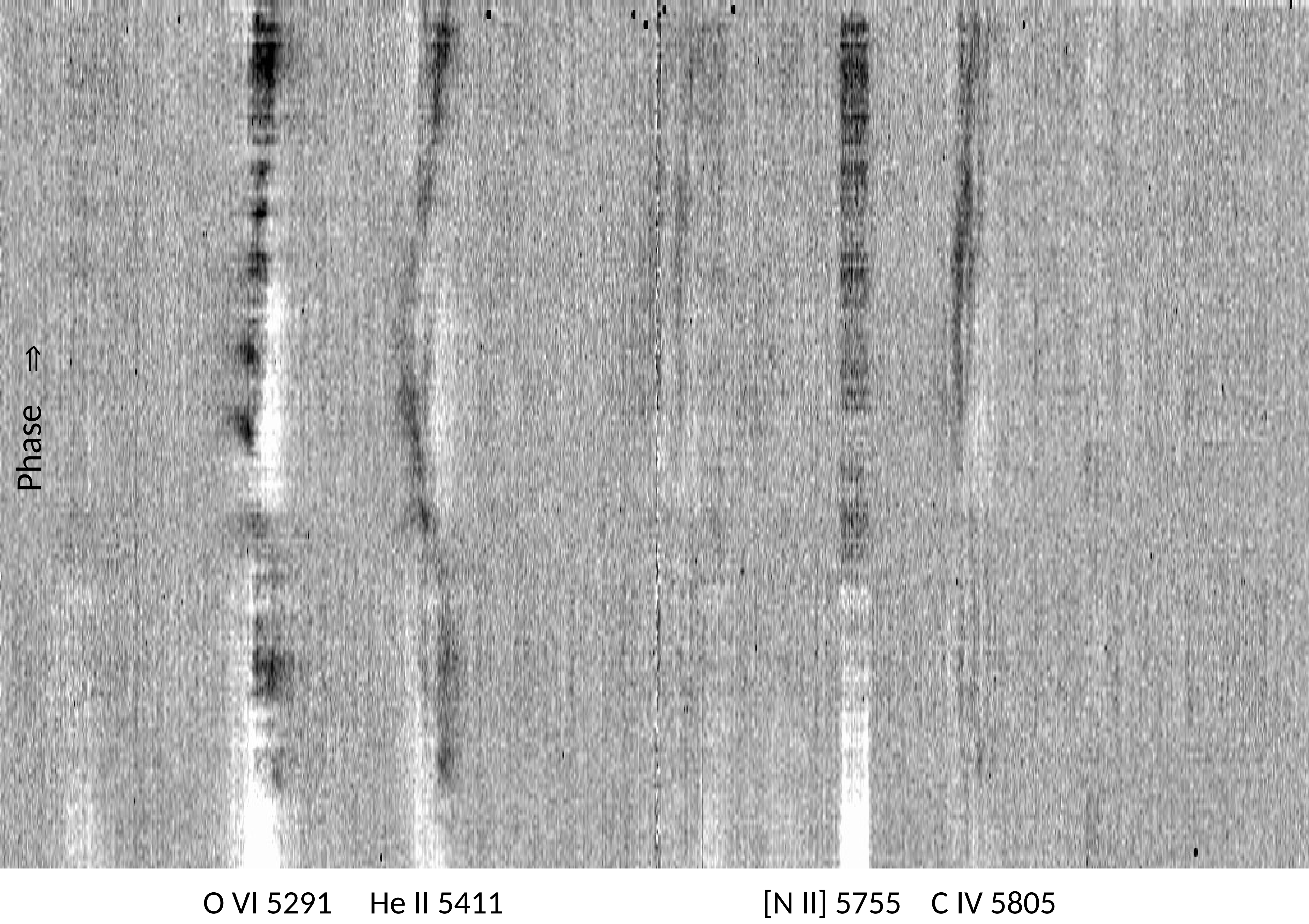


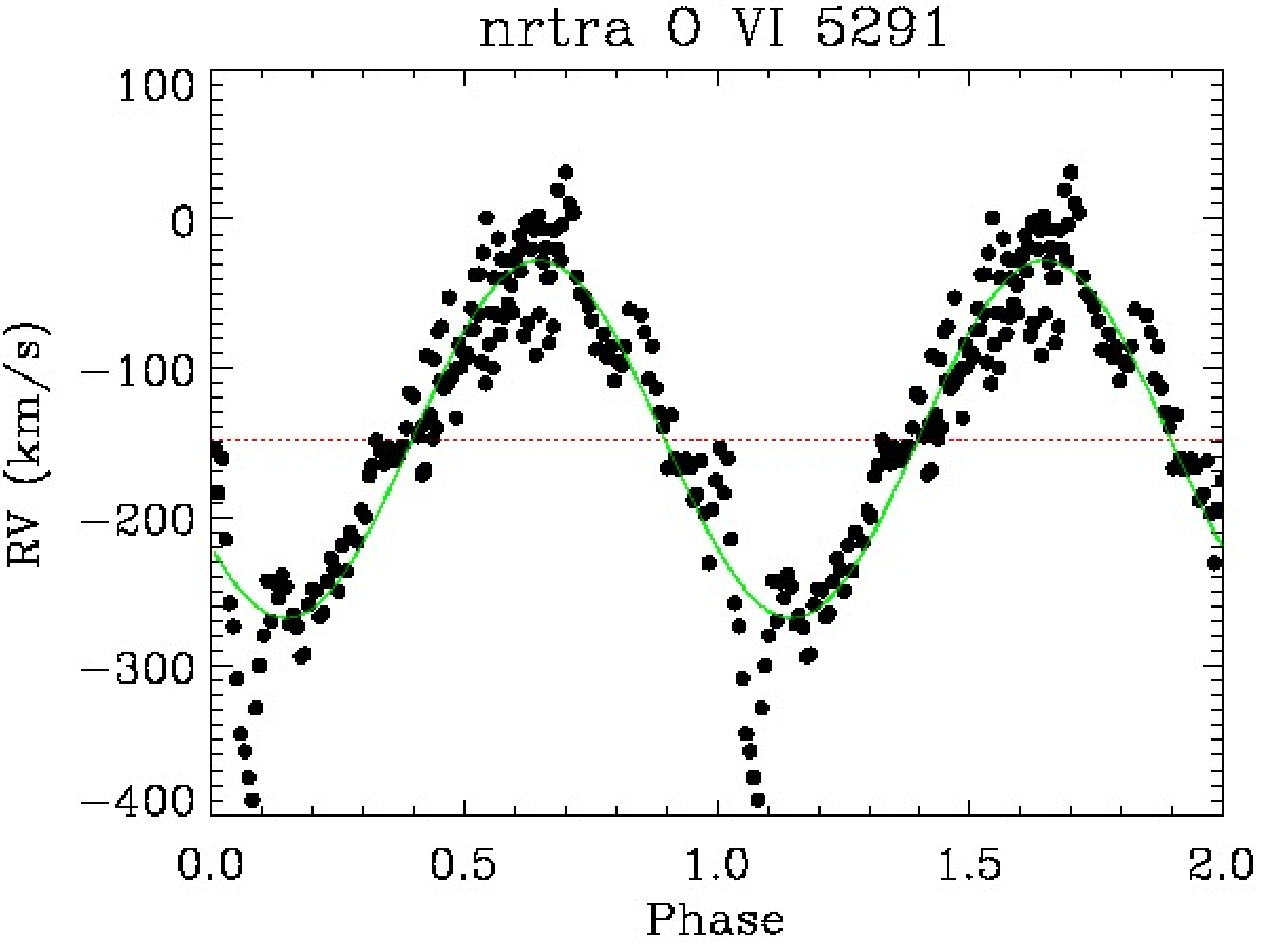

**Folded light curves**. *BVRI*: CTIO 0.9m 30 April - 2 May 2013. *XMM UVW1* is from 2017.

# Mean GMOS-S spectrum 130505



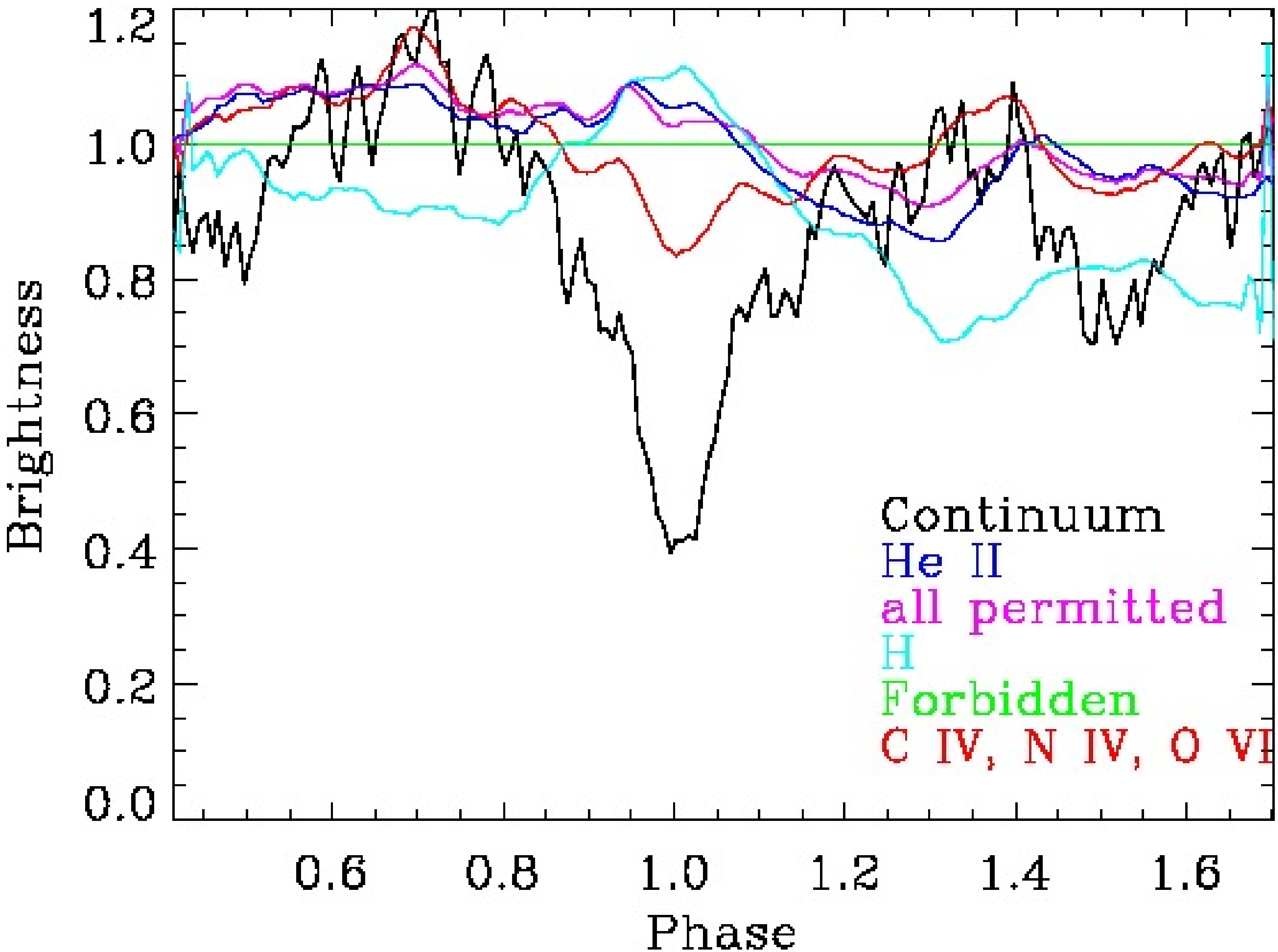

Phase ⇒
H-γ
He II 4686
H-β
[O III] 4959,5007


Phase ⇒
O VI 5291
He II 5411
[N II] 5755
C IV 5805




Consistent with the orbital velocity of an ~solar mass WD; q=1.43 for Roche Lobe-filling donor.

# Fluxes Normalized to Forbidden lines

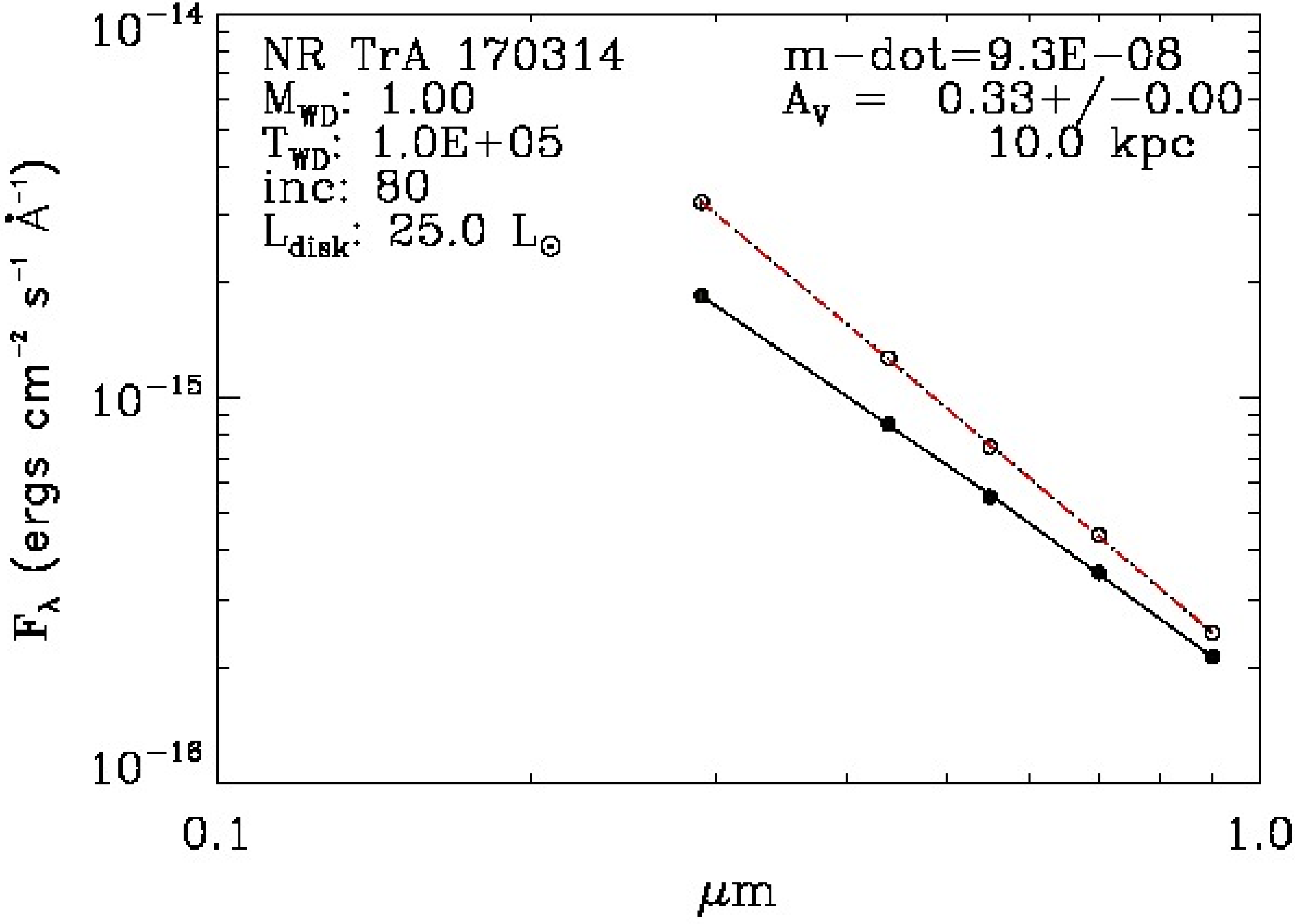


# Disk SED

Use Bertout, Basri & Bouvier (1989 ApJ **330**, 350) formalism.

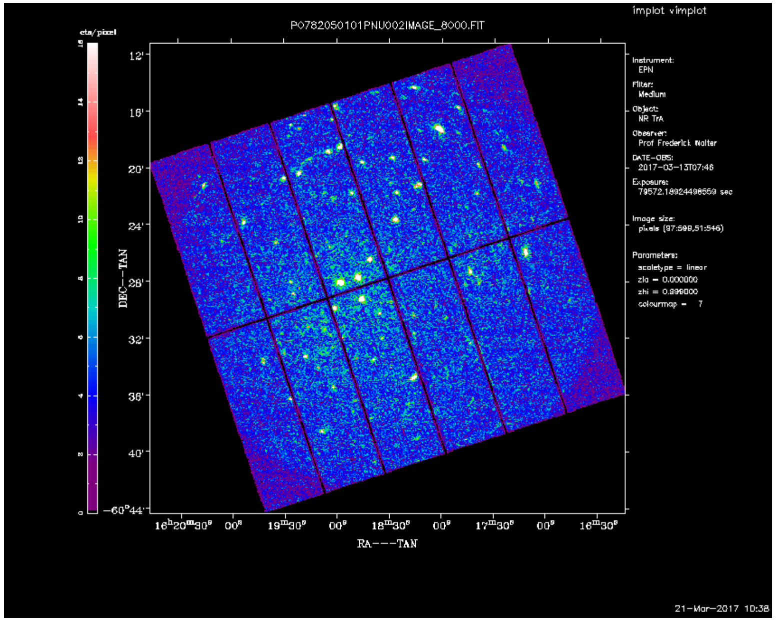
- $L_{acc} = GM_* \dot{M}/R_*$
- $F(r) = 3GM_* \dot{M}/8\pi r^3 \, [1-\sqrt{(R_*/r)}]$ (radiated potential energy)
- $F_{abs}(r) = \sigma/\pi \, T_{eff}^4[\phi - \sin(2\phi)/2]; \;\; \phi = \sin^{-1}(R_*/r)$ (absorbed)
- $\sigma T_D^4(r) = F(r) + F_{abs}(r)$

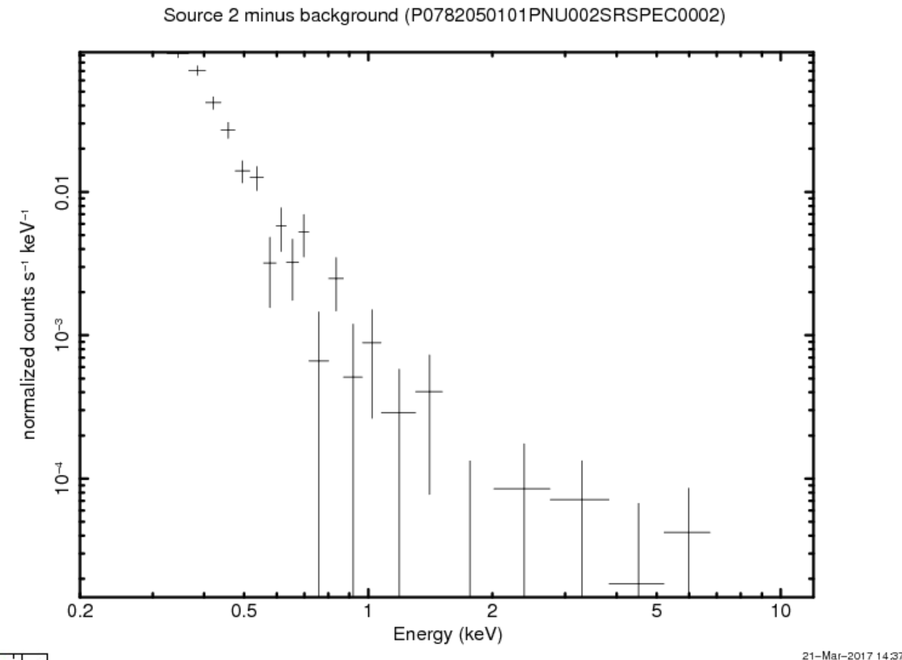
- Disk emission: sum of optically-thick annuli
  - $F_\lambda^D = (2hc^2/\lambda^5)(R_*/d)^2 \cos i \int (\pi + 2\gamma_0(x))/(e^{hc/\lambda k T_D(x)} - 1) \, x dx$
  - $x = r/R_*$
  - $\gamma_0$ corrects for disk shadowing
- Boundary layer
  - $F_\lambda^{BL} = (\pi + 2\gamma_1)(\delta/R_*)(R_*/d)^2 \cos i \, B_\lambda(T_{BL})$
  - $h(r) = \sqrt{(kT_D(r)/G\mu m_H M_*)} r^{3/2}$ (scale height)
  - $\delta = h(R_* + \delta)$
  - $\sin(\gamma_1) \sin i = \sqrt{(1-[R_*/(R_*+\delta/2)])}$

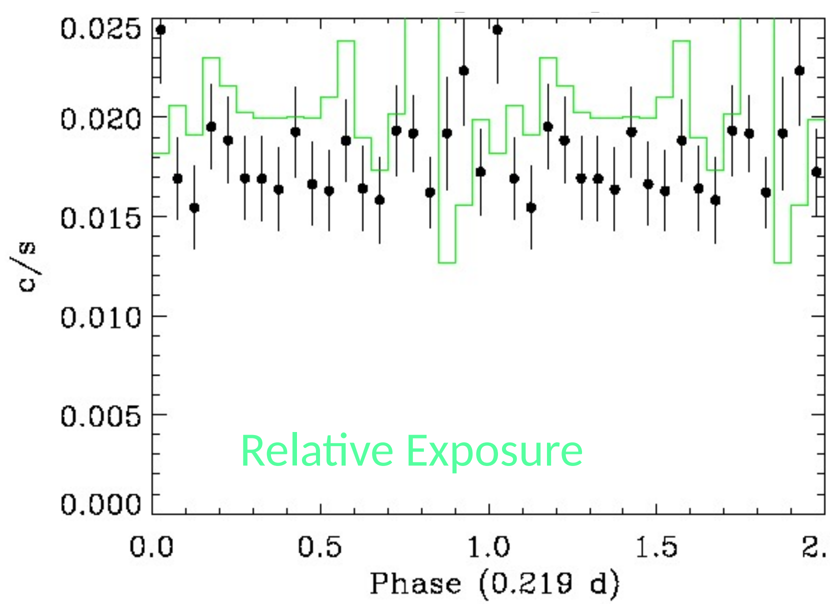



Caveat: mass accretion rate scales with distance

# The X-ray Source




EPIC: 0.036 c $s^{-1}$

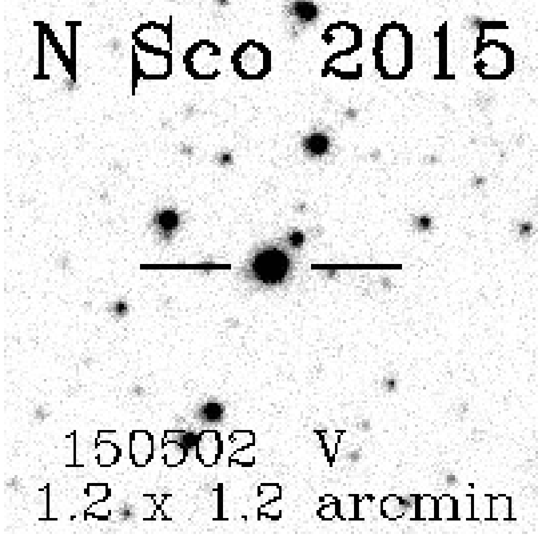
No eclipse

Soft spectrum:

- Comptonized BB:
  kT = 11 eV;  $n_H$ = 4.5x$10^{21}$ $cm^{-2}$
- BB:
  kT=24.8 +/- 2.4 eV ; $n_H$=1.7x$10^{21}$ $cm^{-2}$

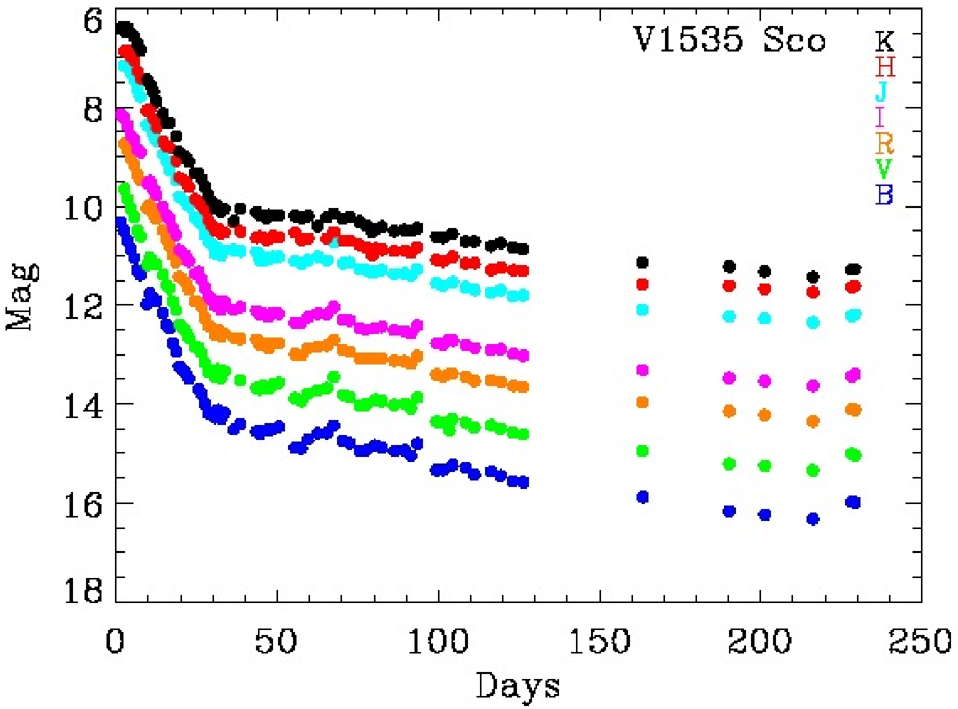
$L_X$ = $10^{37}$ (D/10 kpc)$^2$ erg/s

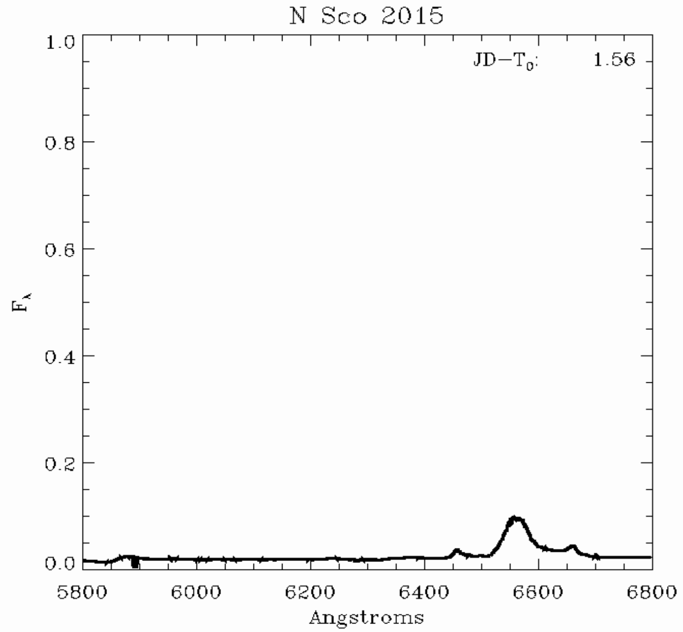
# V1535 Sco (Nova Sco 2015)




- He-N (optically-thin) spectrum
- S-type light curve (smooth)
- Explosion in red giant wind

(Linford *et al.* 2017 ApJ **842**, 73)

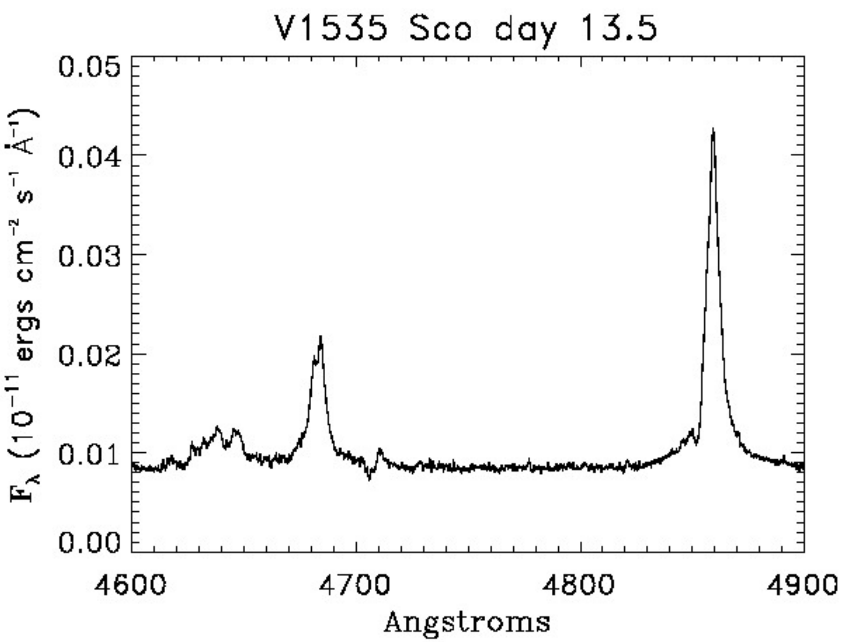


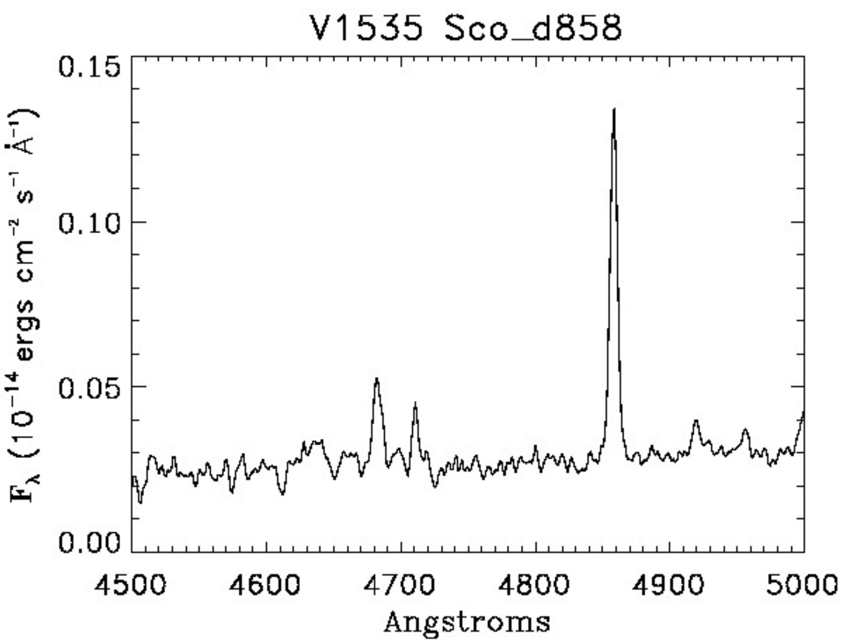



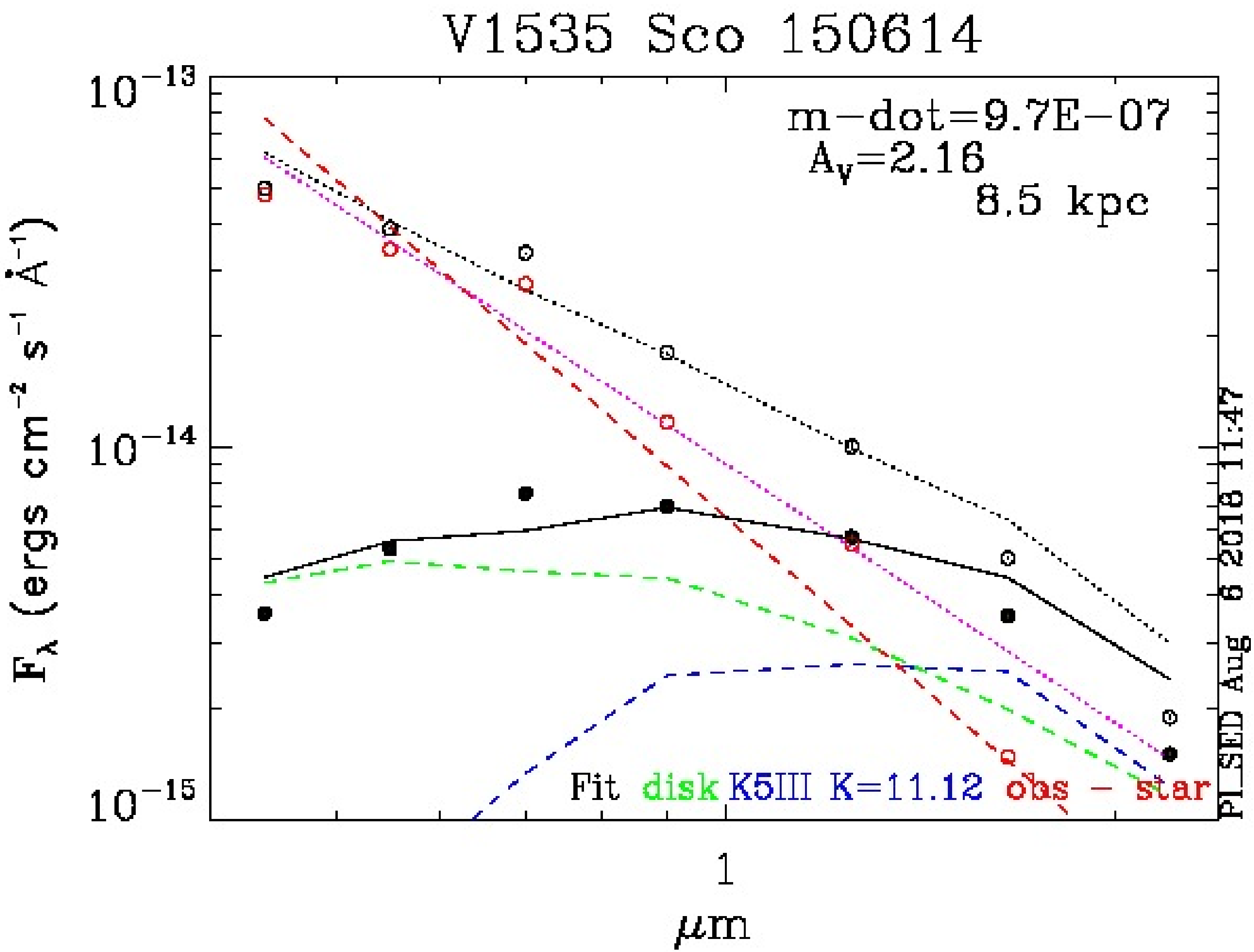
# V1535 Sco

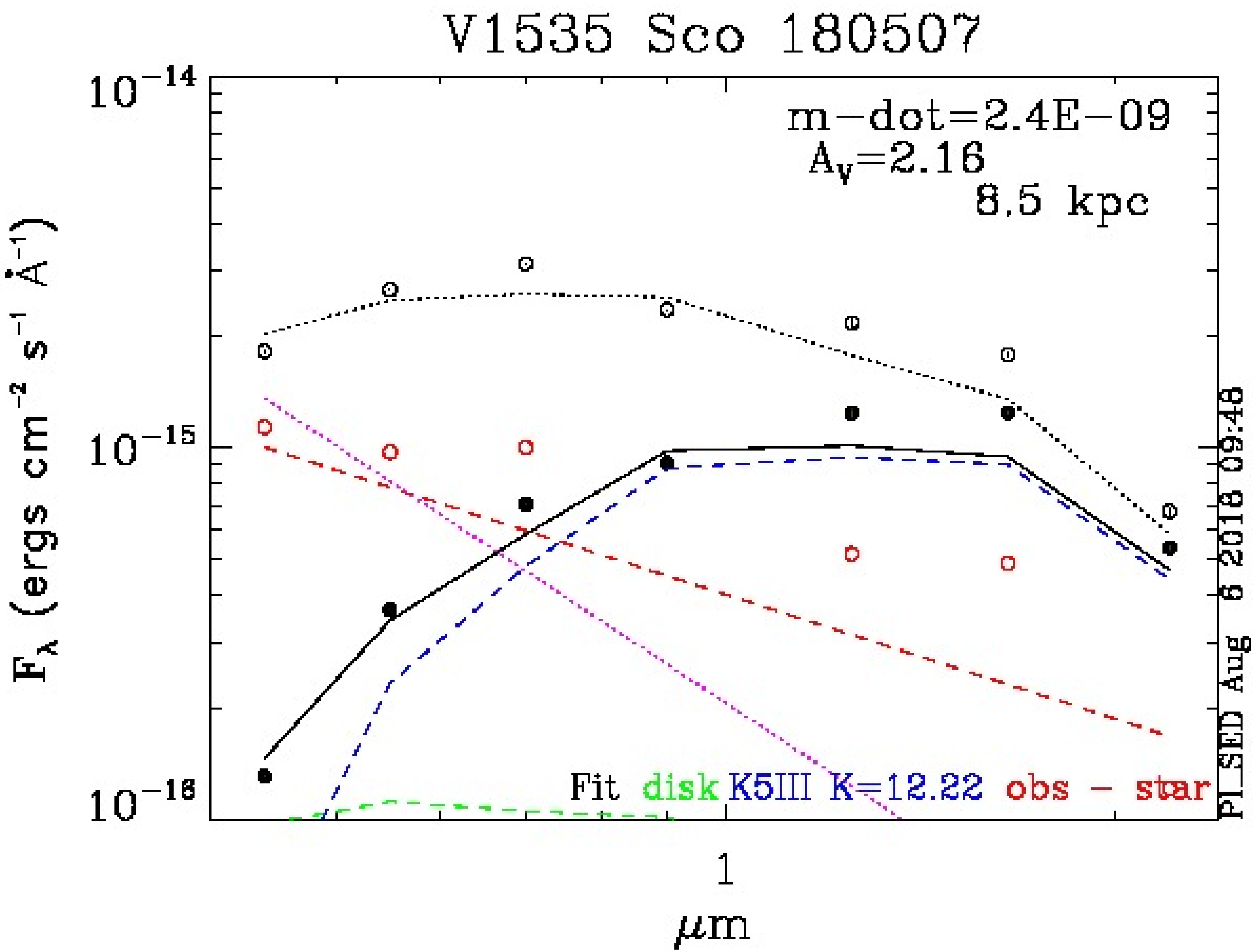
Disk diagnostics

- Double-peaked He II λ4686 days 6.5 – 20
- Single peaked He II at least through day 858
- Bowen N III lines prominent (and narrow)
- Bright X-ray source for 30 days (initially hard; ATel 7085)

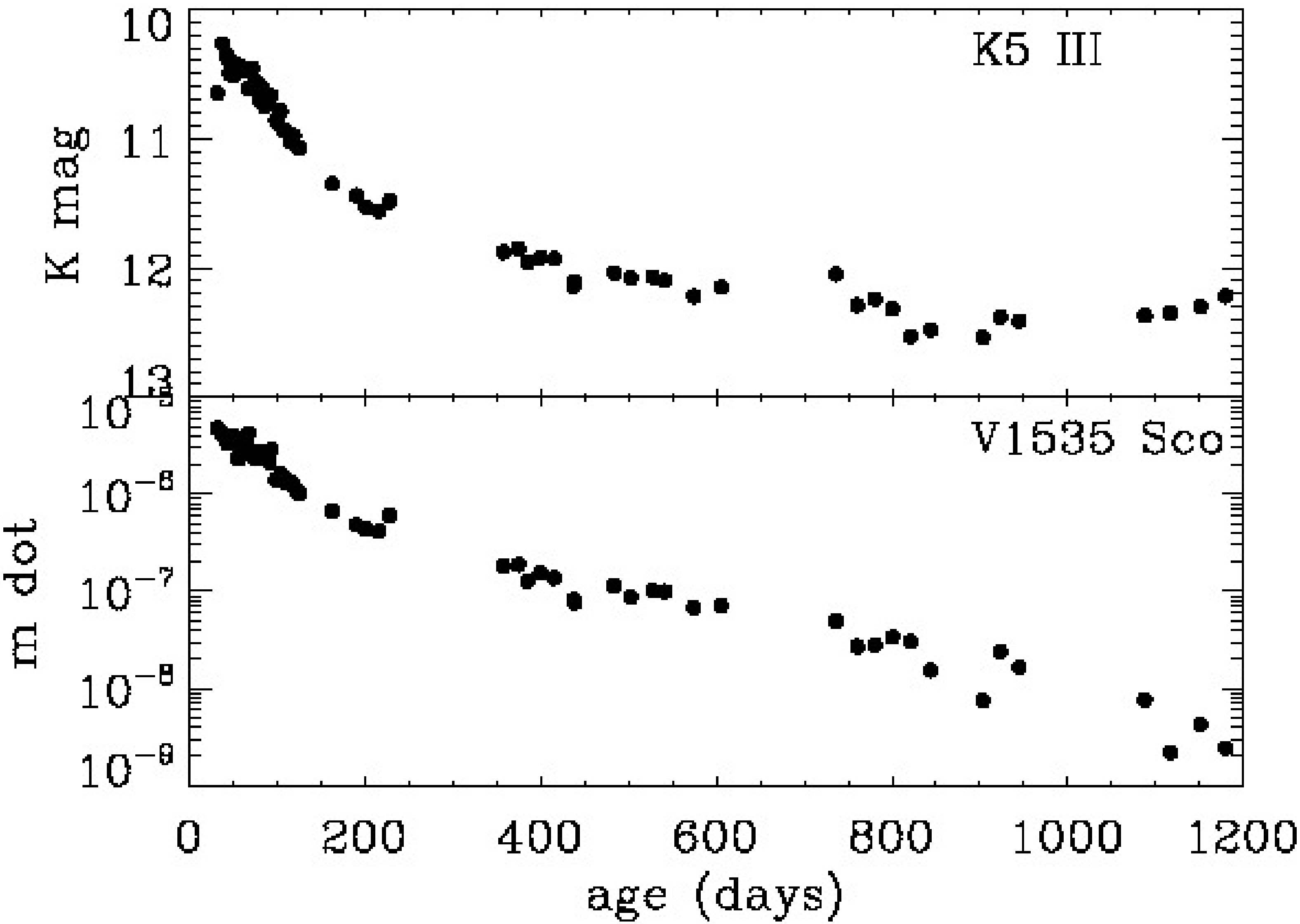


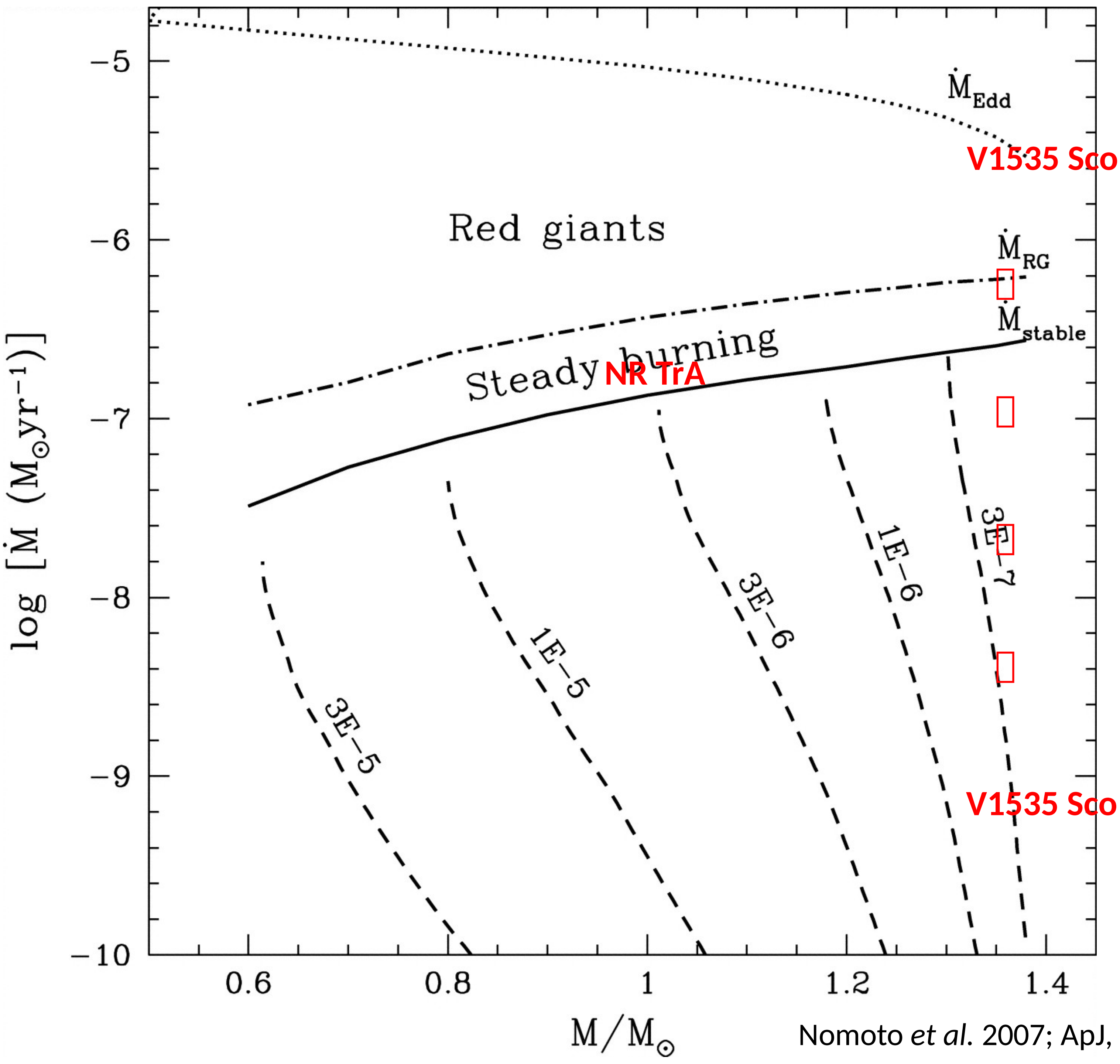




V1535 Sco 150614
m−dot=9.7E−07
$A_V$=2.16
8.5 kpc
$F_\lambda$ (ergs cm$^{-2}$ s$^{-1}$ Å$^{-1}$)
$10^{-13}$
$10^{-14}$
$10^{-15}$
1
μm
Fit disk K5III K=11.12 obs − star
PL SED Aug 6 2018 11:47



V1535 Sco 180507
m-dot=2.4E-09
A_V=2.16
8.5 kpc
10^-14
10^-15
10^-16
F_λ (ergs cm^-2 s^-1 Å^-1)
1
μm
Fit disk K5III K=12.22 obs - star
PI_SED Aug 6 2018 09:48


K5 III
V1535 Sco
K mag
m dot
age (days)
10
11
12
13
$10^{-5}$
$10^{-6}$
$10^{-7}$
$10^{-8}$
$10^{-9}$
0
200
400
600
800
1000
1200




Nomoto *et al*. 2007; ApJ, **663**, 1269

# Summary. I.

At least some young post-novae show strong signatures of accretion disks.

- Only 2/105 novae (NR TrA and V1375 Cen = XMMU 115113.3-623730) have developed hot lines
  - V1375 Cen lost its hot lines within a year
- Few fast He-N novae continue to fade past the first year; generally red giant dominates SED

We do not address the question of **how fast the disks reform**

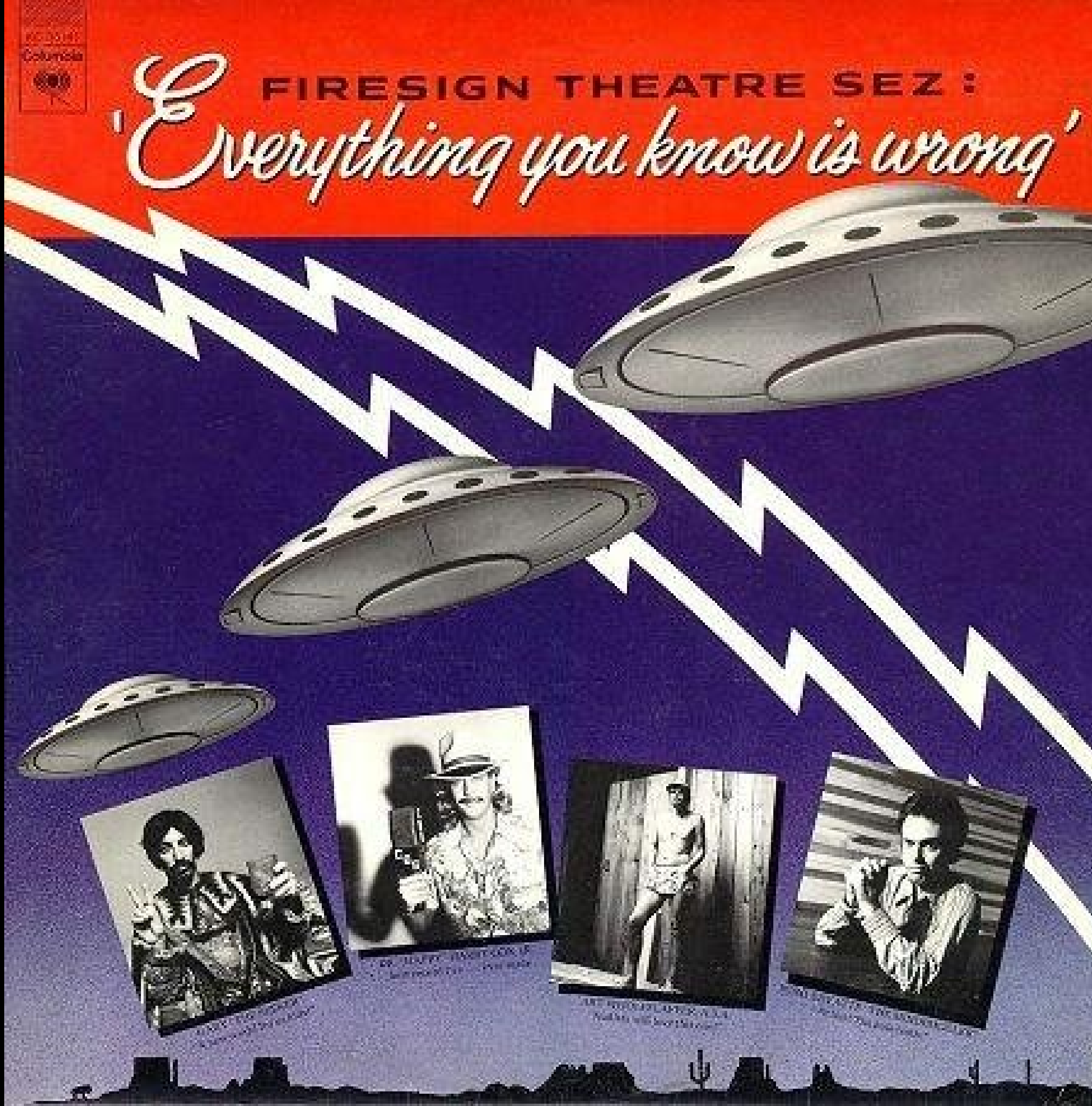
# Summary. II.

NR TrA  age ~ 10.4 years

- Fe II type suggests low mass WD
- Hot accretion disk
- Resembles a persistent SSS
- Disk first seen at 3.5 years
- $\dot{M}_{acc}$ ~ $10^{-7}$ $M_{\odot}$ $yr^{-1}$, stable for 7 years
- In stable burning regime
- How long can this continue?

V1535 Sco  age ~ 3.3 years

- Speed suggests near-Chandrasekhar mass WD
- Fading accretion disk
- $\dot{M}_{acc}$ decreased over 1000 times in 3.3 years
- K giant now dominating SED


Columbia
FIRESIGN THEATRE SEZ:
'Everything you know is wrong'