Observed Properties of Accreting White Dwarfs

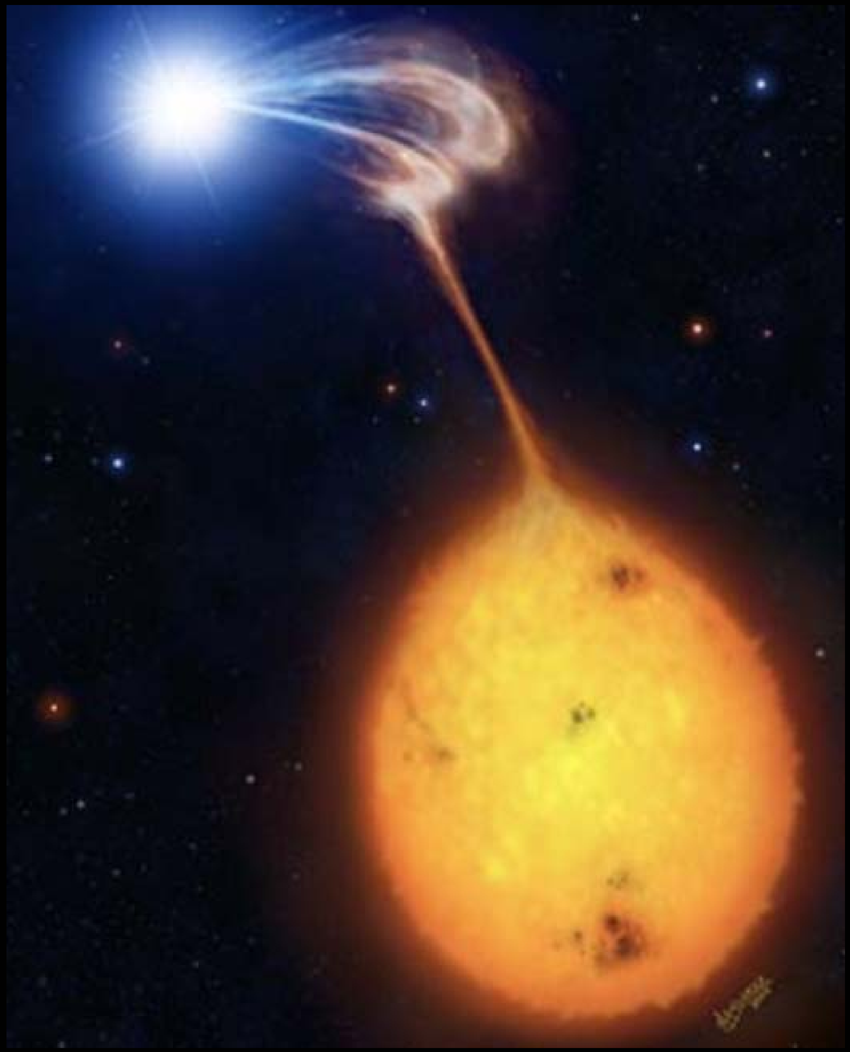
Paula Szkody Santa Barbara March 20, 2007

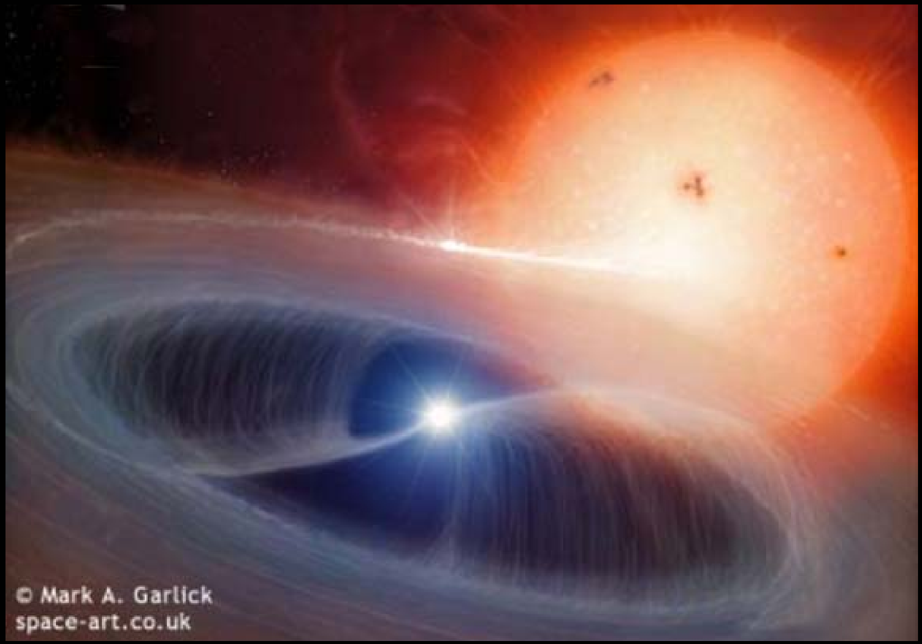
Important WD Parameters:

- Mass
- Temperature
- Composition
- Rotation

Disk

Polar



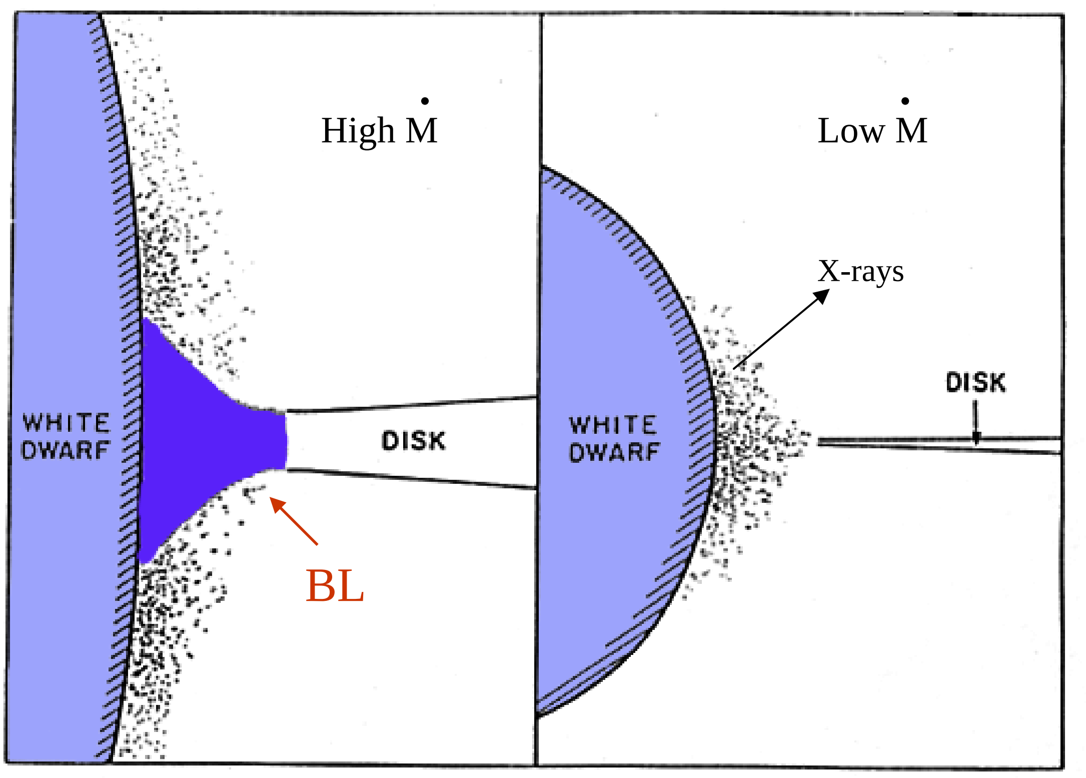


Intermediate Polar

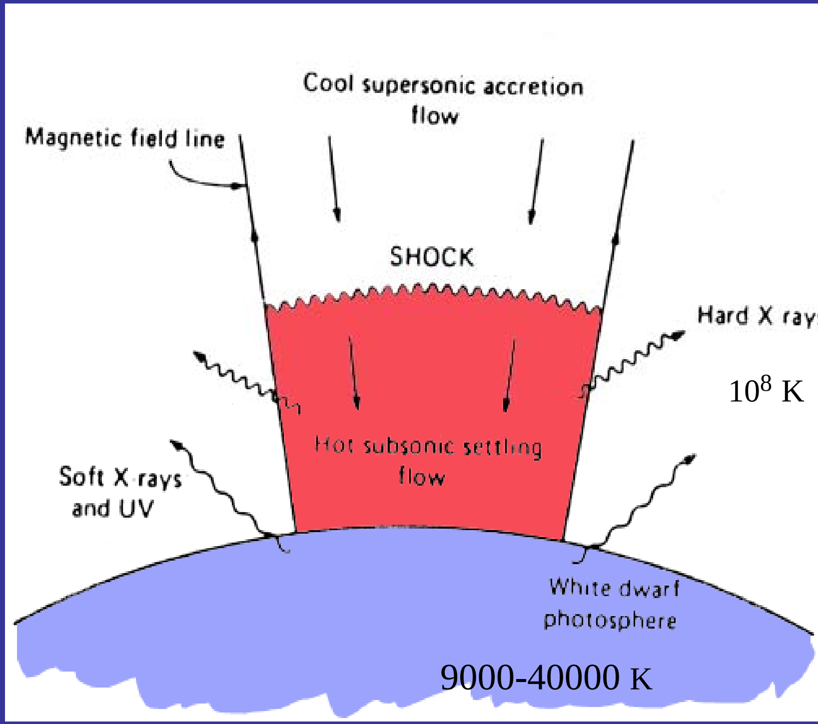
DISK ACCRETION

For slowly rotating WD:

$$L_{disk} = L_{BL} = 1/2 G\dot{M} M_{wd}/R_{wd}$$



MAGNETIC ACCRETION



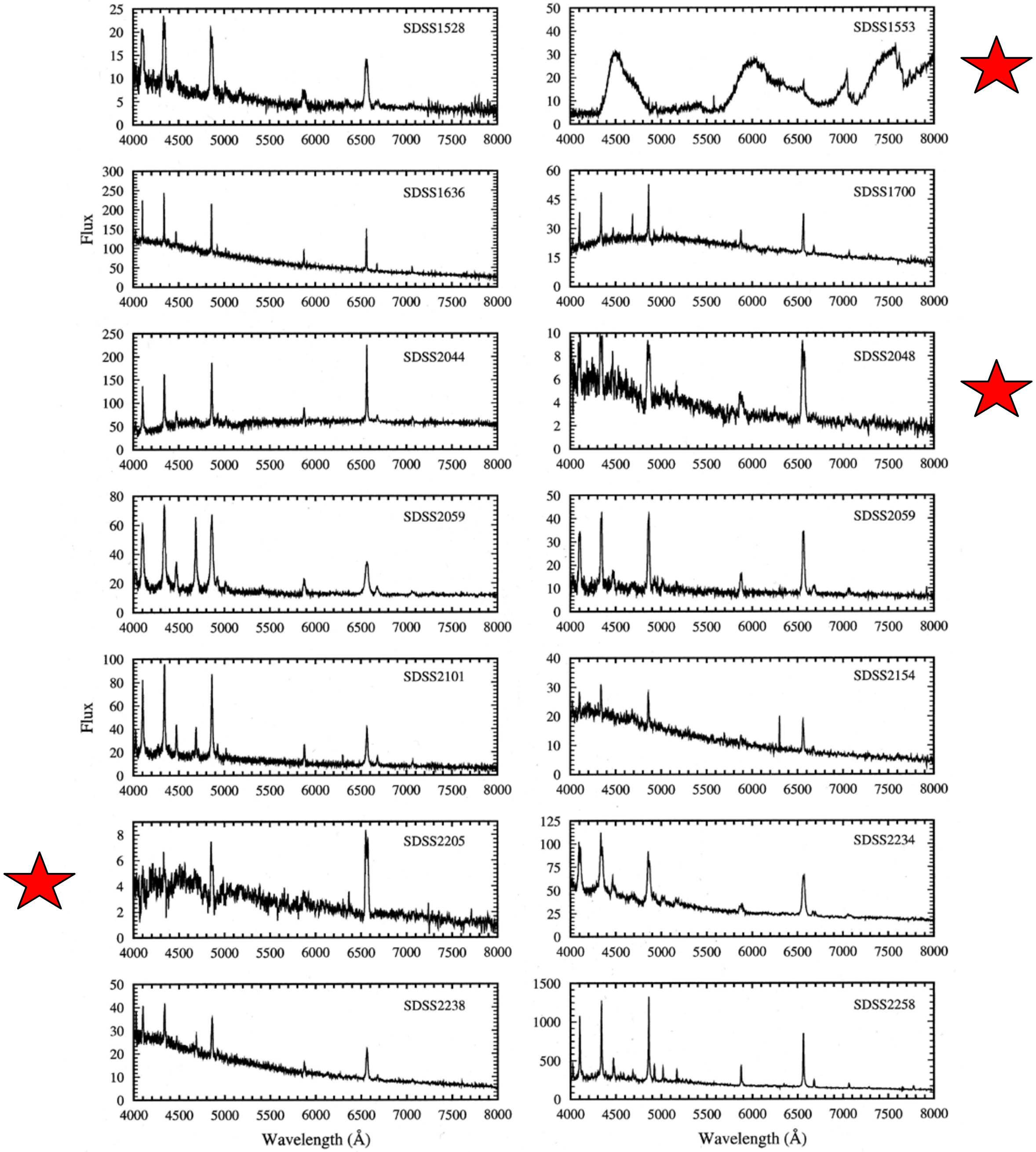
Hard X-rays

Soft X-rays

Cyclotron

Typical CV spectra

Szkody et al. 2003, AJ, 126, 1499



To get accurate masses, need:

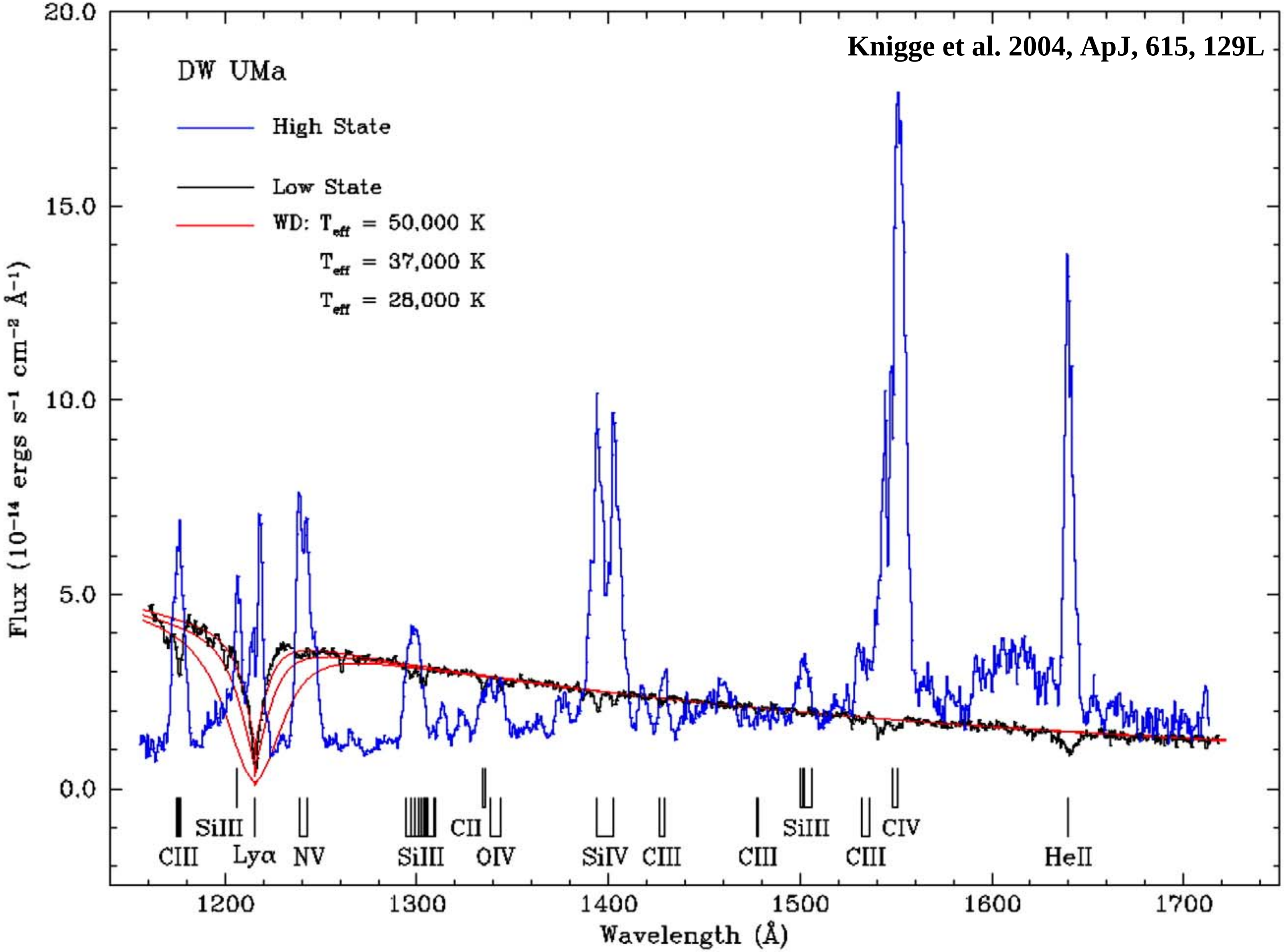
- double-lined, eclipsing, spectroscopic binary
- photometric solution from resolved eclipse

Dwarf Novae		Polars		Novae		AMCVn	
U Gem	1.12M_o	V1500 Cyg	>0.9 ↔	DQ Her	0.66	SDSS0926	0.84
IP Peg	1.09	AM Her	0.88				
SDSS1035	0.94	MR Ser	0.71				
SDSS1702	0.94	QQ Vul	0.70				
OU Vir	0.9	ST LMi	0.52				
EC13471	0.78						
EX Dra	0.75						
OY Car	0.7						
Z Cha	0.6						
HT Cas	0.6						

Temperature: need to separate WD from disk

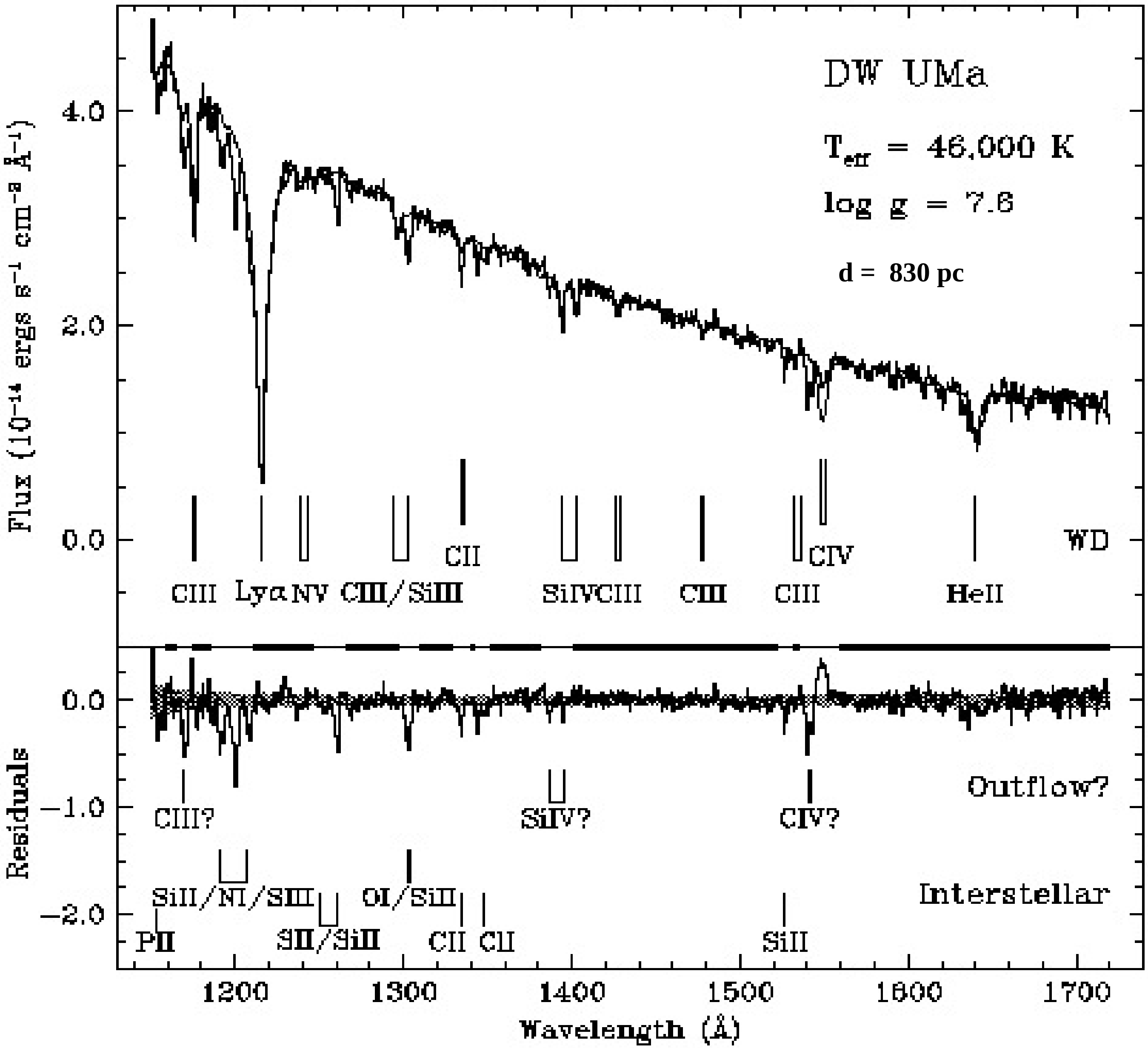
- Observe in the UV
- Observe at quiescence or low states
- Work on short P systems

Difference between High and Low states in NLs

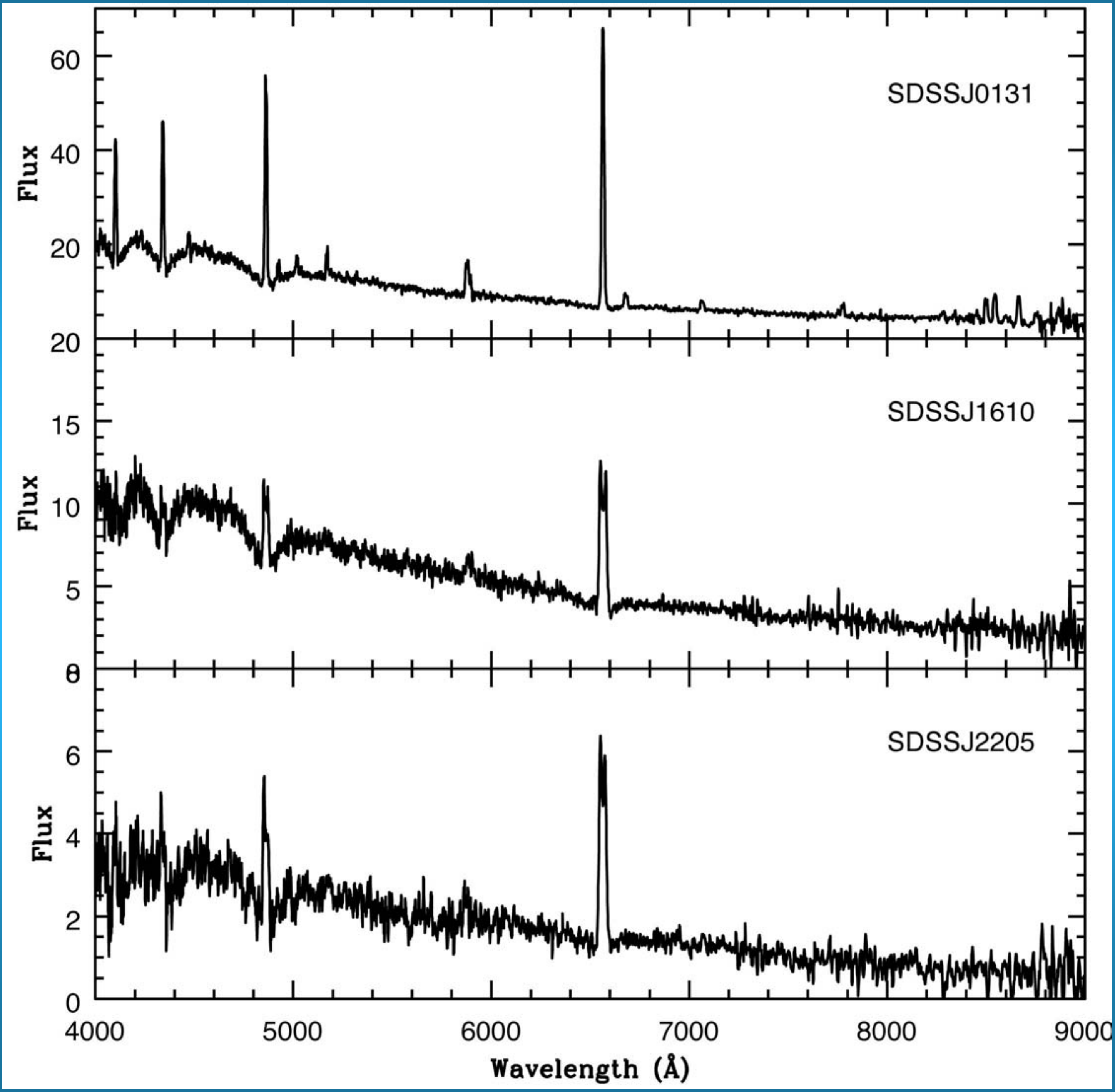


Knigge, Long, Hoard, Szkody, Dhillon, 2000 ApJ, 539, L49

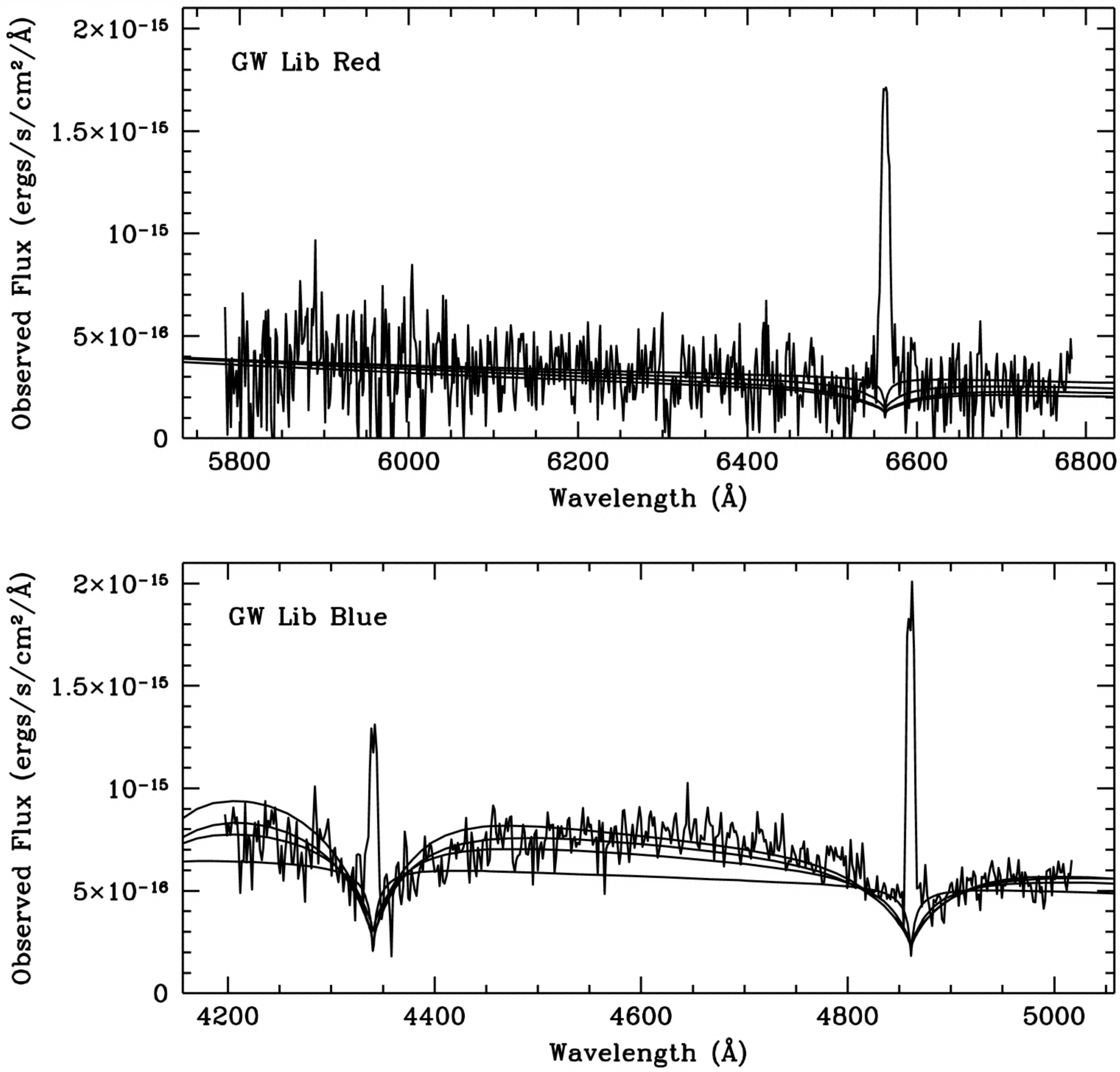
Low state accretion disk system with a hot WD

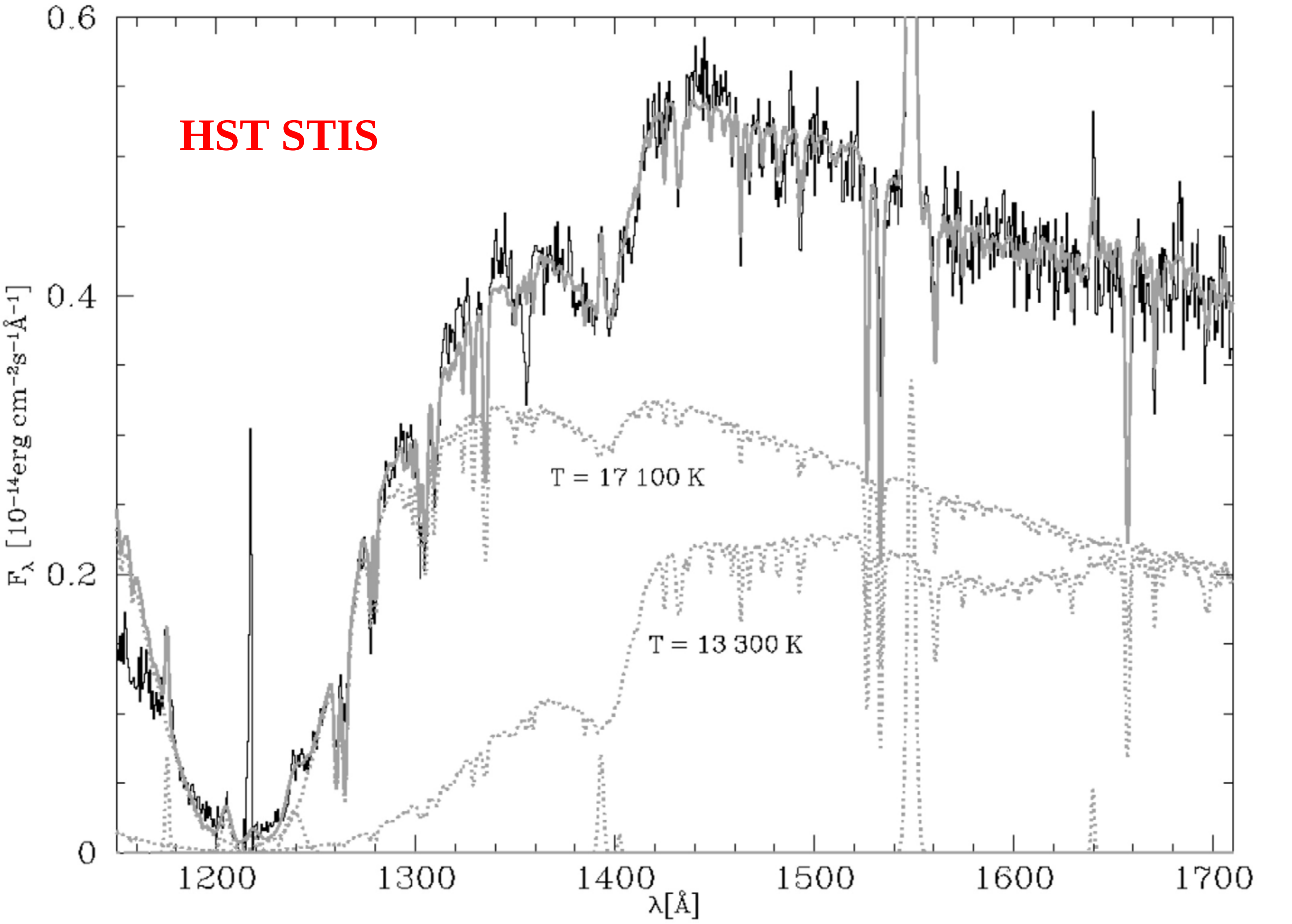


Short P, low mass accretion CVs



T=11,000 +/- 1000K

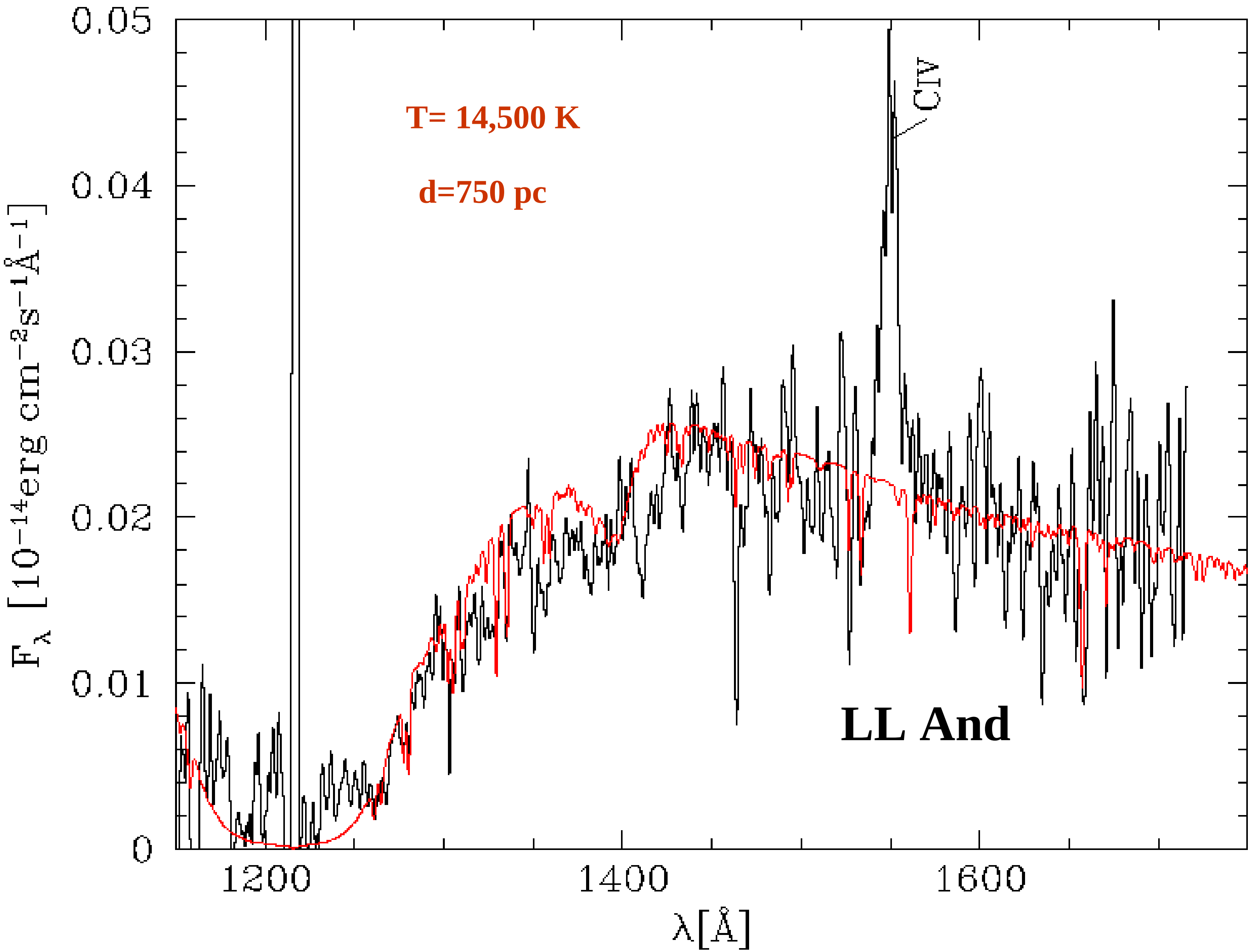




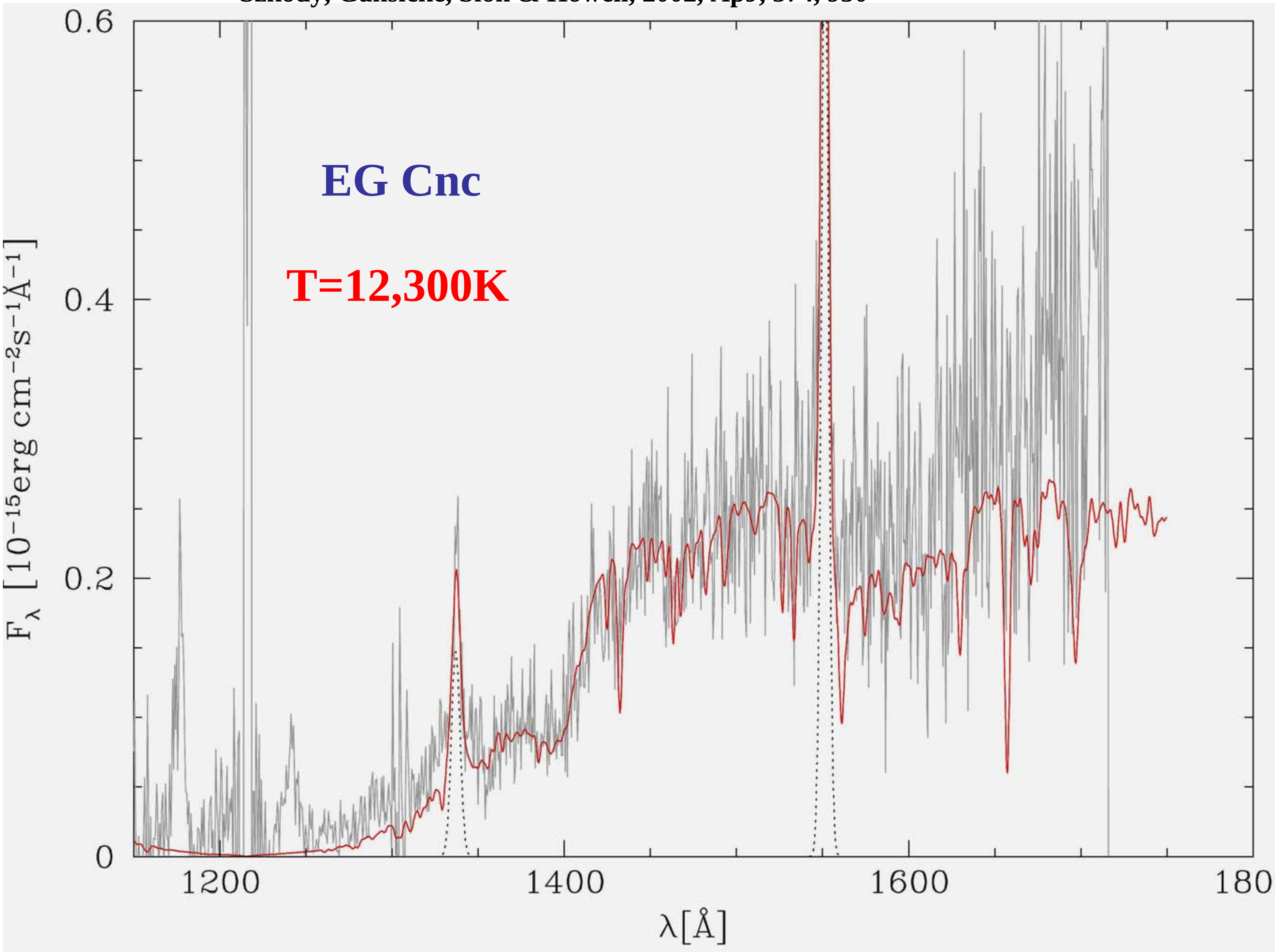
GW Lib fit with 2 component WD: 63% at 13,300K, 37% at 17,100K

Low accretion rate system with cool WD

Howell, Gansicke, Szkody, Sion, 2002, ApJ, 575, 419

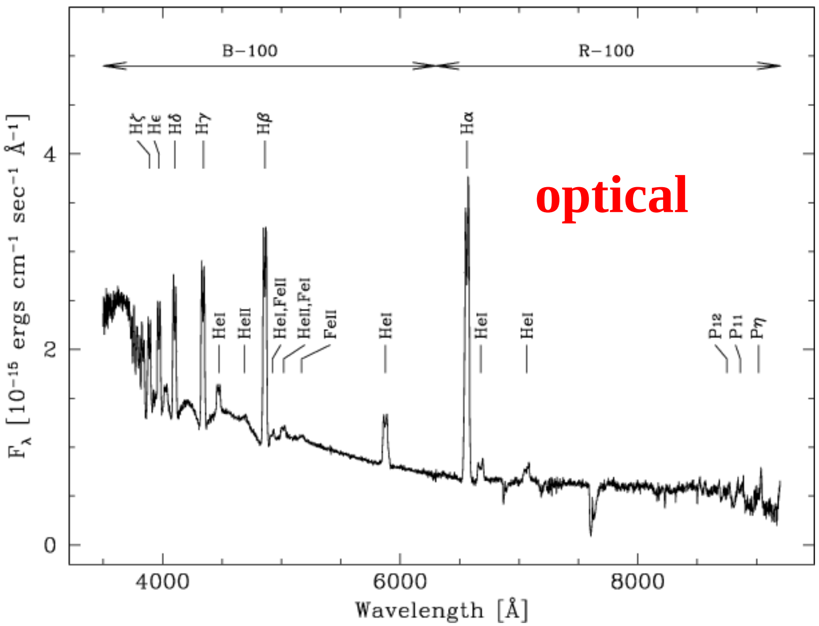


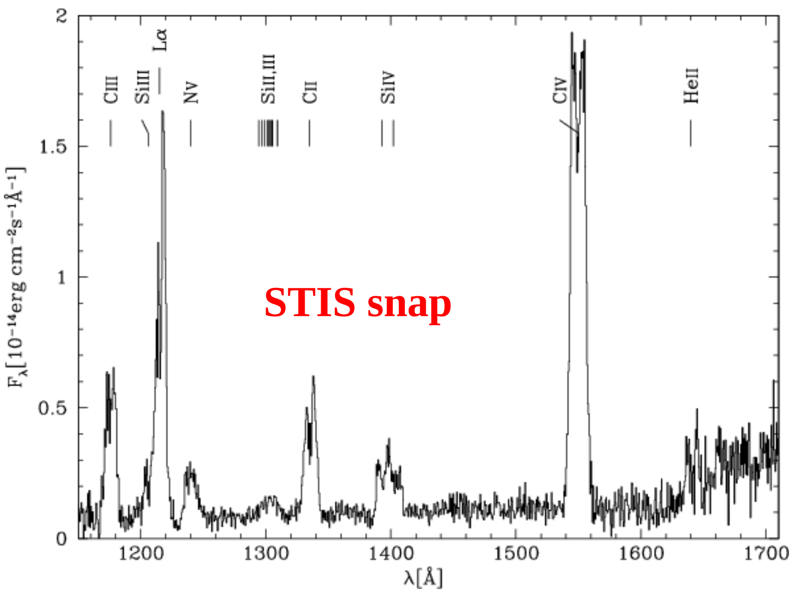
Szkody, Gansicke, Sion & Howell, 2002, ApJ, 574, 950



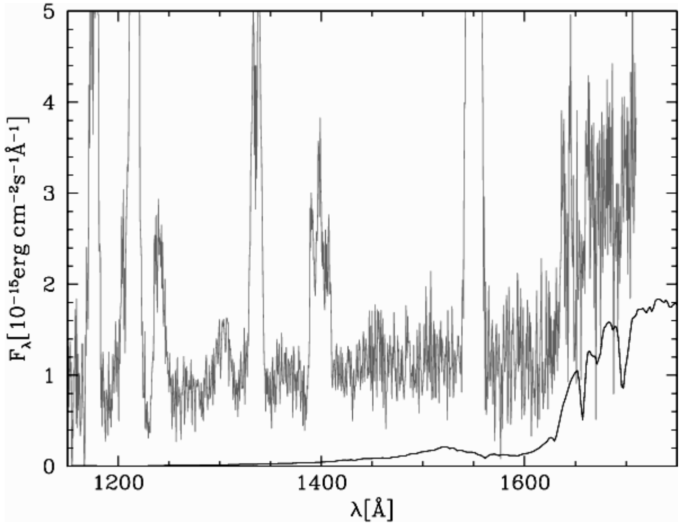
HS 2331+3905

Araujo-Betancor et al.
2005, A&Ap, 430, 629

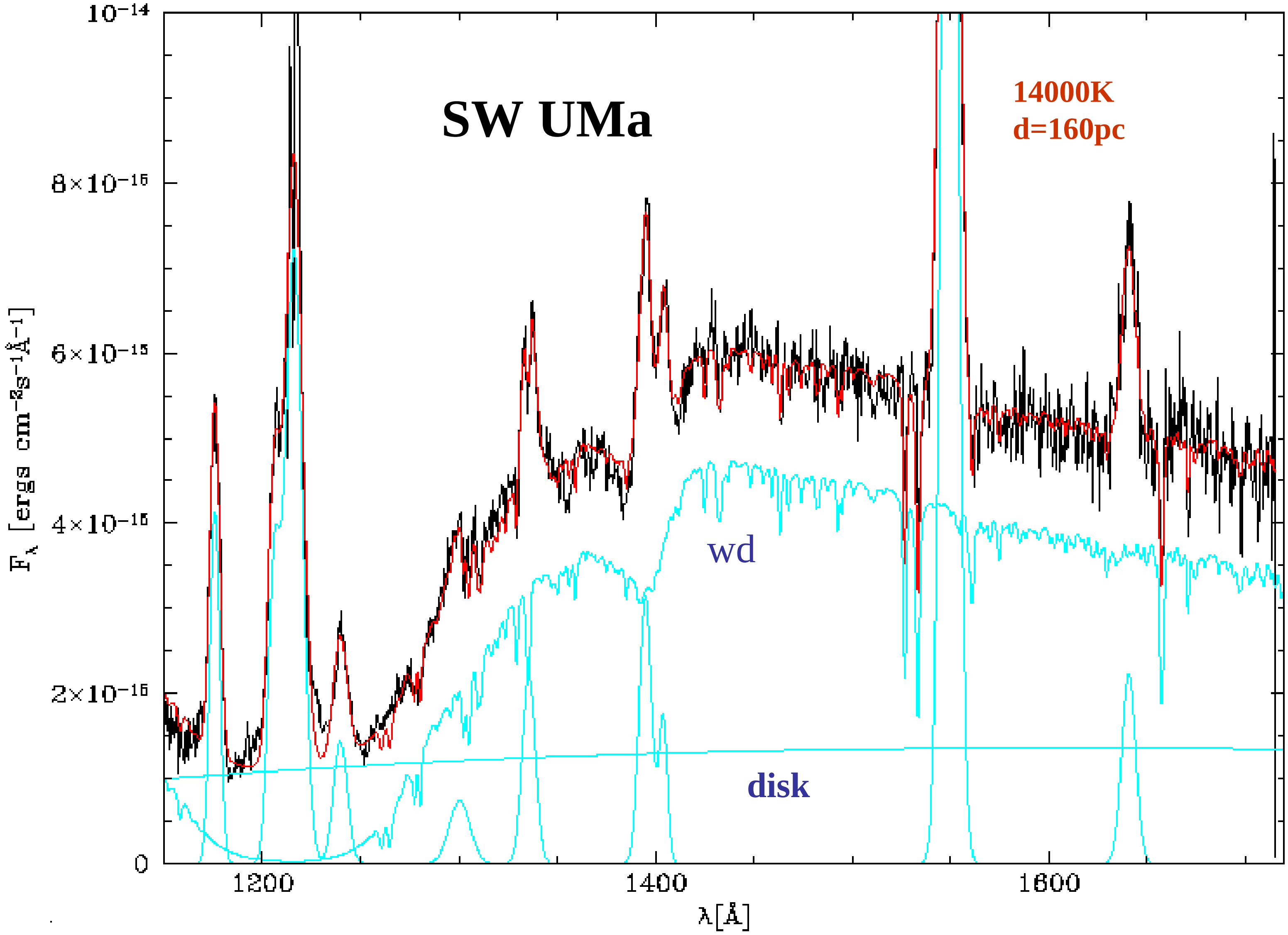




T_{wd}=10,500K,
d=90pc



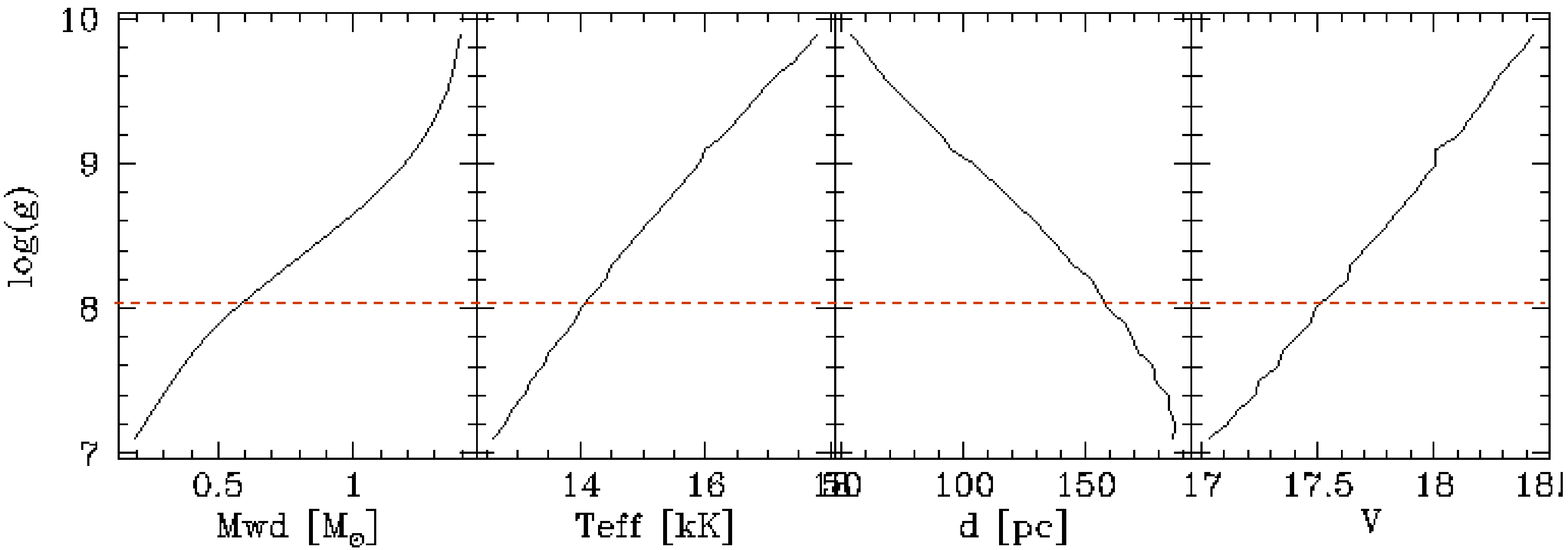
Low accretion rate with some disk contribution



Caveat 1:

Variation of WD Mass, Temp, distance and V mag with log g

Ivan Hubeny WD models

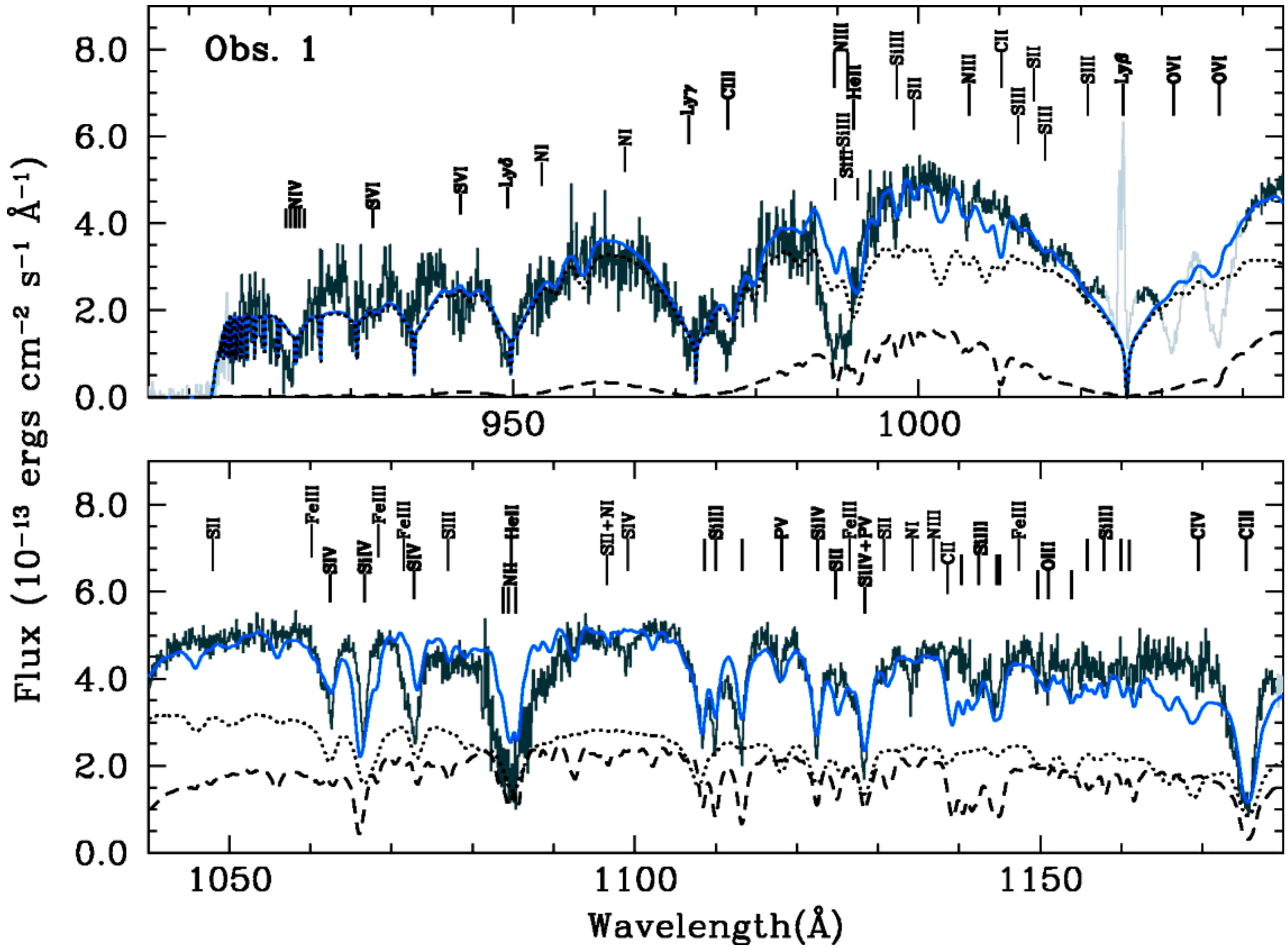


Lower limit to log g from V mag; upper limit from WD mass

Caveat 2:

Two components fit better than one

FUSE U Gem study by Long et al. 2006, ApJ 648

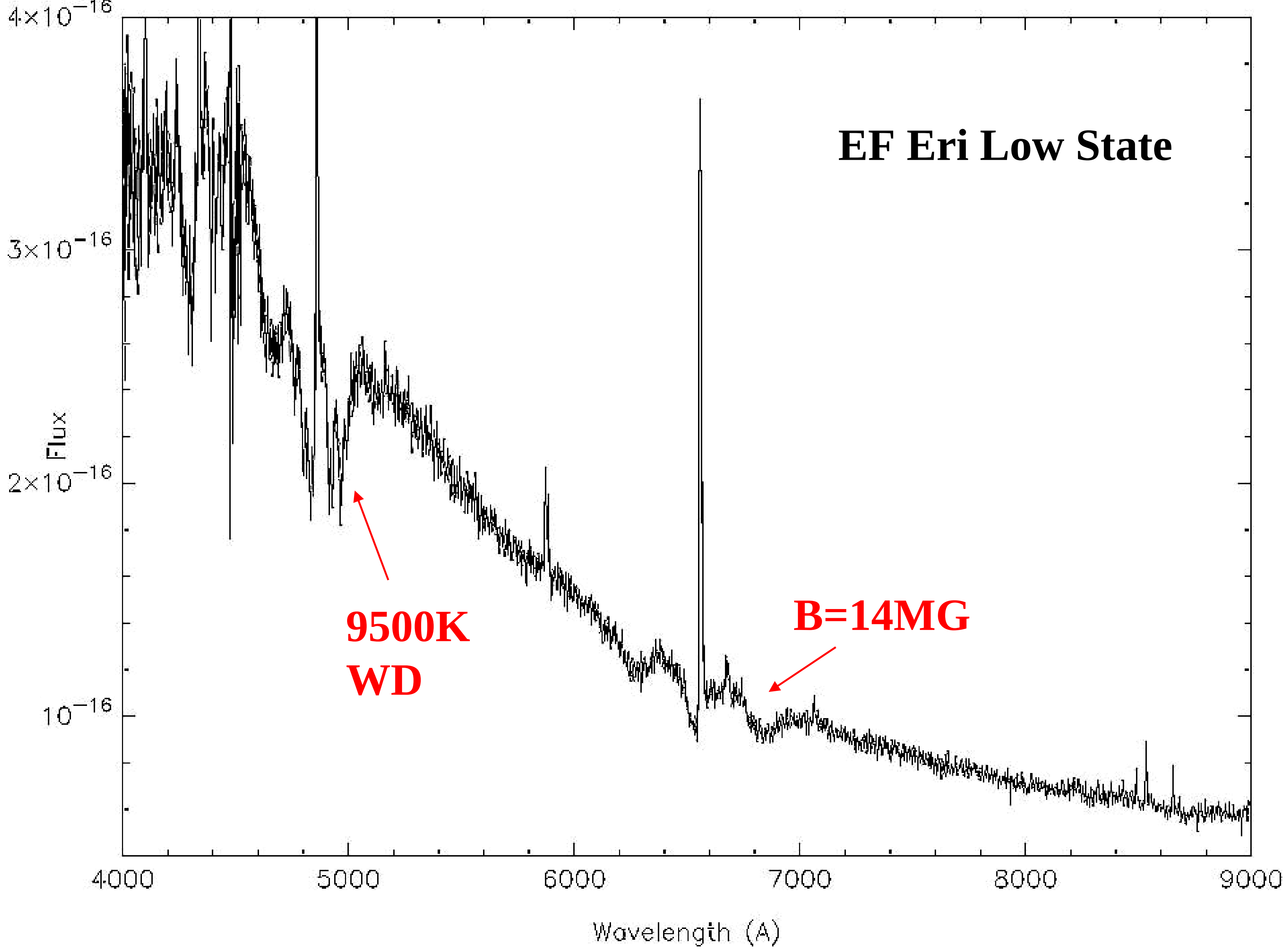


Long dash = 28,500K covering 82% of WD; dotted = 70,000K over 18% of WD

For Magnetic systems (Polars)

To separate WD from accretion column:

- **Wait for a low state**
- **Work on LARPs**



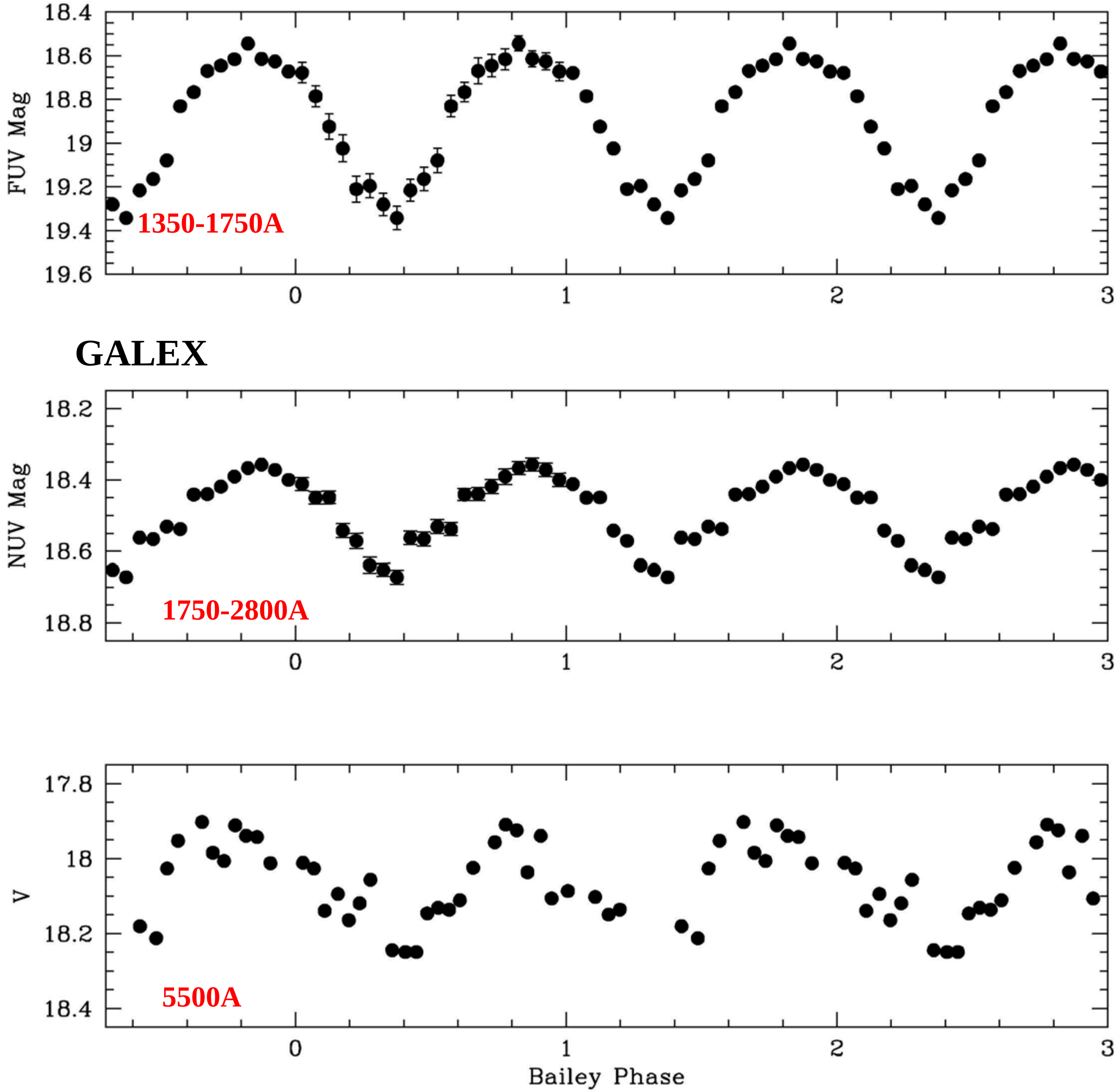
EF Eri Low State
9500K
WD
B=14MG
Flux
Wavelength (A)
4×10⁻¹⁶
3×10⁻¹⁶
2×10⁻¹⁶
10⁻¹⁶
4000
5000
6000
7000
8000
9000

EF Eri
Low State
T_{wd}=9500K

Caveat:

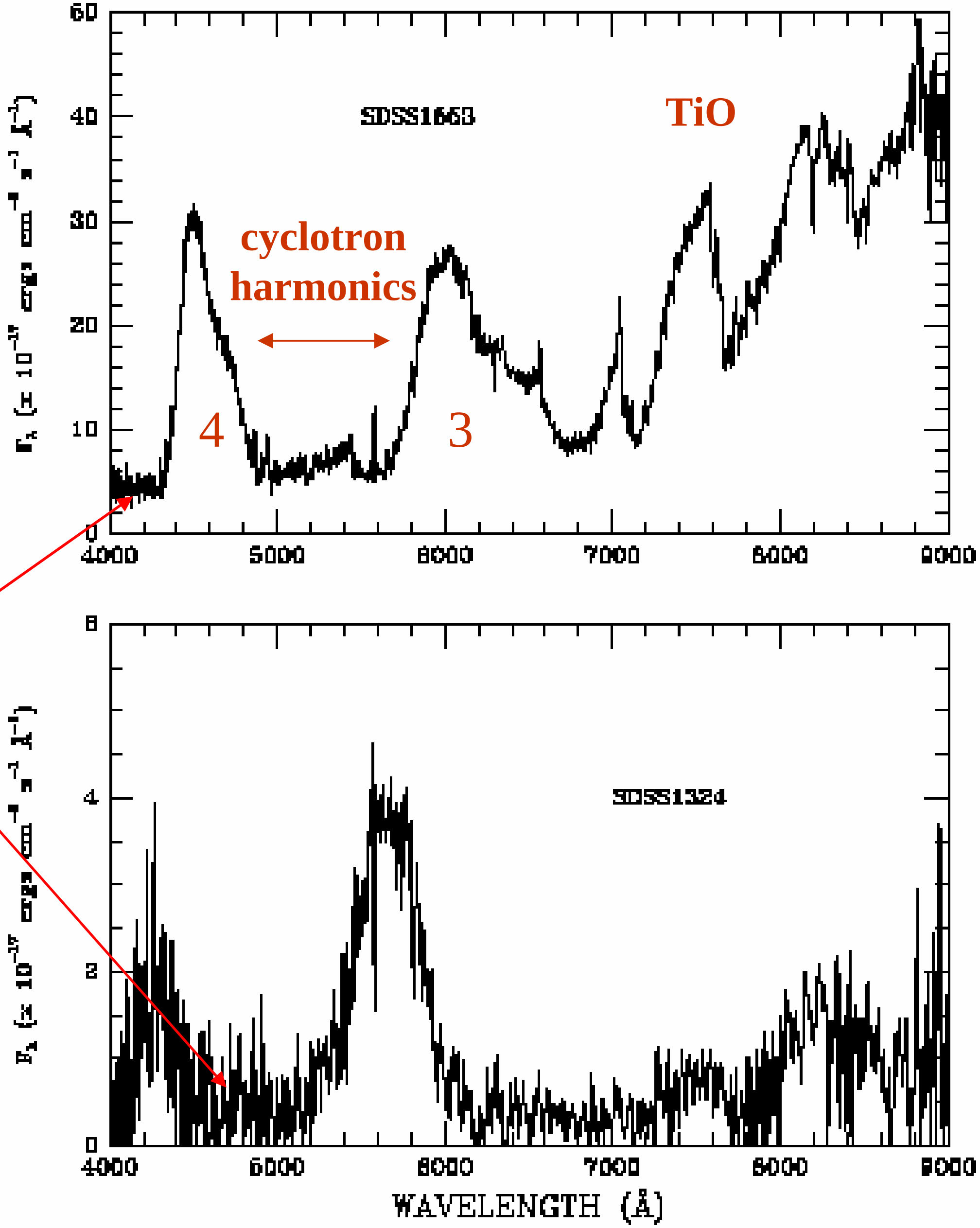
A hot 20,000K component still exists!

Szkody, Harrison, Plotkin, Howell, Seibert, Bianchi, Ap, 646, L147, 2006



(Extremely) Low Accretion Rate Polars

Szkody et al. ApJ, 583, 902, 2003



B ~ 60 MG

T < 1keV

$\dot{M}$~$10^{-14} M_\odot$ /yr

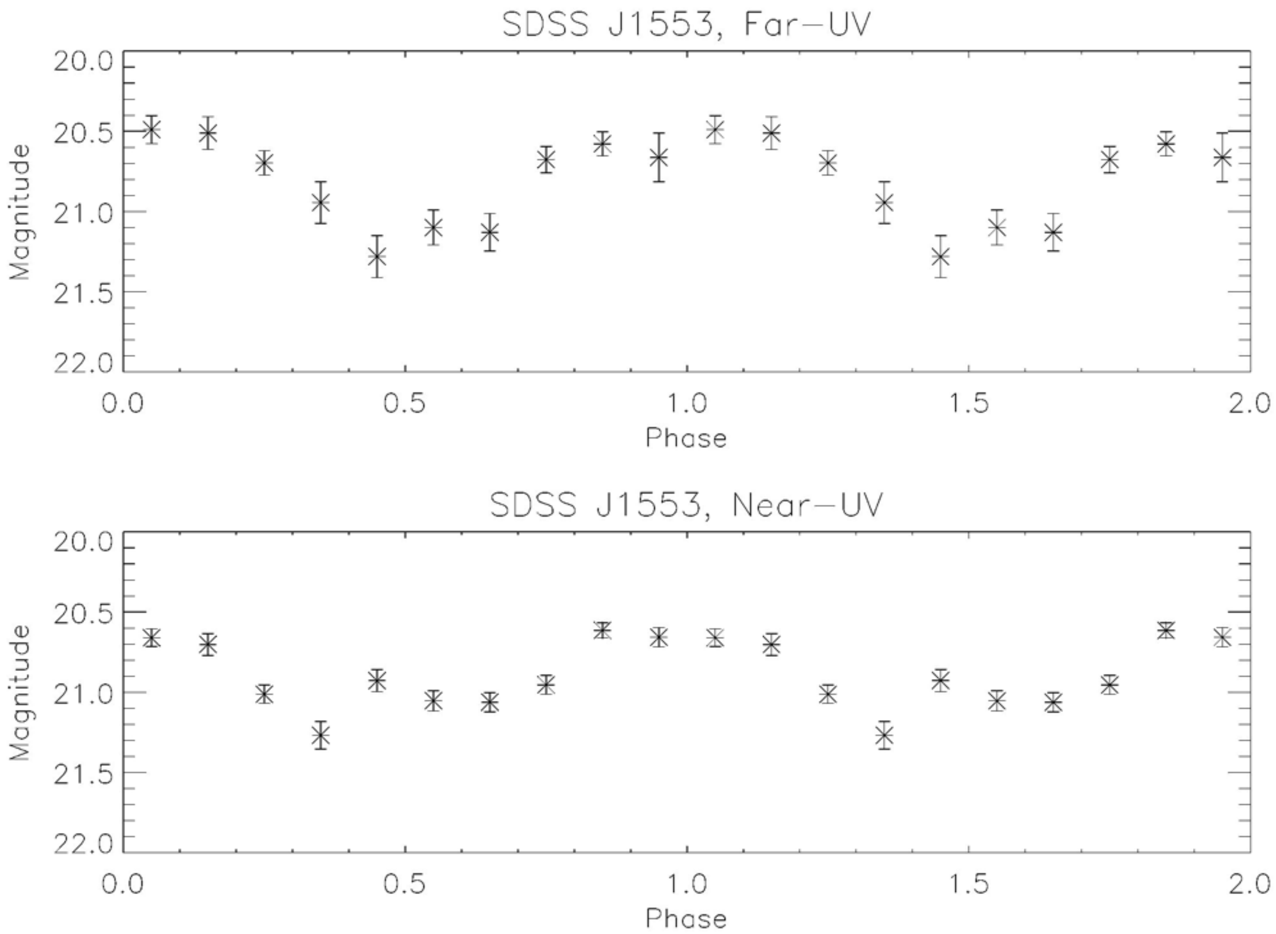
P=4.4 hrs

D=100pc

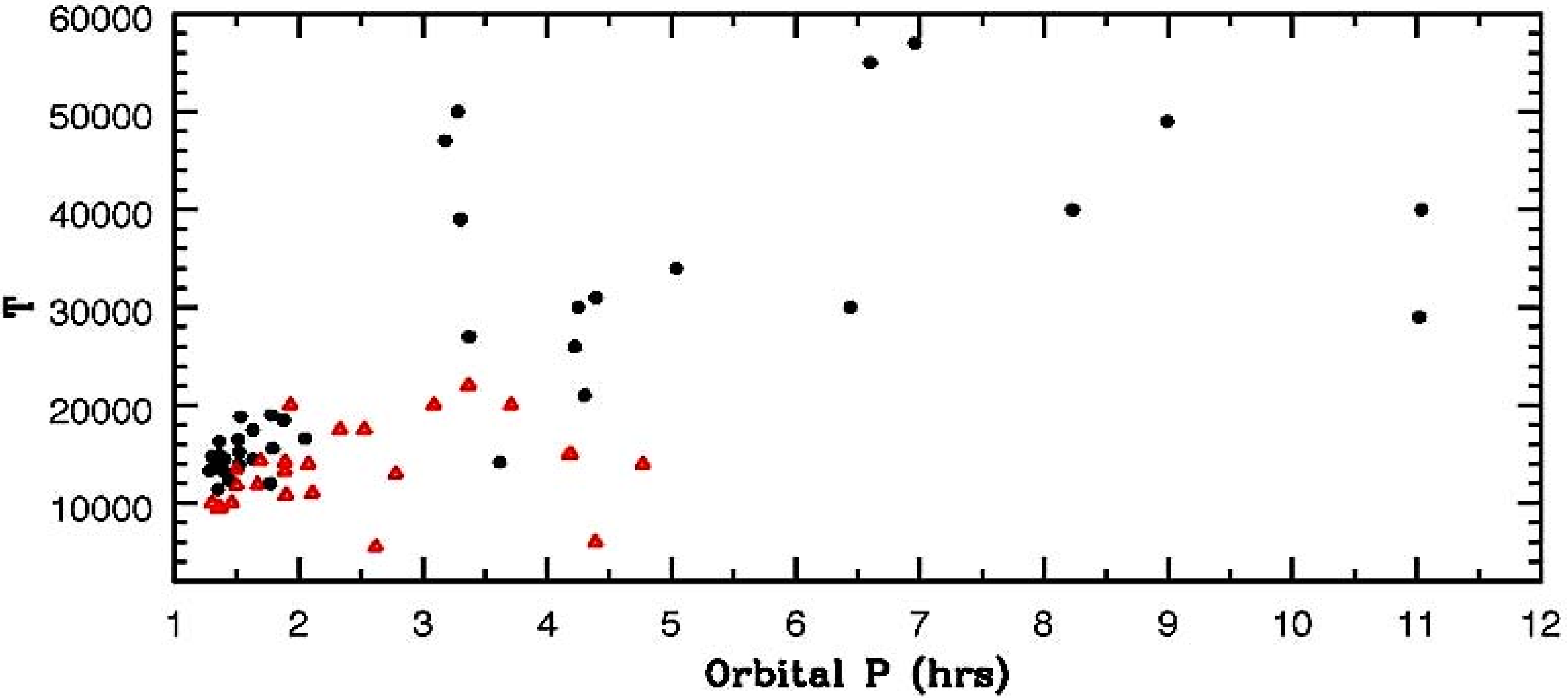
WD

T<6000K

Low Accretion Rate Polar T_{wd} < 8000K

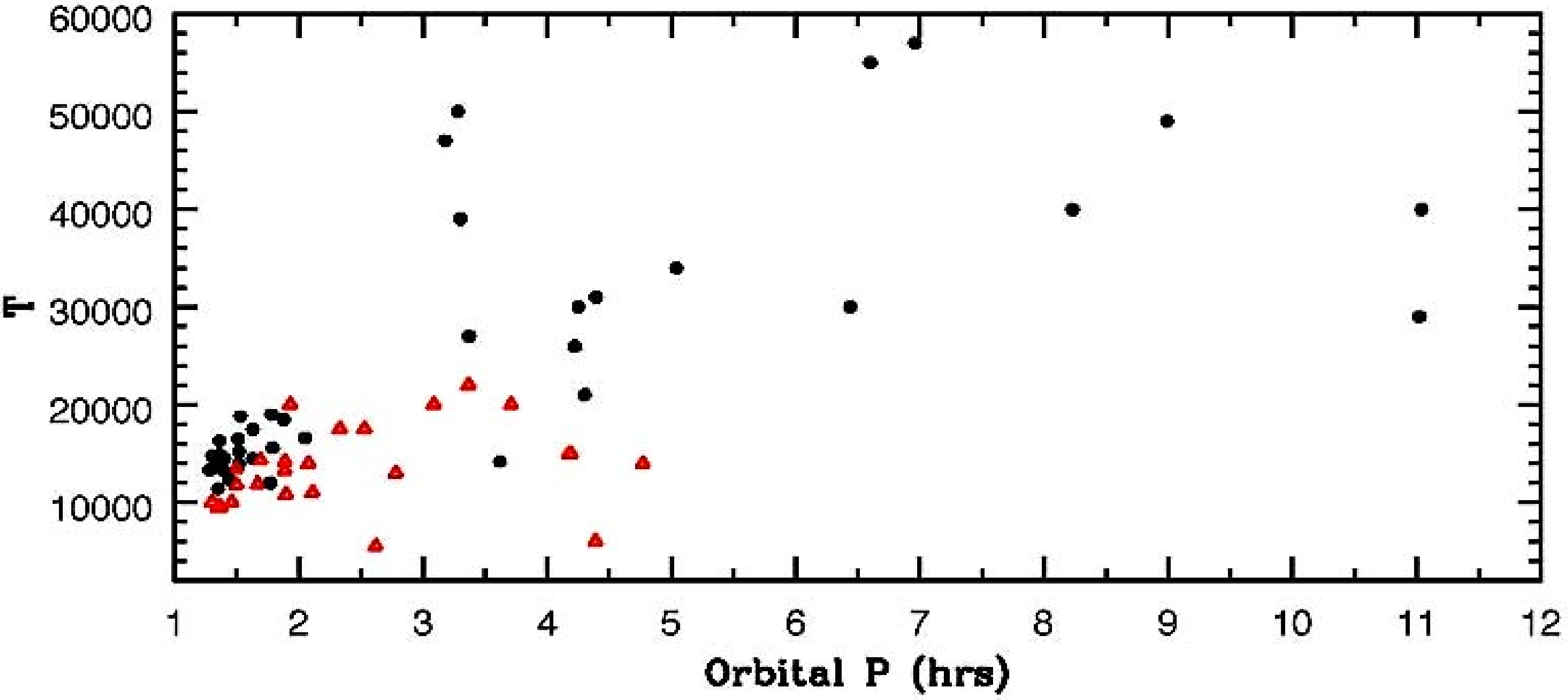


WDs in CVs at Quiescence or Low States

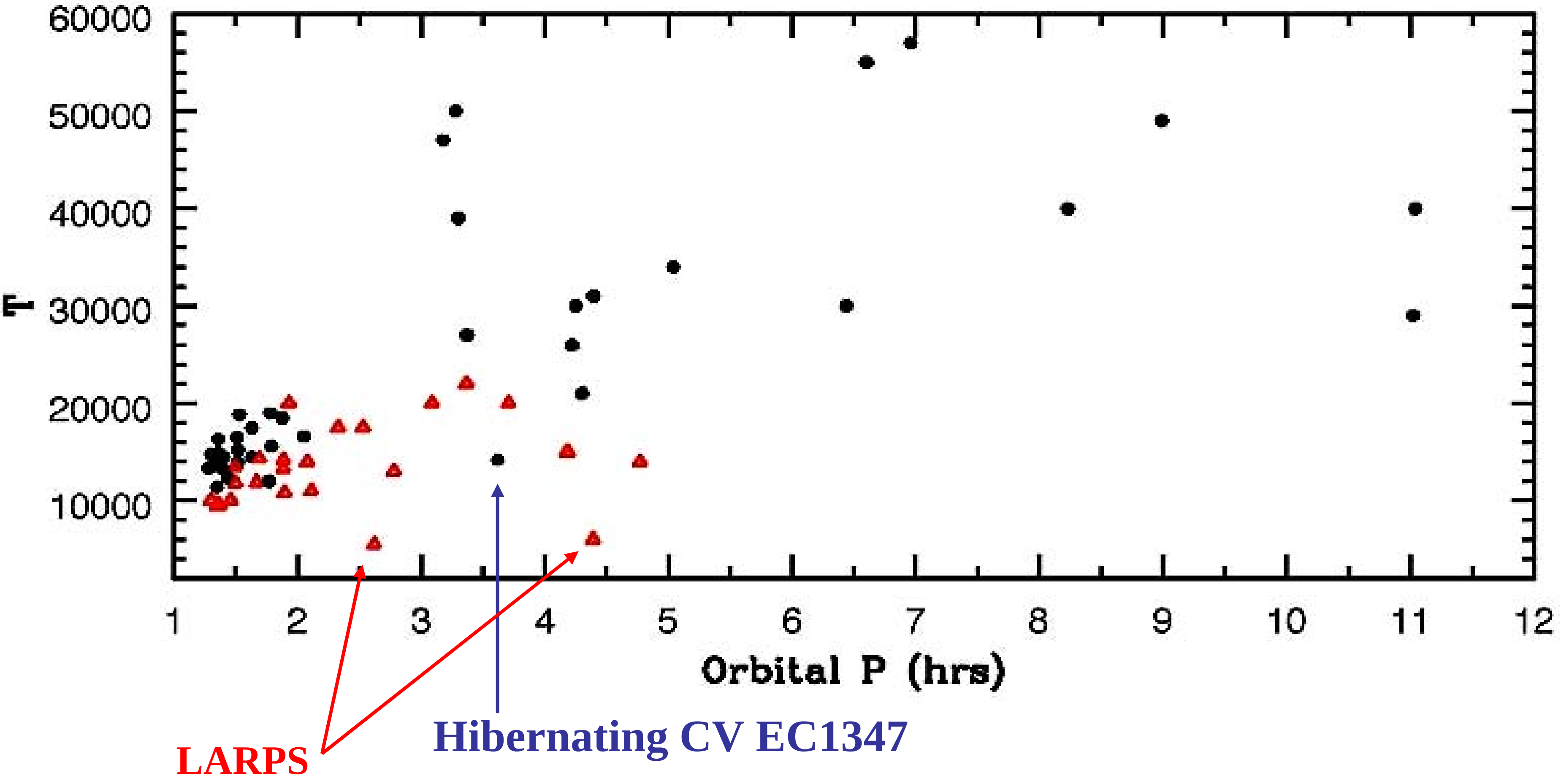


Dots are disk CVs

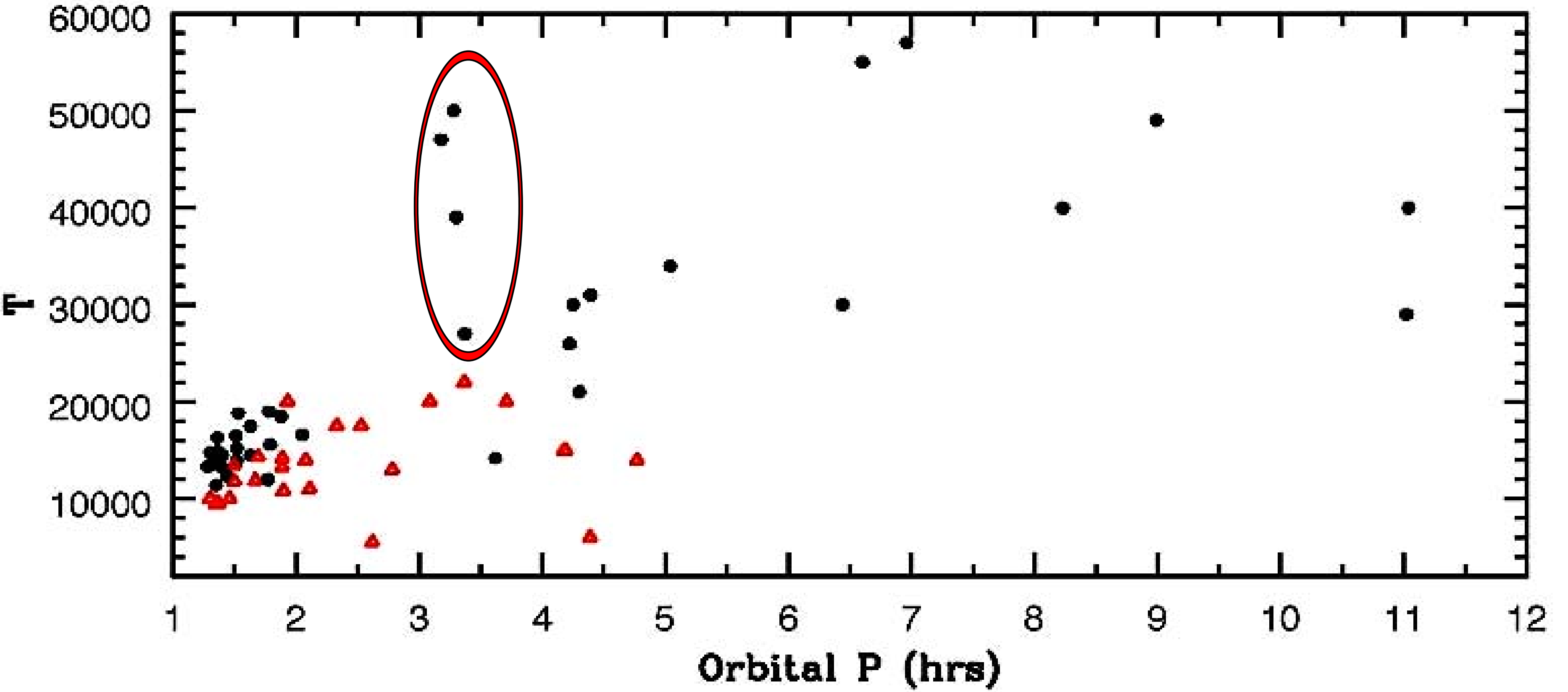
Triangles are Polars



1. Coolest temps are at shortest Periods



2. WDs in Polars are cooler than in Disk Systems

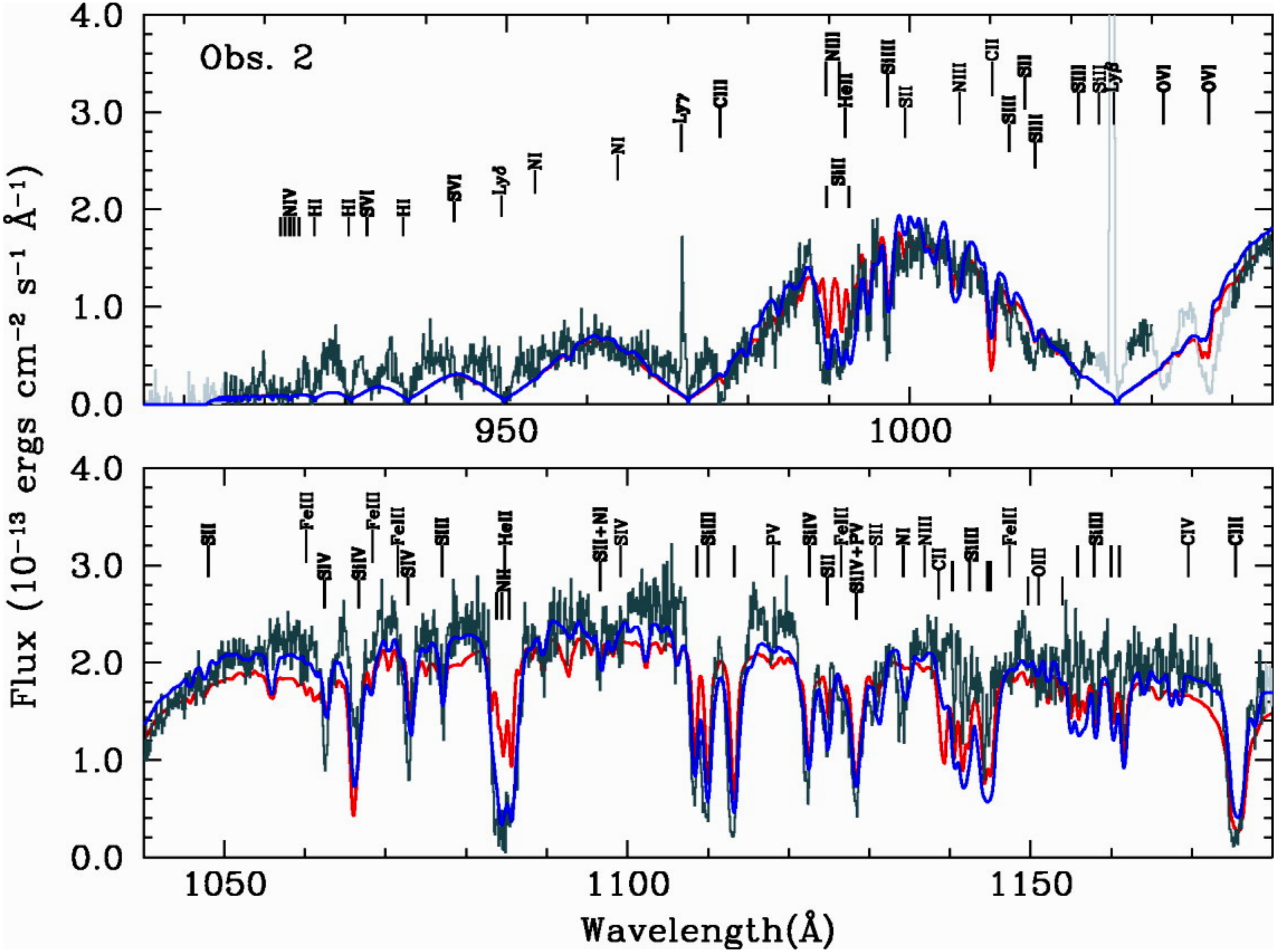


3. Spike in T at 3-3.5 hr periods

Composition and Rotation:

need resolution (minimum 1 Å) and high S/N to resolve lines (STIS on HST or FUSE)

U Gem FUSE by Long et al.



Red is solar abundance, blue is varying abundances

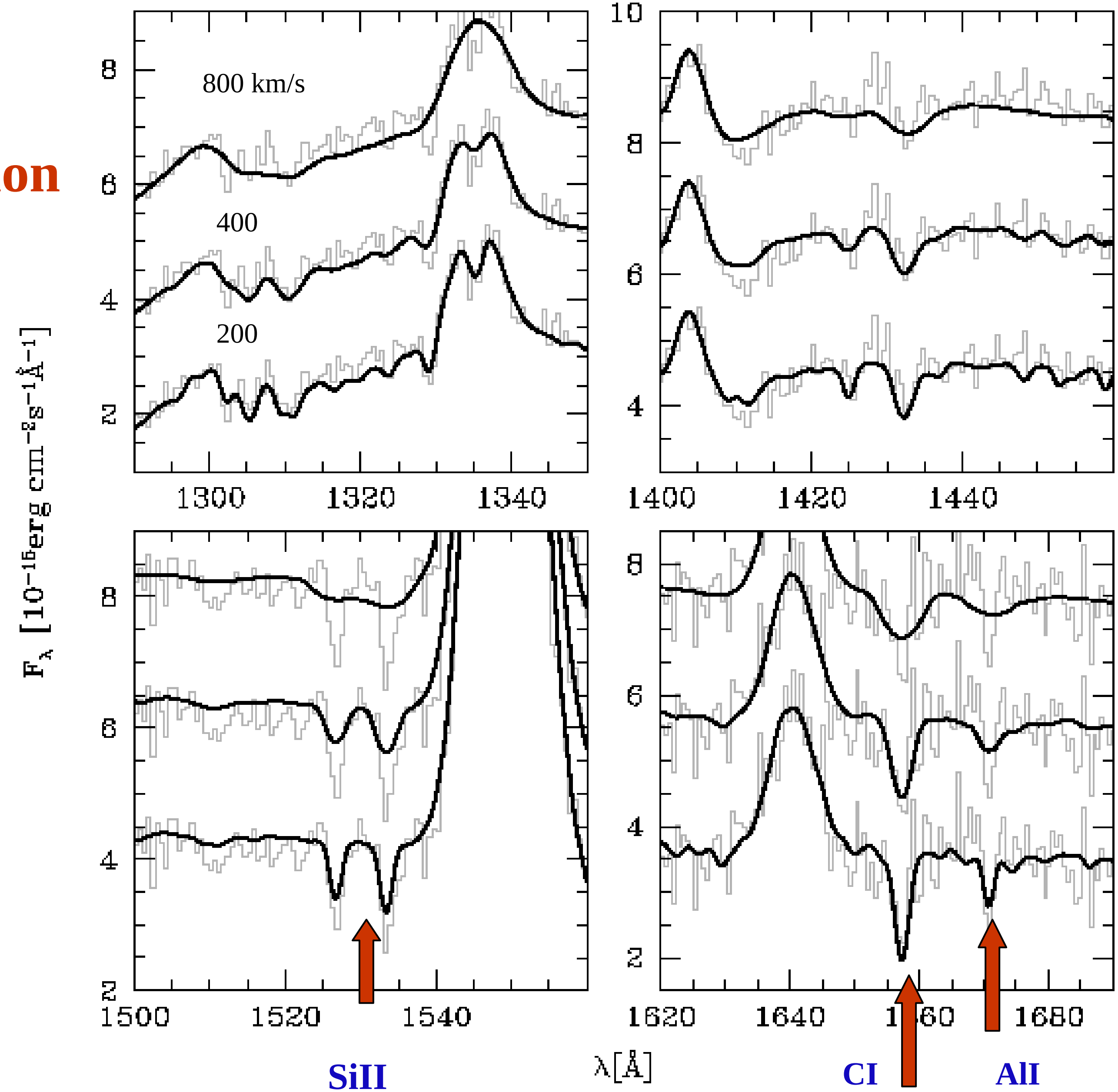
Rotation

and

Composition

SW UMa

Gansicke, Szkody, Howell, Sion 2005, ApJ, 629



Vsini=200 km/s

z=0.1; Al=0.8

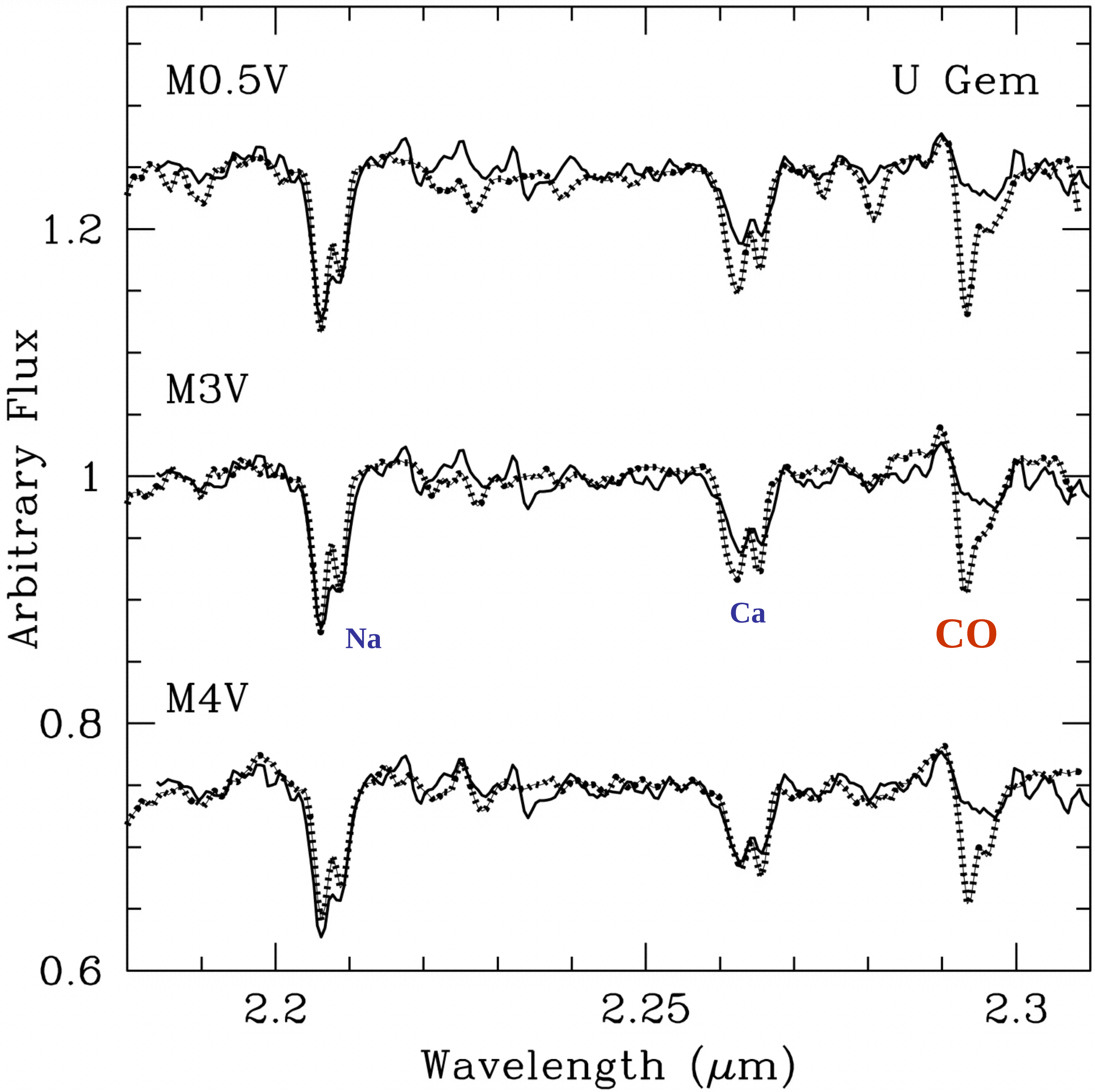
Compositions:

Disk systems	Polars
Disk systems: 0.1-0.3 solar WDs	Polars: WDs show no metals
N enhanced, C depleted	
Secondaries depleted in CO	Secondaries normal

~10 magnetic/disk systems have inverted NV/CIV emission lines

Harrison, McNamara, Szkody, Gilliland, 2000, AJ, 120, 2649

sec comp



WD Rotation Rates and Compositions

Object	P (hrs)	Vsini (km/s)	i (deg)	Metals (solar)
LL And	**1.33**	**< 500**		**0.3**
WZ Sge	**1.36**	**400-1200**	**75**	**0.01, C 0.5- 5, N 0.05-3**
AL Com	**1.36**	**< 800**		**0.3**
SW UMa	**1.36**	**200+-50**	**45**	**0.1, Al 0.8, Si 0.3, C 0.05**
HV Vir	**1.39**	**400+-100**		**0.3**
WX Cet	**1.40**	**400+-100**		**0.1**
OY Car	**1.51**	**< 200**	**83**	
VY Aqr	**1.52**	**400+-100**		**Si 0.5, C 1.0**
BC UMa	**1.52**	**300+-100**		**0.2, Al 1.5, Si 0.4**
EK TrA	**1.53**	**200 +-100**		**Sub-solar**
VW Hyi	**1.78**	**400**	**60**	**Si,C 0.3, N,O 3 Al 2**
EF Peg	**2.05**	**300+-100**		**0.1-0.3**
DW UMa	**3.28**	**370+-100**	**82**	**0.5**
U Gem	**4.25**	**< 100**	**65**	**C 0.05-1,Si 0.4-1.3, N 4**
DA WDs		**< 40**		**10^{-6} to 10^{-9}**
EC1347	**3.62**	**400+/-100**		**0.3**
Polars	**1.3-8**	**locked to orbit**		**none**

Where we stand:

- **Masses are still mostly unknown but generally > 0.6 solar**
- **Temps are getting there, but 2nd component presents problems**
- **Compositions show clear separation into disks vs magnetic cases, but sec differences present problems**
- **Rotations are low, with 2nd component showing higher values**