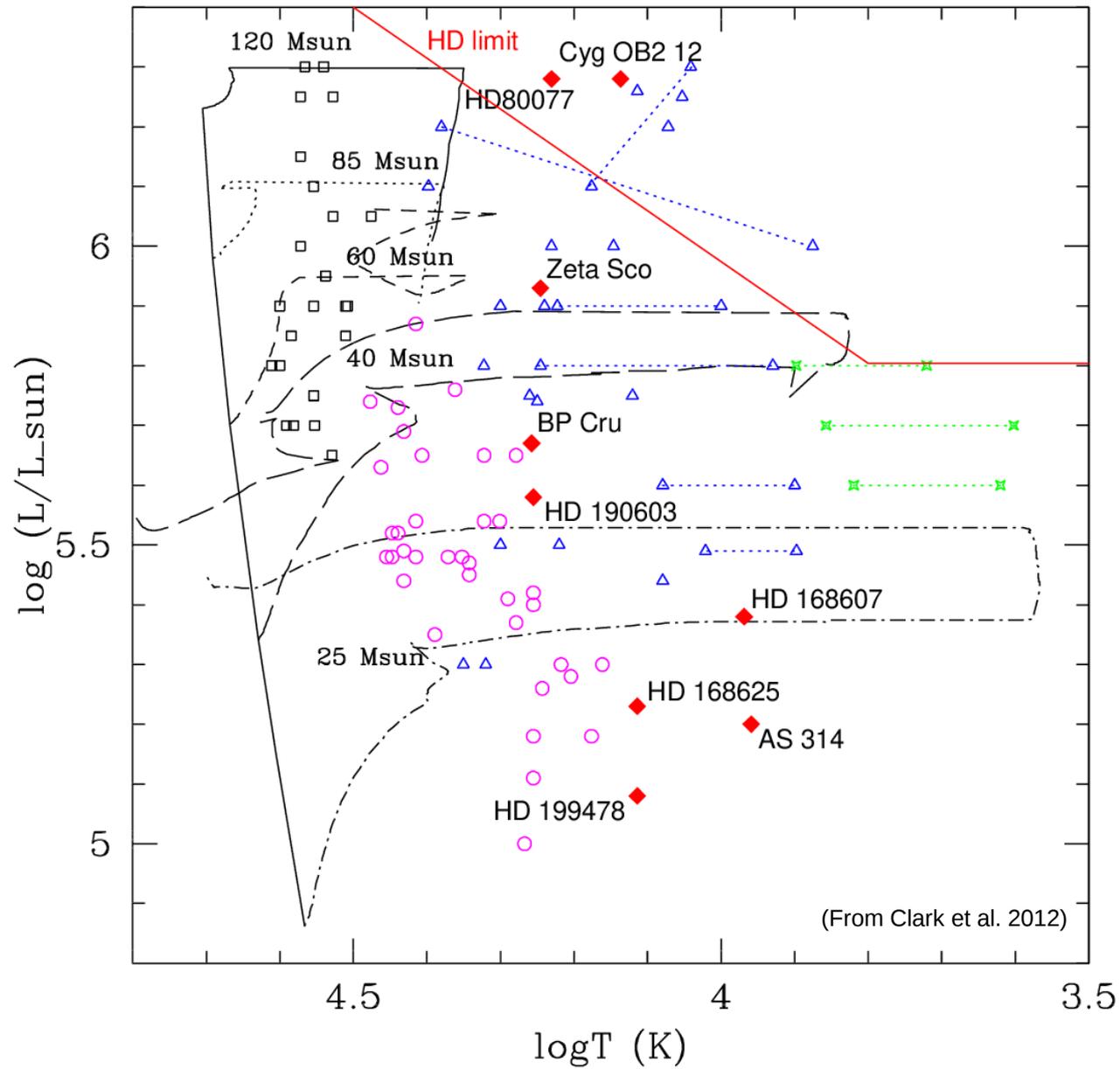


Long-Term Monitoring of Luminous Blue Variables and Hypergiant Stars. Current Status

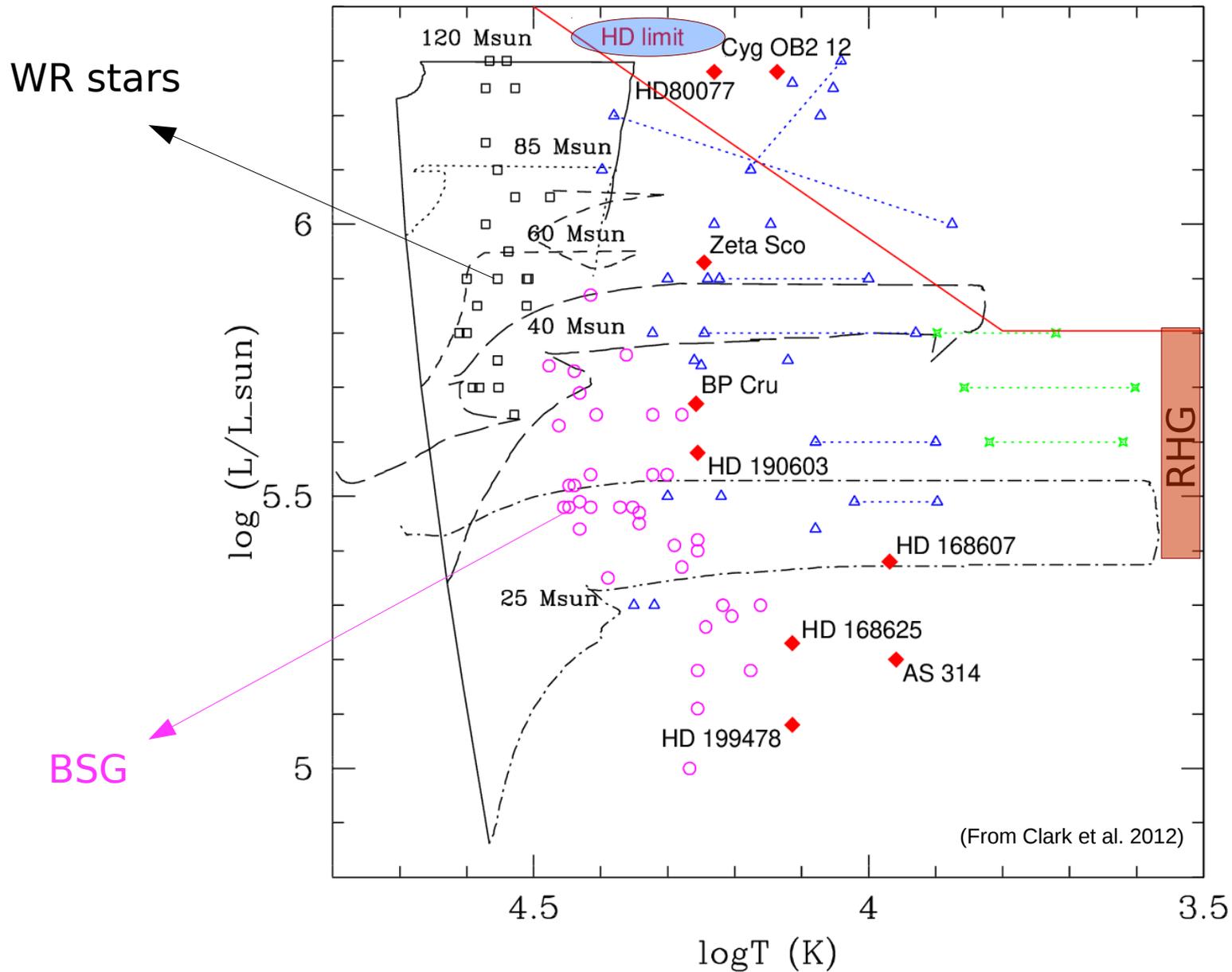
Damien Hutsemékers (Uliège),

Eric Gosset (ULiège) and Laurent Mahy (ULiège / KUL)

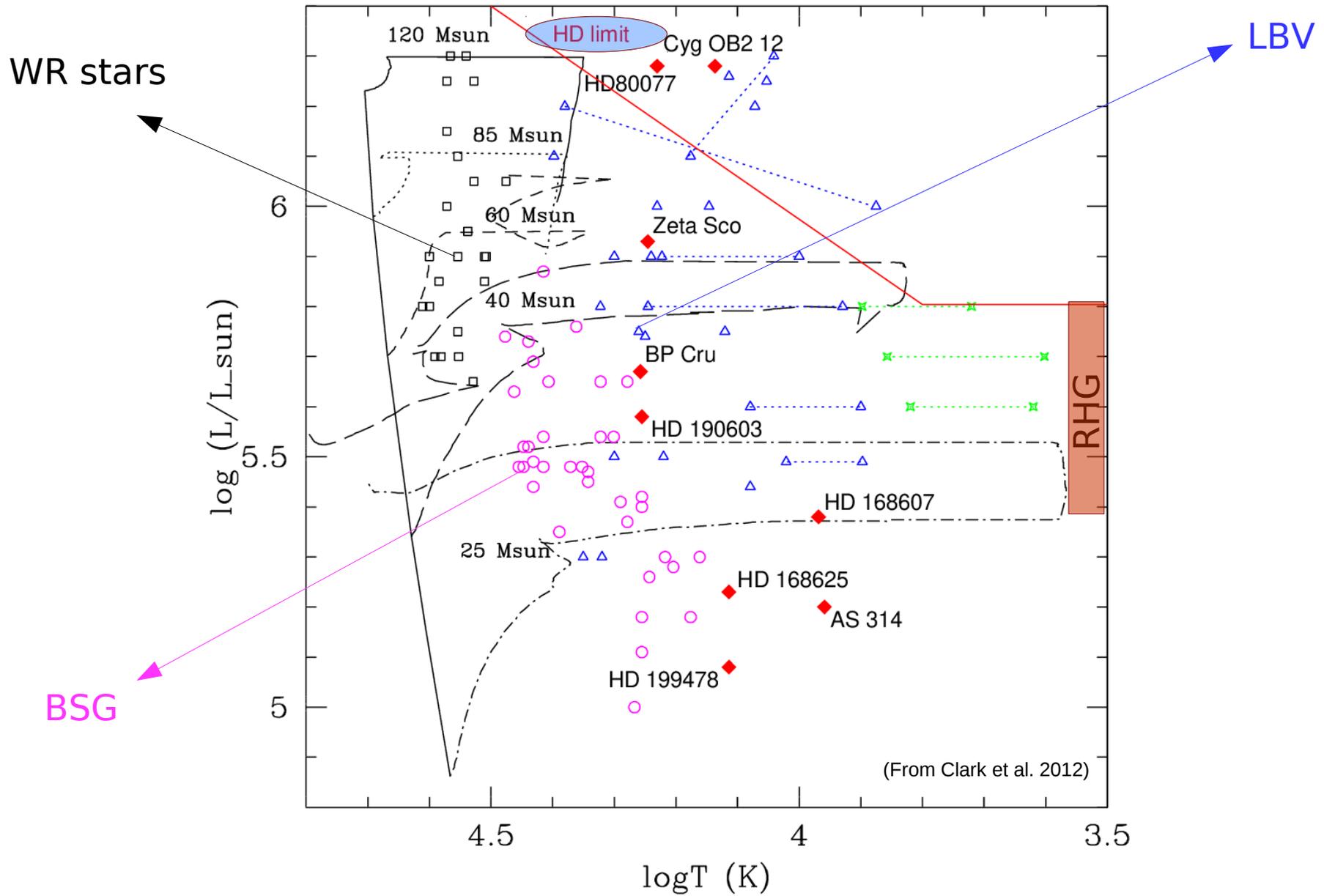
The upper HR diagram



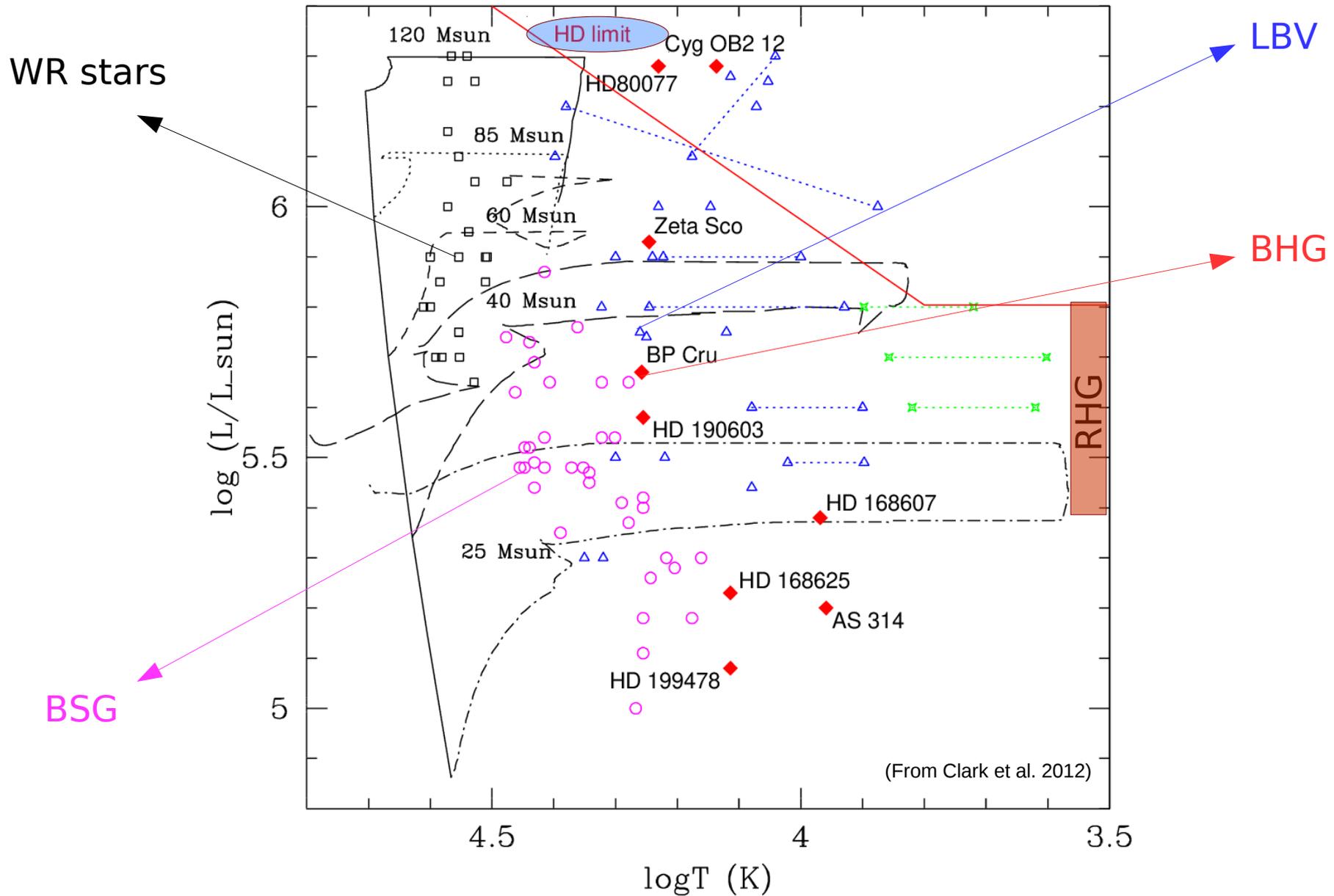
The upper HR diagram



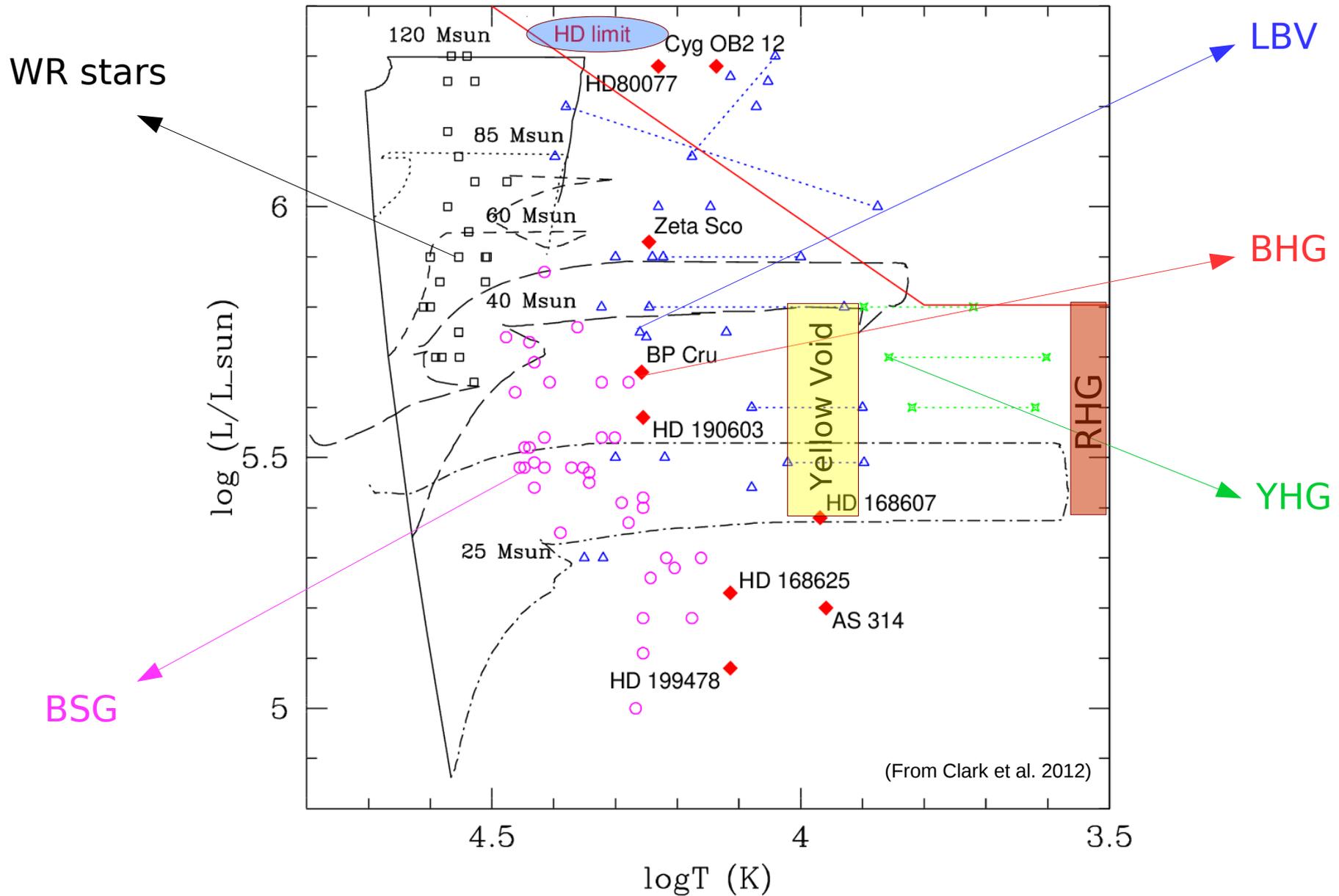
The upper HR diagram



The upper HR diagram

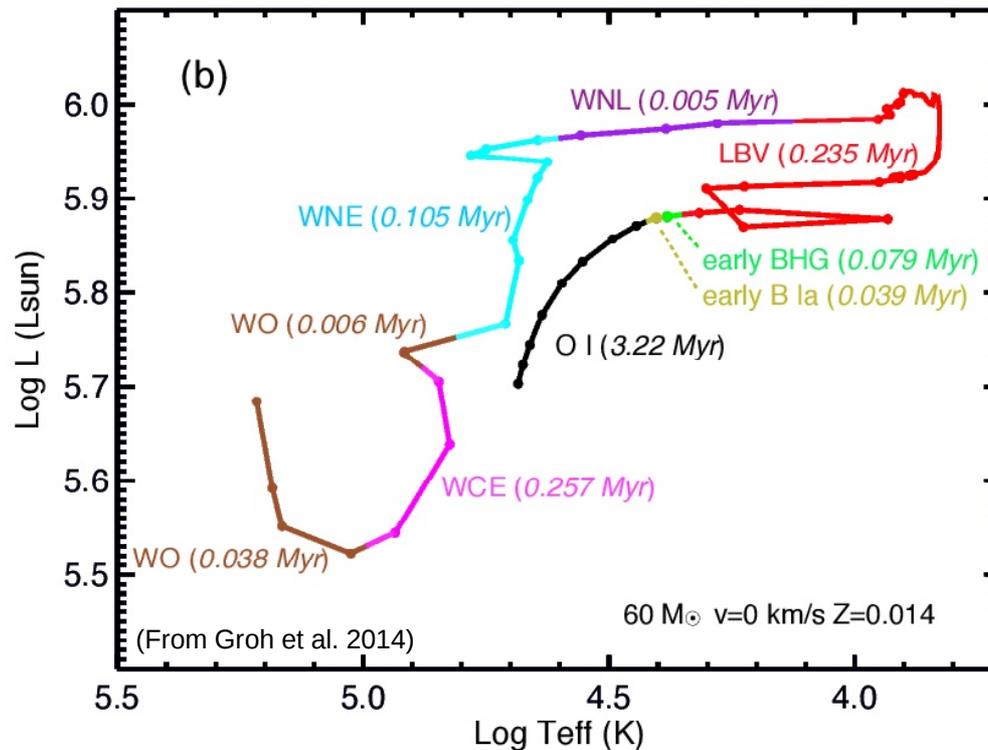


The upper HR diagram



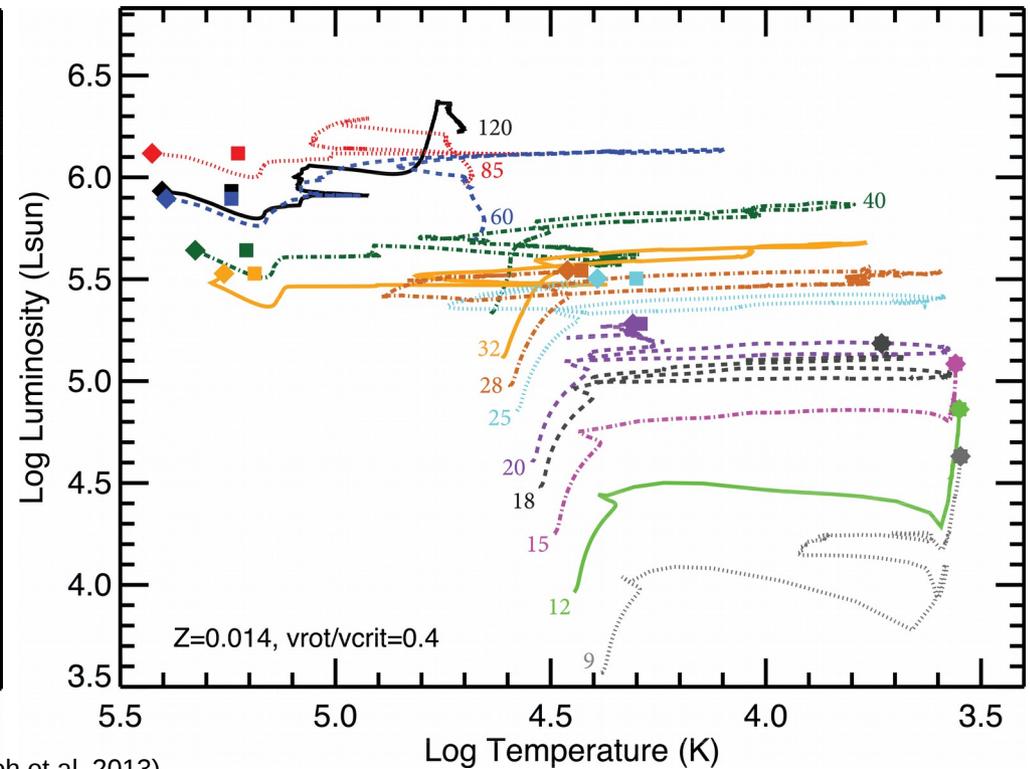
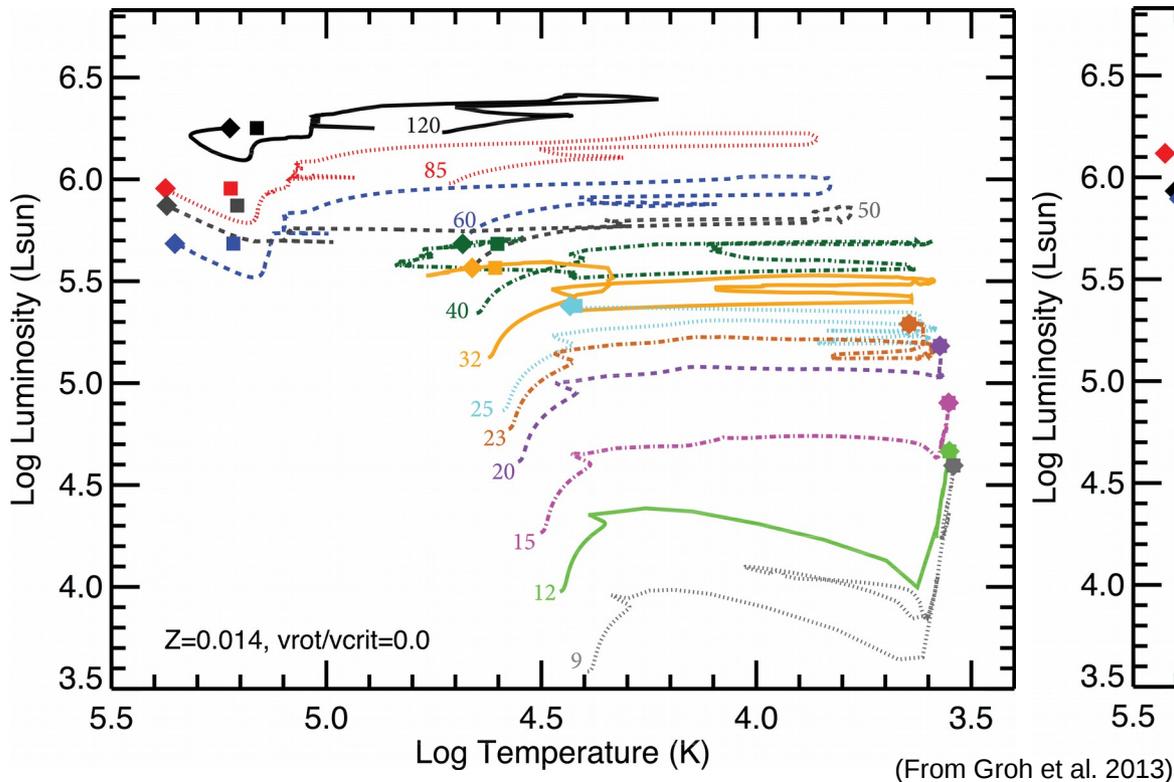
The upper HR diagram

- Rare, luminous ($\sim 10^6 L_{\odot}$) and massive ($\sim 50 M_{\odot}$) stars
- High mass-loss rates ($\sim 10^{-5} M_{\odot}/\text{yr}$) + ejected nebulae
- Short-lived ($\sim 10^4\text{-}5$ yr) transition stage in massive star evolution



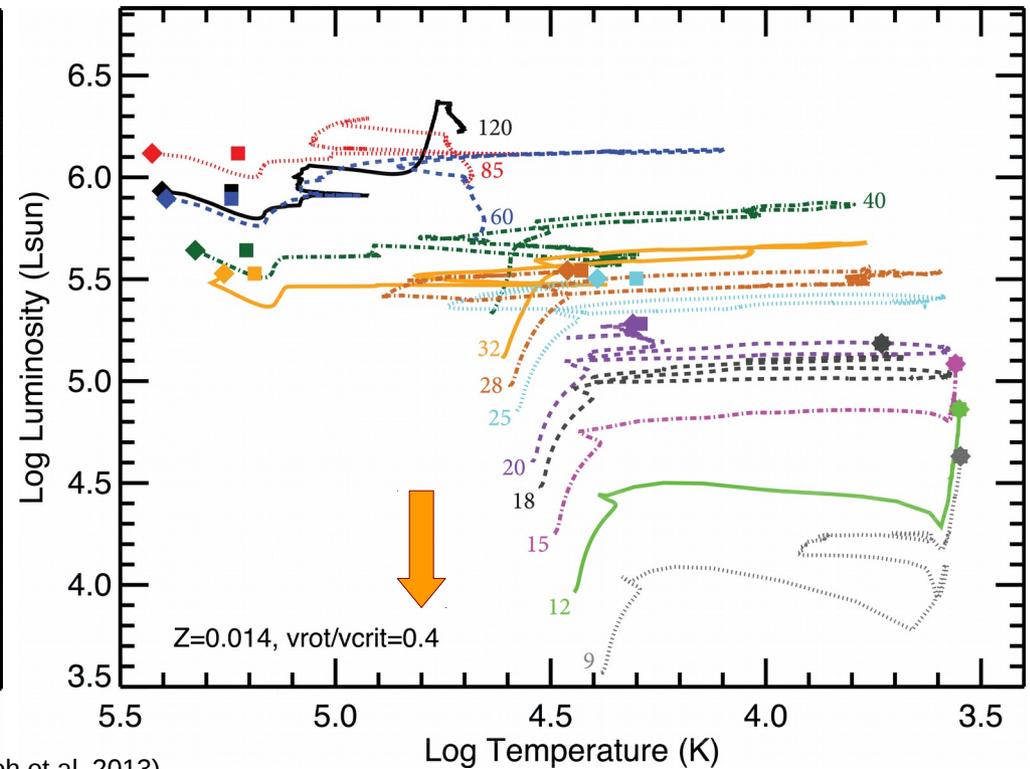
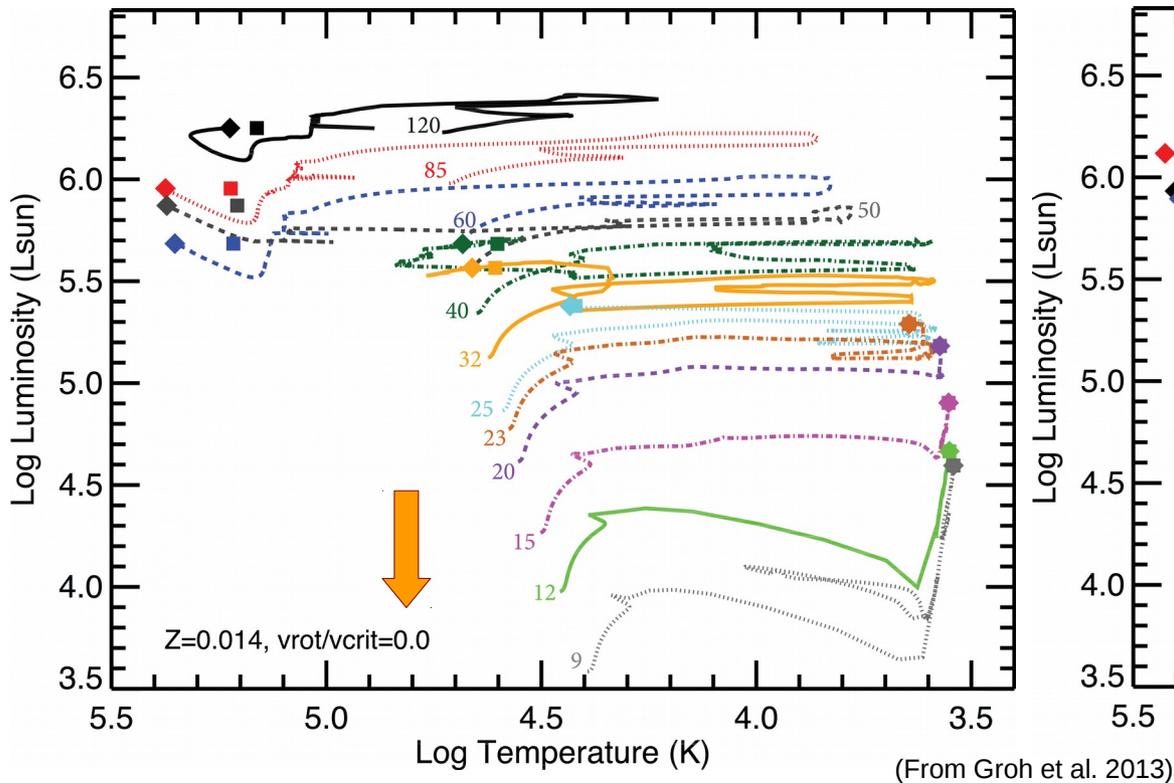
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The upper HR diagram

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The upper HR diagram

- Rare, luminous ($\sim 10^6 L_{\odot}$) and massive ($\sim 50 M_{\odot}$) stars
 - High mass-loss rates ($\sim 10^{-5} M_{\odot}/\text{yr}$) + ejected nebulae
 - Short-lived ($\sim 10^{4-5}$ yr) transition stage in massive star evolution
- *Uncertain evolutionary paths, strong dependence on rotation*
- *Needed to correctly identify supernova progenitors*
- *What is the incidence of binarity (e.g. η Car)?*

Binarity ?

2018

Periodicity in the Light Curve of P Cygni – Indication for a Binary Companion?

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¹*Department of Physics, Ariel University, Ariel, POB 3, 40700, Israel*

State University, E. Kharadze Abastumani Astrophysical Observatory, Kakutsa Cholokashvili ave. 3/5, Tbilisi, 0162, Georgia

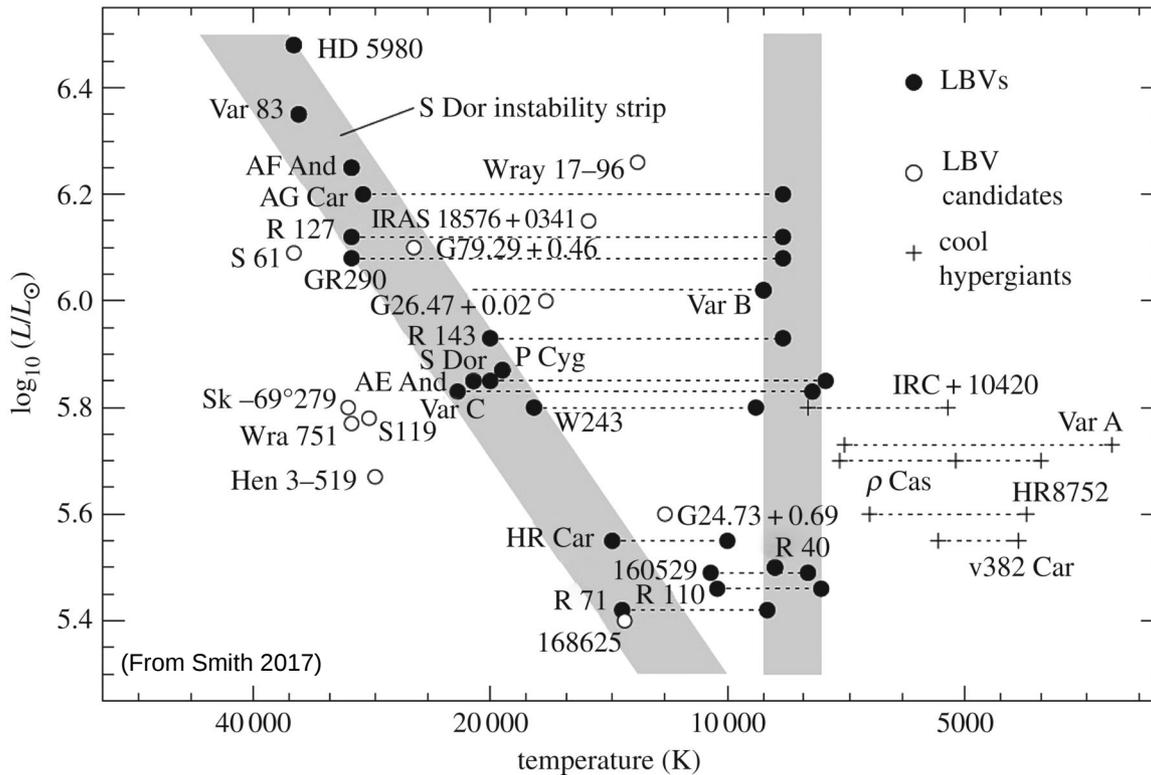
ABSTRACT

We use observations of the Luminous Blue Variable (LBV) P Cygni spanning seven decades, along with signal processing methods, to identify a periodicity in the stellar luminosity. We find a distinct period of 4.7 ± 0.3 years together with shorter periods. The periodicity is a possible indication of a binary companion passing in an eclipse-like event from the dense LBV wind, and if so it is the first observational indication that P Cygni is a binary system. This may support models that contribute giant LBV eruptions to interaction with a binary companion. We discuss other interpretations for the periodicity as well.

Other binary candidates : MWC314, Cyg OB2#12, HD168625
with wide orbit companions (e.g., Martayan et al. 2016)

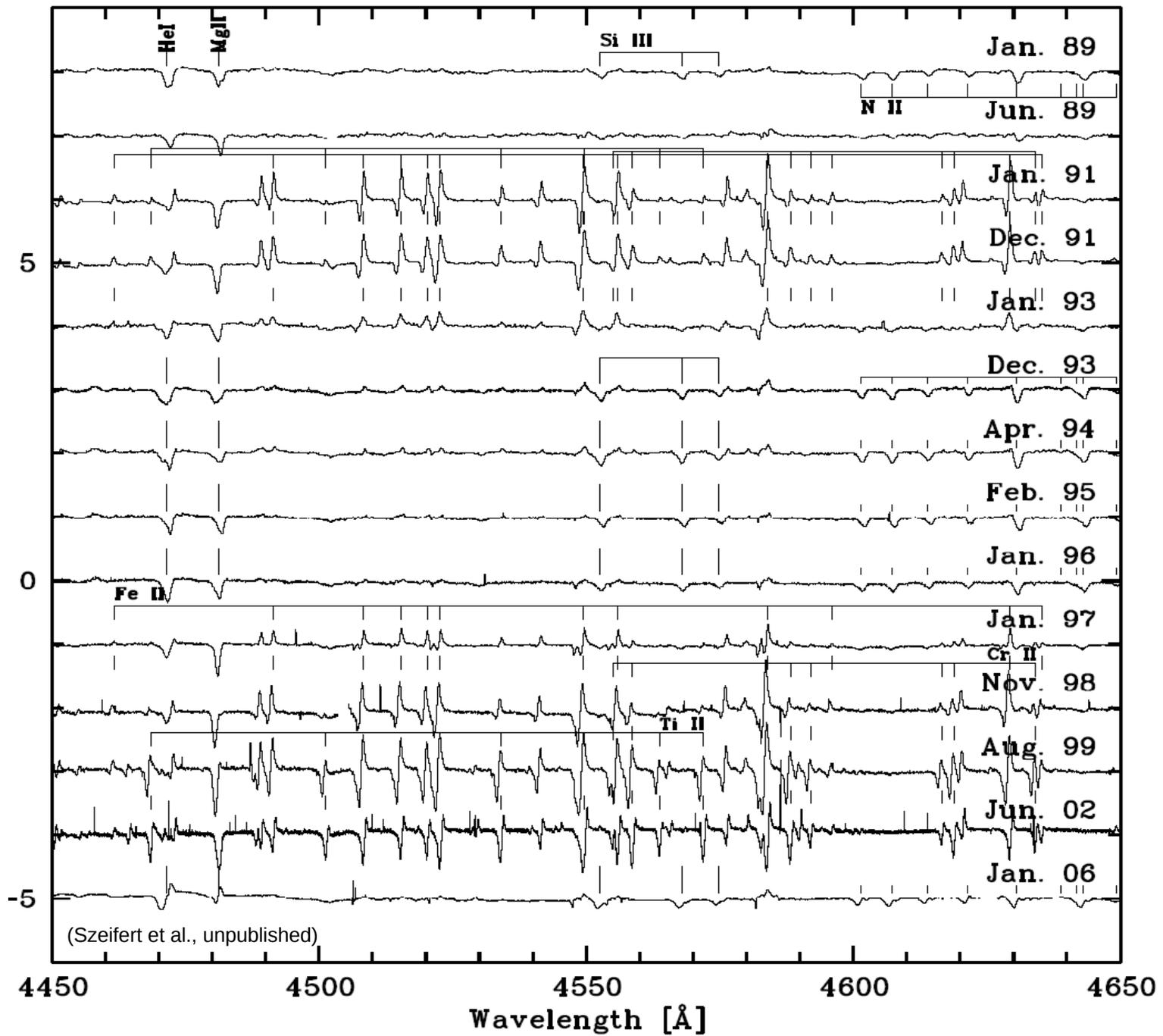
On the other hand, weak X-ray emission from most LBV indicates that they are likely single (Nazé et al. 2012)

Unstable stars → Variability



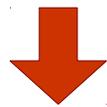
- Various timescales (days to decades)
- Variation at constant M_{bol} (But AG Car ?)
- BHG : dormant LBV ?
- LBV candidates → true LBV
- Variability mechanism(s) still unknown

HR Car
(LBV)



Long-term regular monitoring

- Document the variability of changing-look objects, in particular LBV, YHG
- Will YHG cross the yellow void and become LBV ?
- Determine the exact extent of their variations in the HR diagram
- Classify variations and relation with timescales
- Catch the variations of LBV candidates and BHG (dormant LBV ?)
→ accurate census of LBV
- Search for possible long-period binaries



High resolution spectroscopy over 15 years

Strategy with TIGRE

- Spectroscopic monitoring over more than 10 years with roughly one spectrum per month. S/N ~ 50 needed. Not possible with conventional facilities (ESO, La Palma, etc)
- A sample of 10 transition objects:
3 LBV(c), 4 BHG, 3 YHG, i.e., all bright enough ($V < 8.5$)
- With 6 observations during 8 months of object visibility : ~ 20 h/yr

Current status of observations

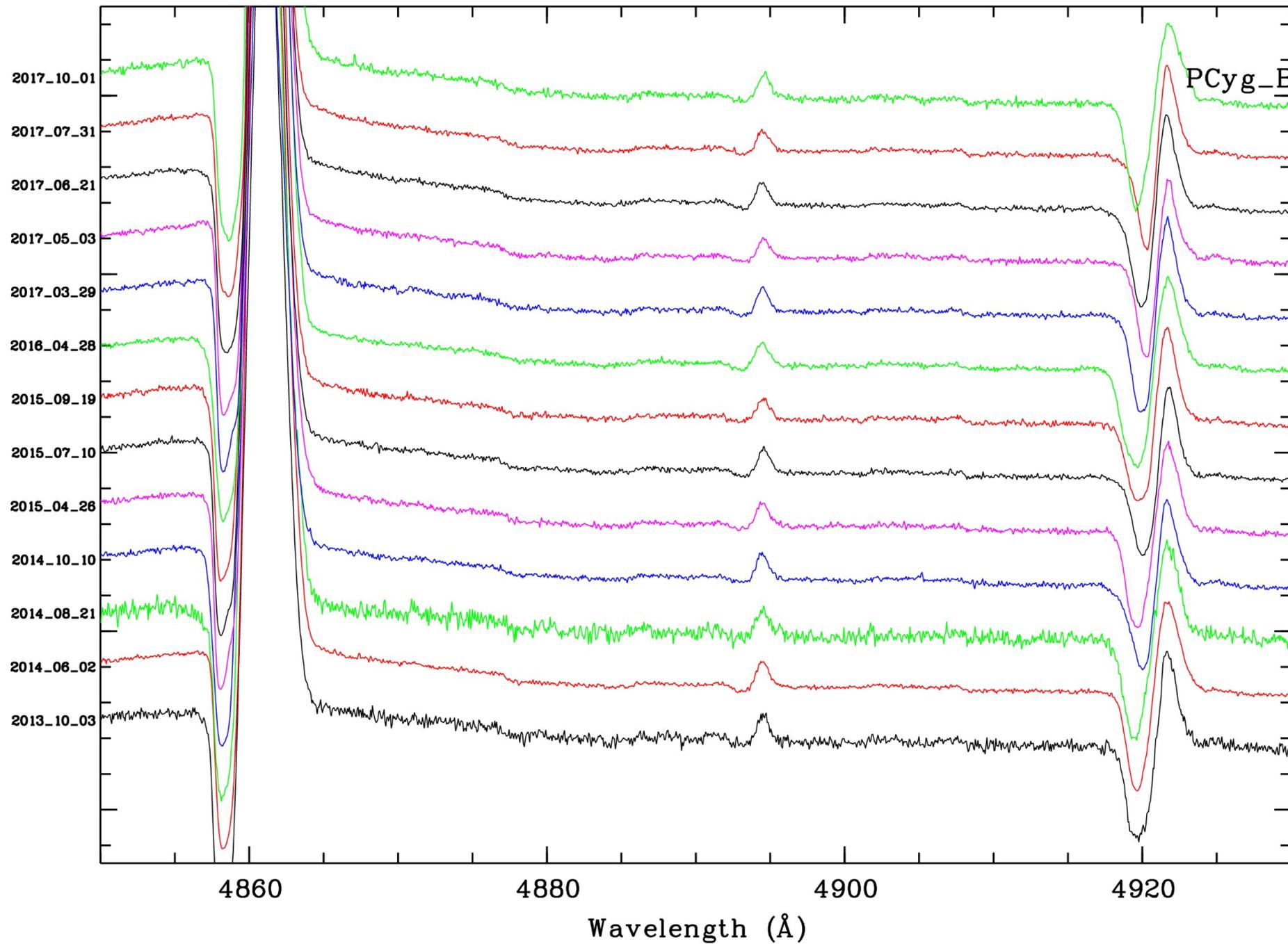
		N_spectra	
		2014-2017	
PCyg	LBV	13	
HD168607	LBV	10	
HD168625	LBVc	6	
HD169454	BHG	14	
HD183143	BHG	13	
HD190603	BHG	11	
HD199478	BHG	14	
HD179821	YHG	9	
HR8752	YHG	12	
Rho Cas	YHG	12	

LBV

H β

NII

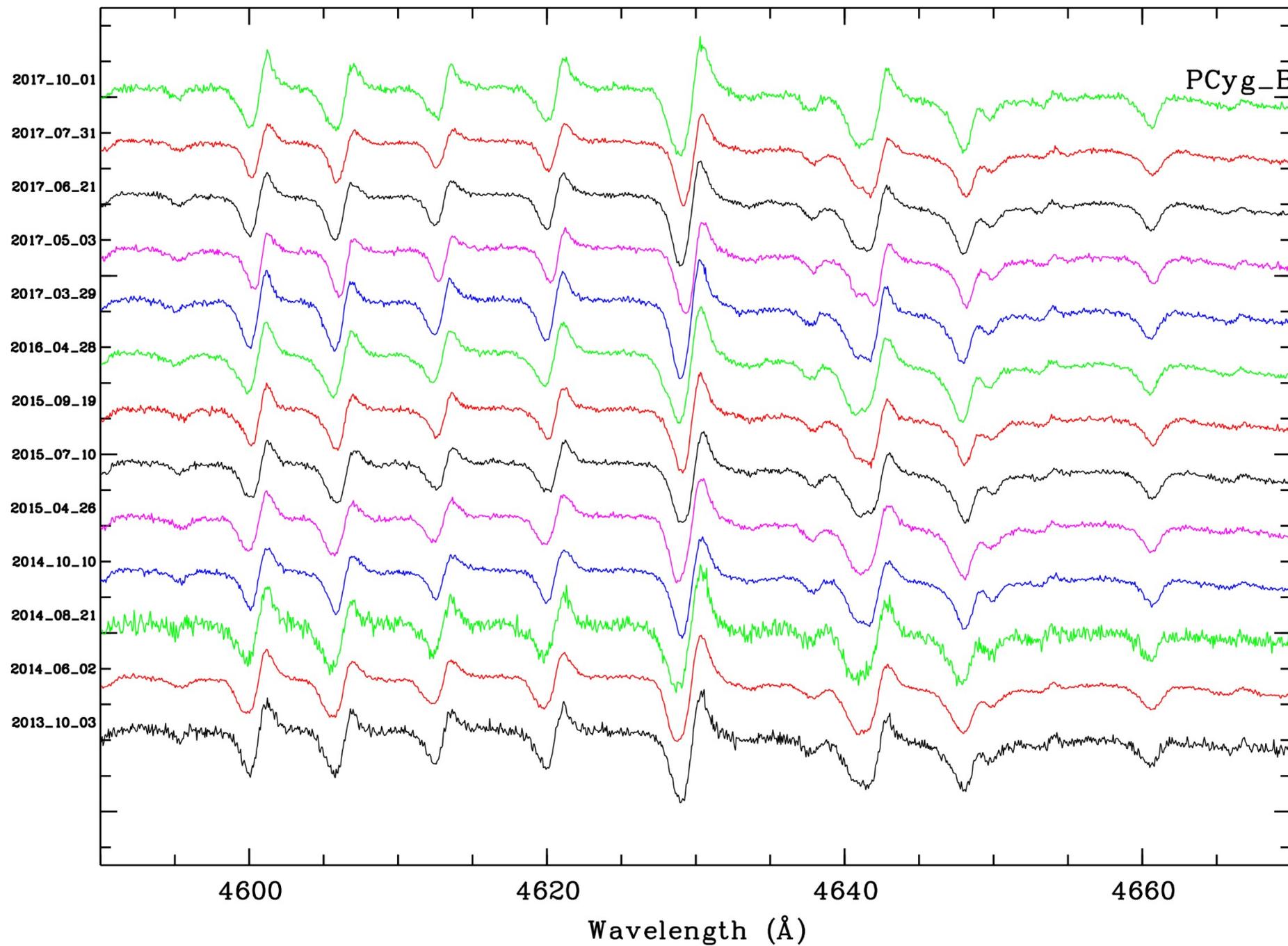
HeI



LBV

NII

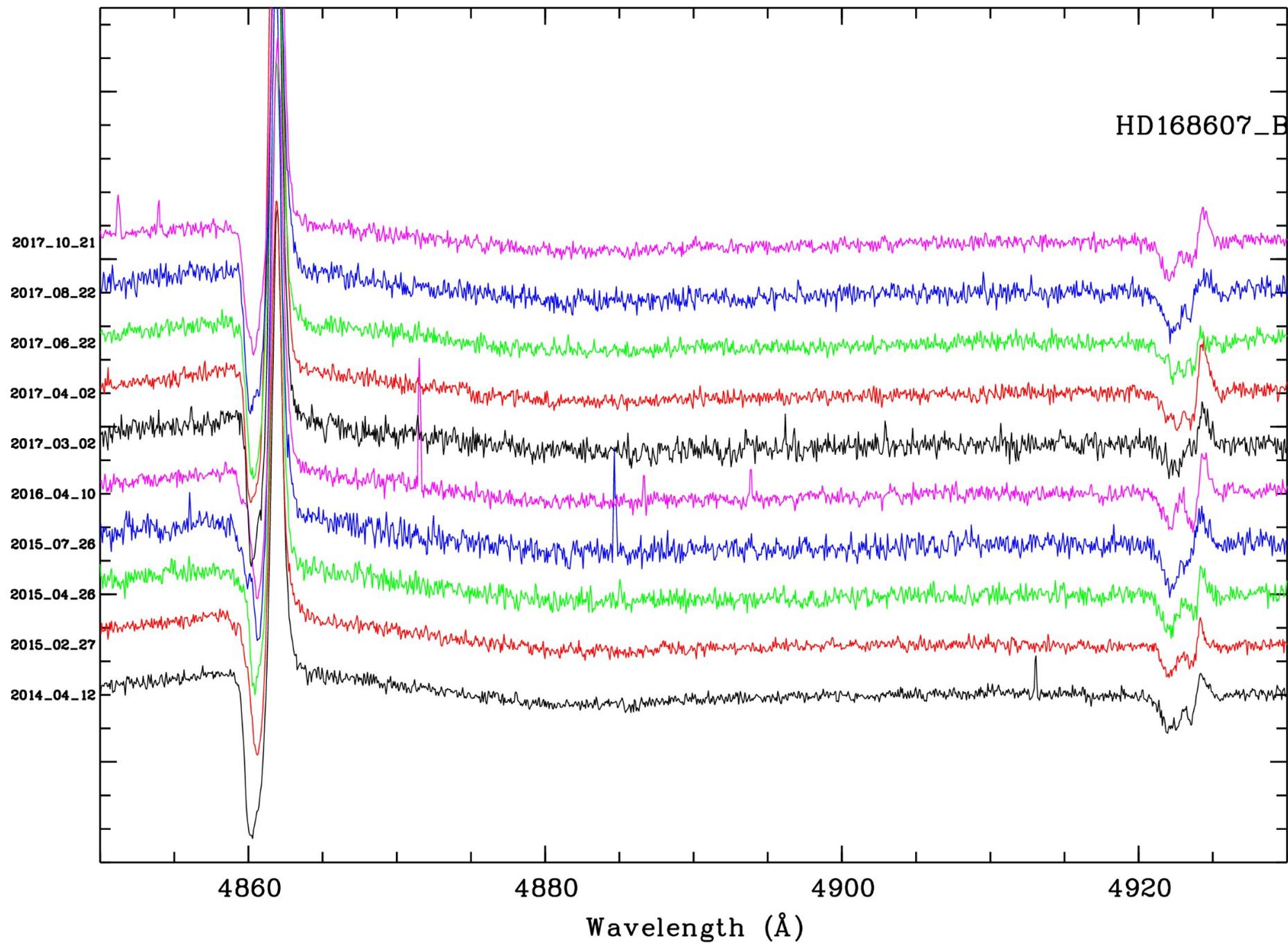
NIII



LBV

H β

HeI



LBVc

H β

HeI

HD168625_B

2017_10_23

2017_08_22

2017_06_20

2017_04_28

2017_03_19

2015_02_28

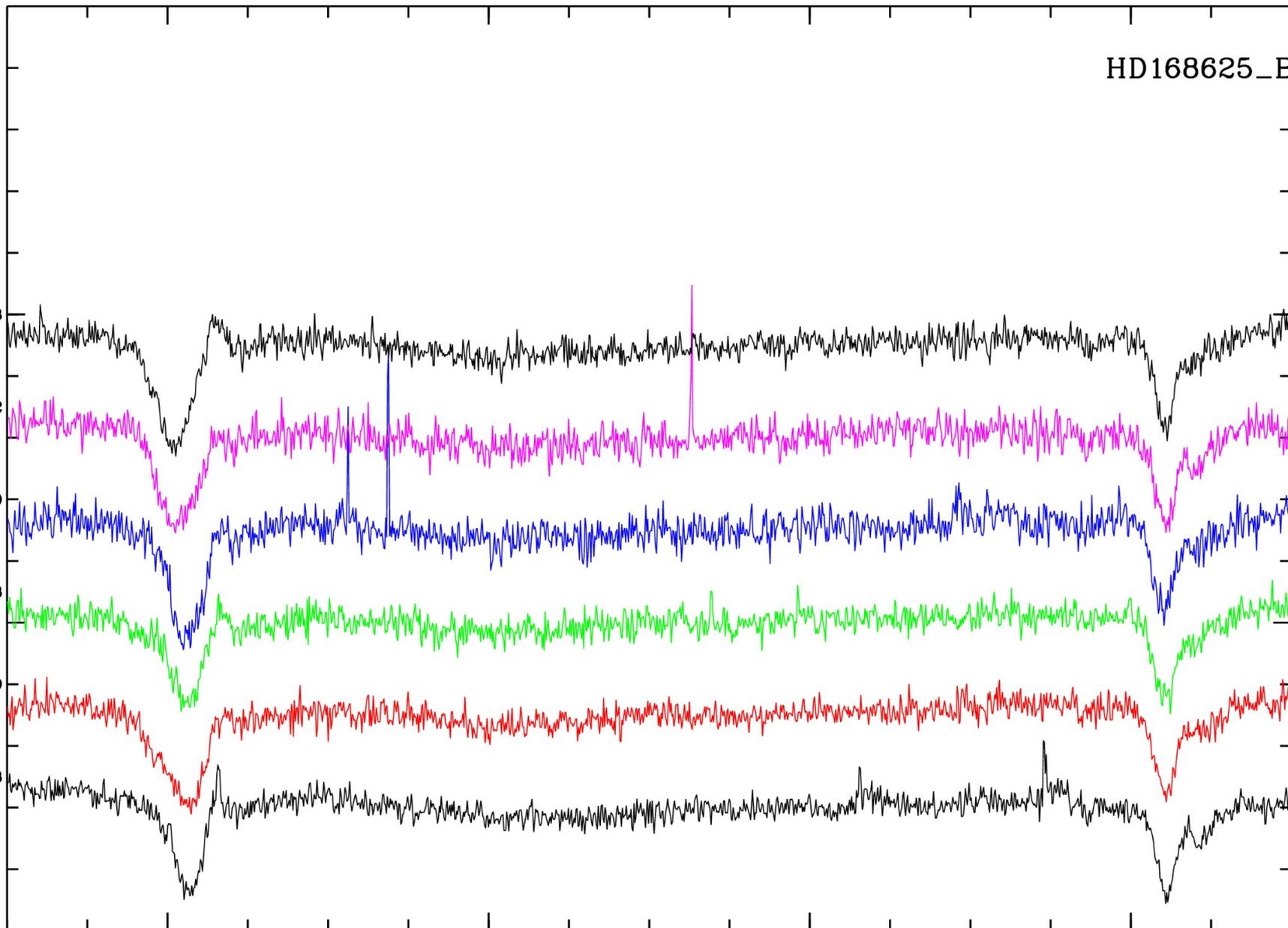
4860

4880

4900

4920

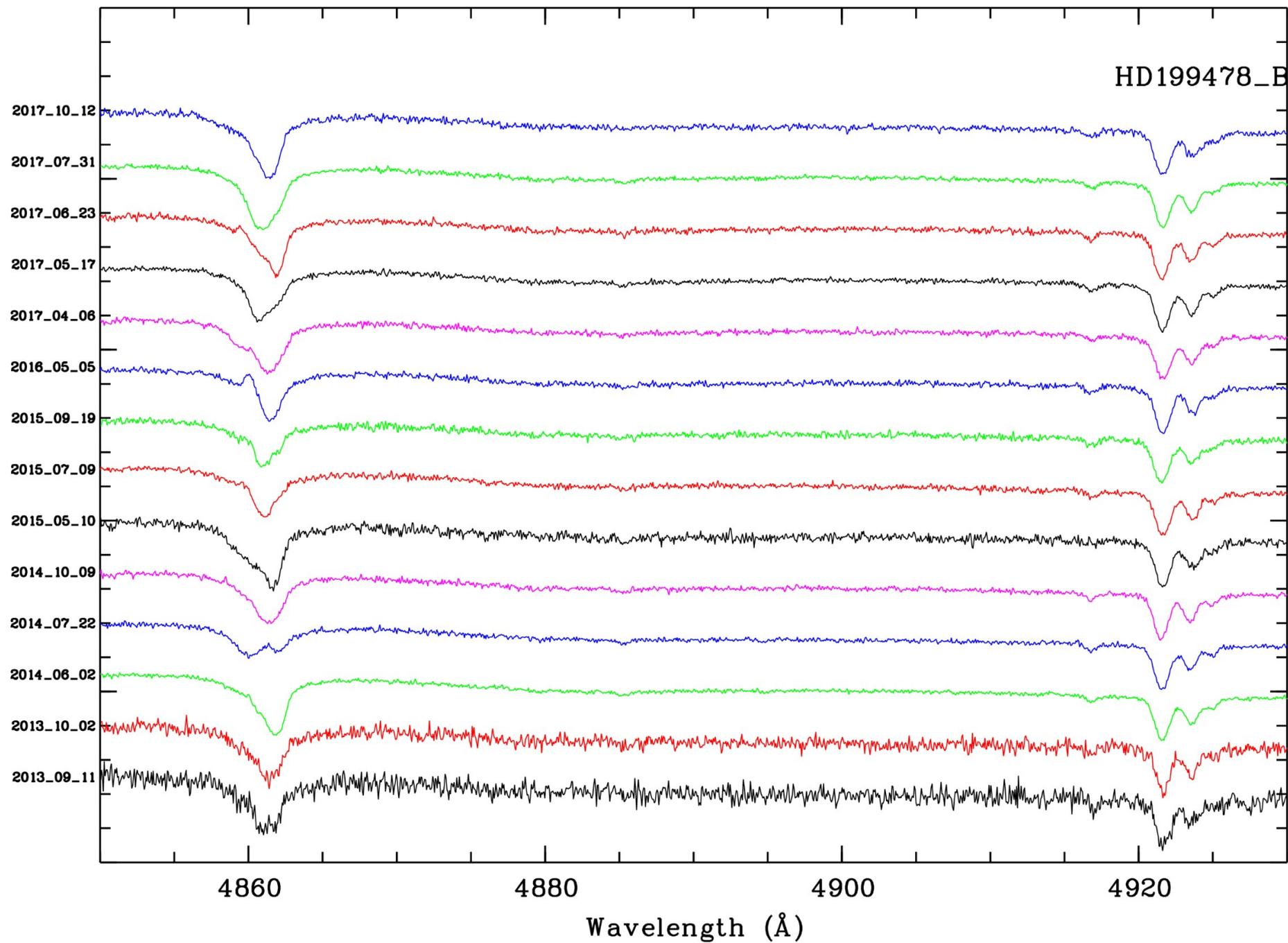
Wavelength (\AA)



BHG

H β

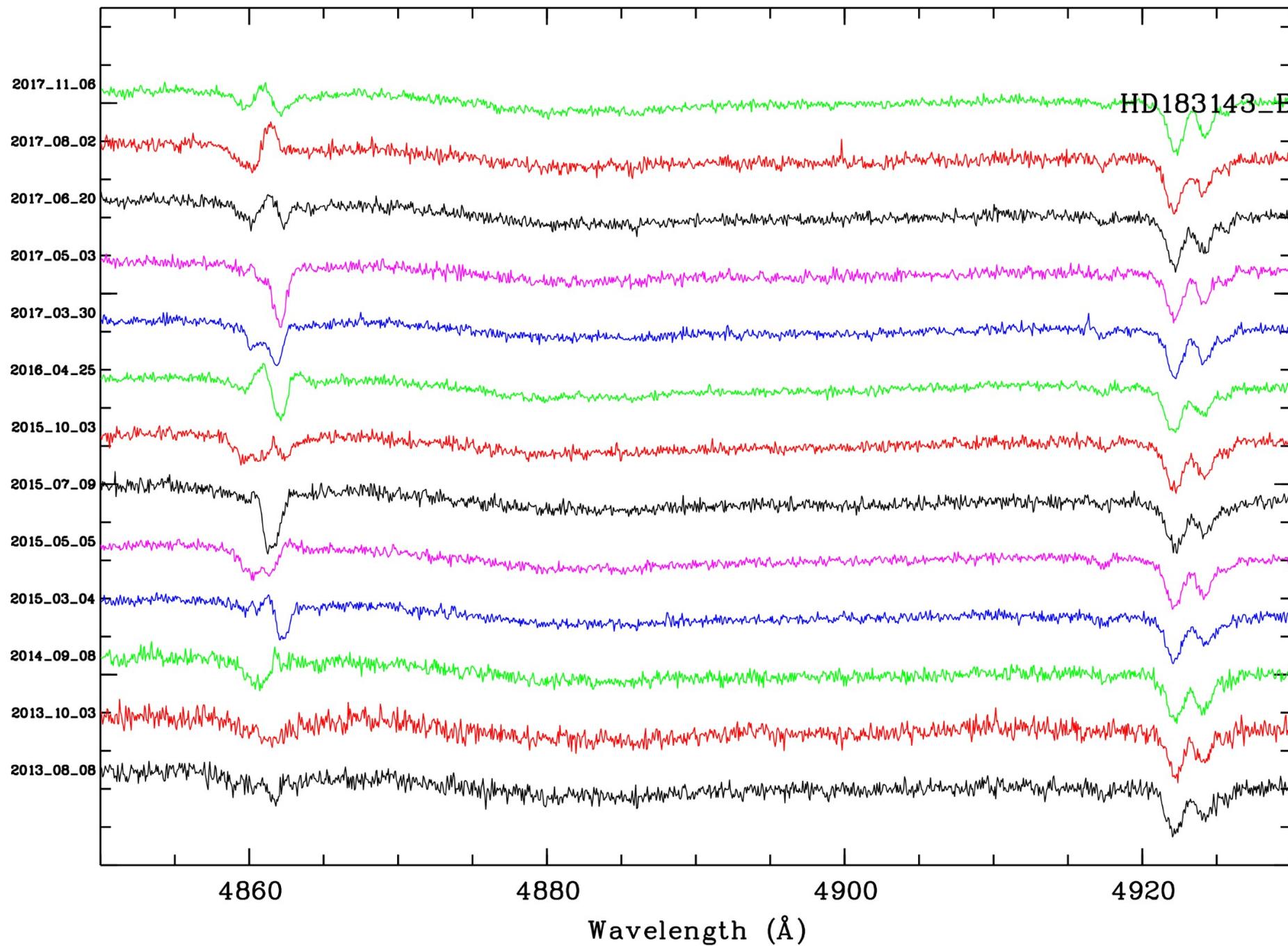
HeI



BHG

H β

HeI



YHG

FeI blend

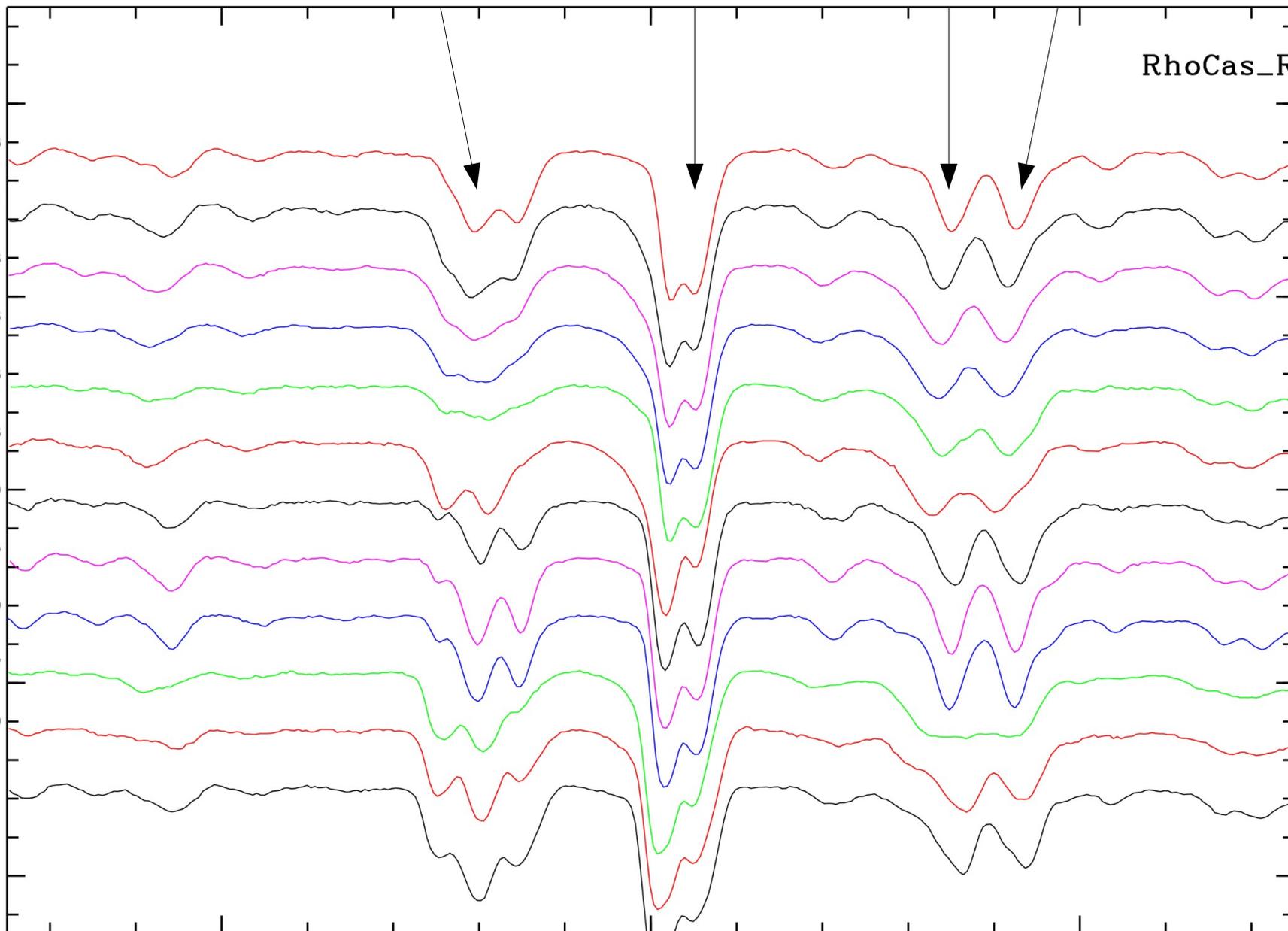
Ball

FeI

FeII

RhoCas_R

2017_11_18
2017_09_21
2017_08_13
2017_07_16
2017_05_28
2015_12_13
2015_09_30
2015_08_05
2015_07_09
2014_11_17
2014_10_09
2014_08_14



6130

6140

6150

Wavelength (Å)

YHG

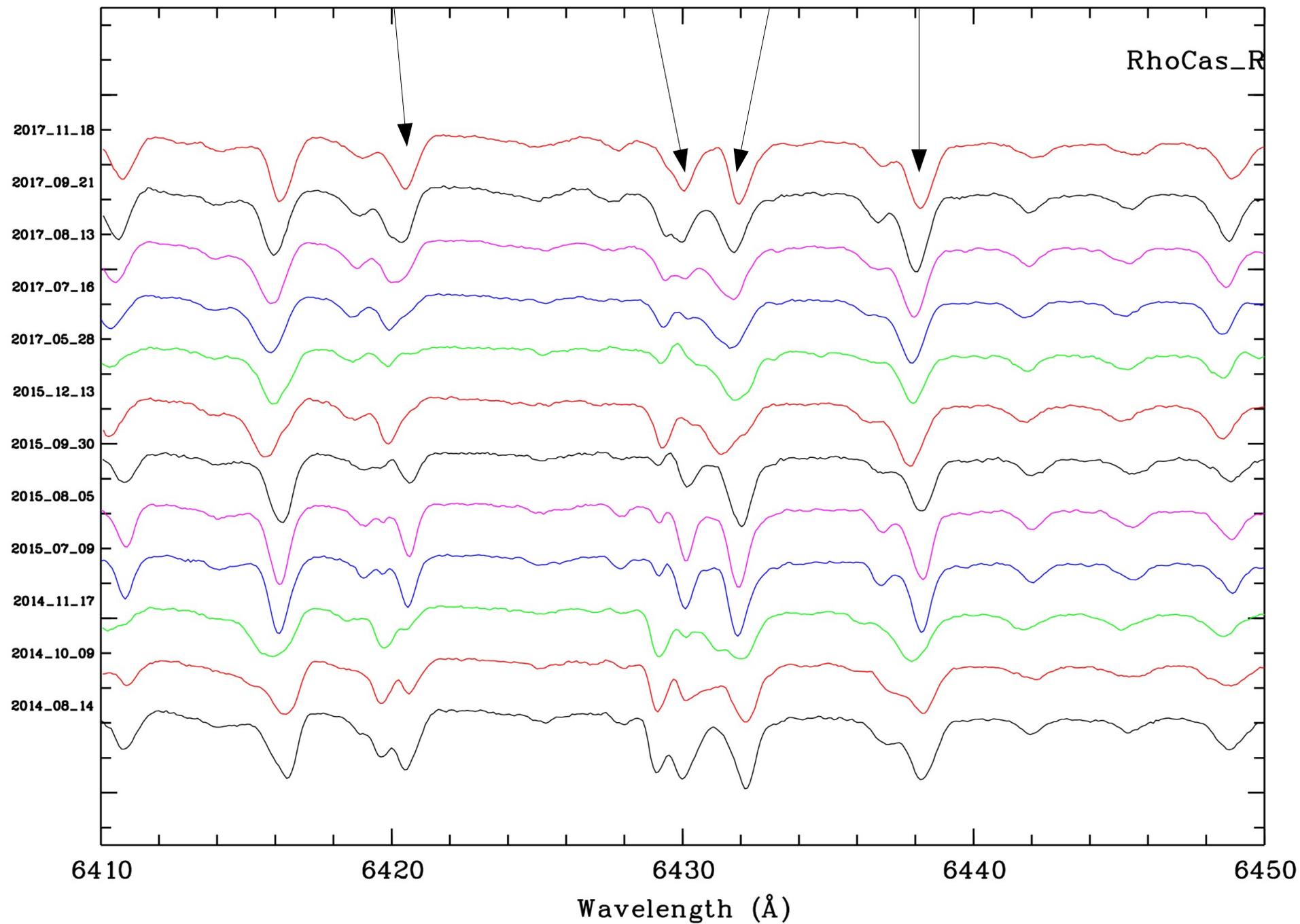
Fel

Fel

FelI

CaI

RhoCas_R



Current status of observations

		N_spectra	
		2014-2017	
PCyg	LBV	13	Small wind variability (HI / HeI)
HD168607	LBV	10	Wind variability (HI / HeI)
HD168625	LBVc	6	Wind variability (HI / HeI?)
HD169454	BHG	14	Small variations
HD183143	BHG	13	Clear variability in HI, not in HeI
HD190603	BHG	11	Small variations (HI only)
HD199478	BHG	14	Clear variability in HI, not in HeI
HD179821	YHG	9	Subtle variations in some lines
HR8752	YHG	12	Small variations; known binary
Rho Cas	YHG	12	Clear but complex variations in some lines

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HR8752	YHG	12	Small variations; known binary
Rho Cas	YHG	12	Clear but complex variations in some lines

Only small variations up to now, most likely from the wind

No new indication of binarity yet

The future : hopefully catching
large variations / changes of look



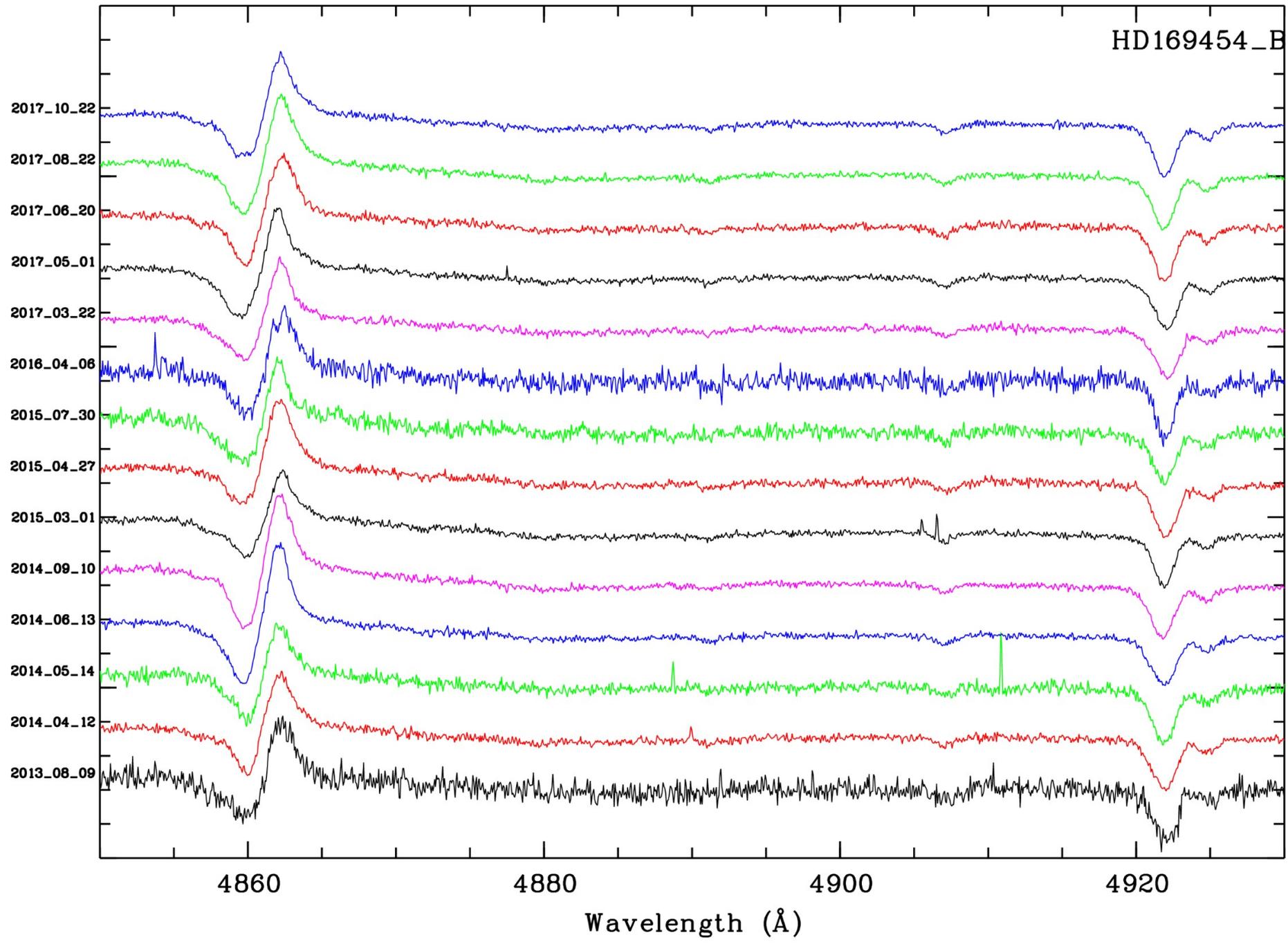
The future : hopefully catching large variations / changes of look



and collecting enough observations of smaller variations to better characterize them

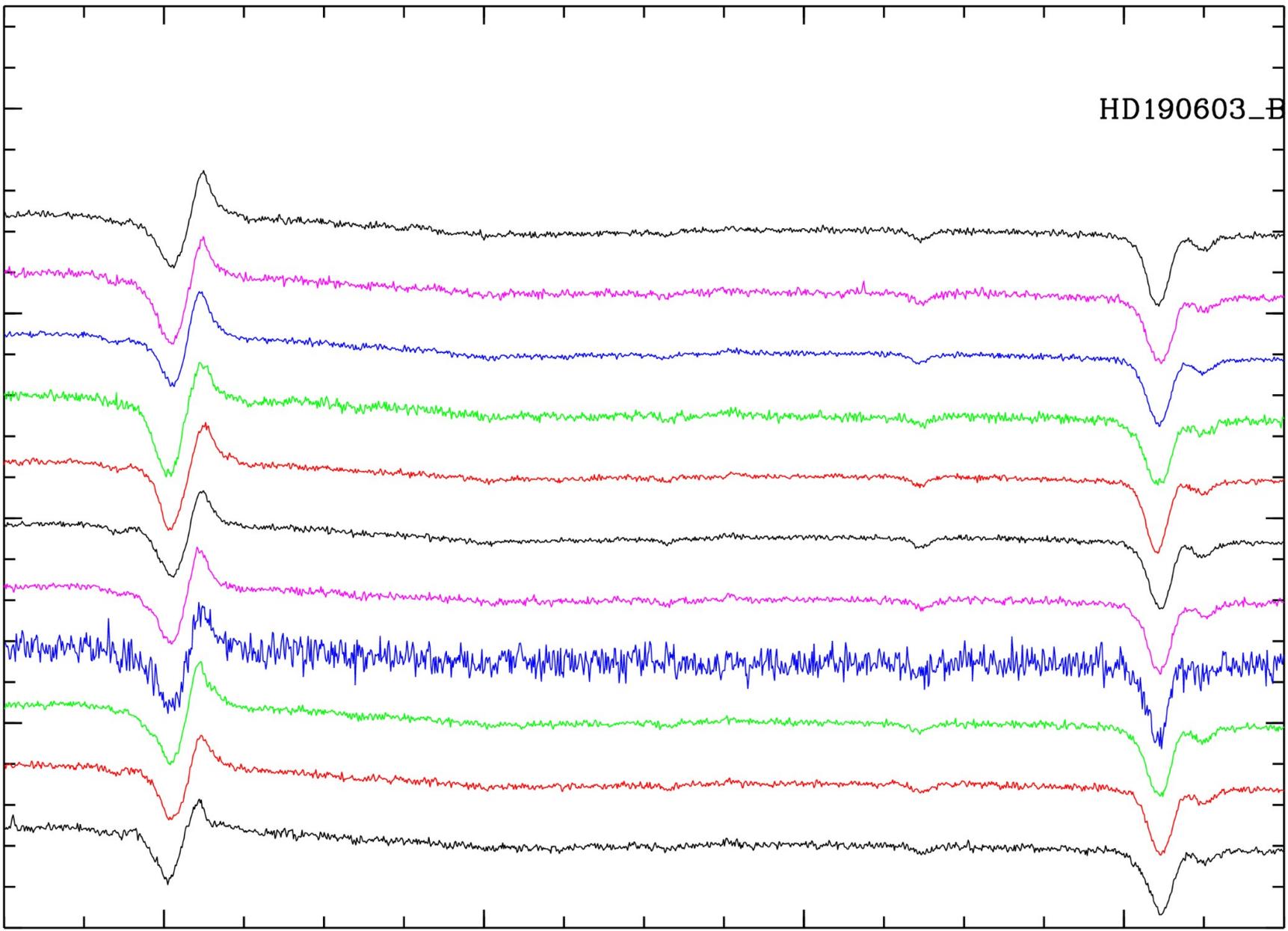
Other spectra

HD169454_B



HD190603_B

2017_10_29
2017_09_28
2017_07_30
2017_06_15
2017_05_01
2017_03_29
2016_05_01
2016_04_15
2015_07_10
2015_05_07
2014_08_27



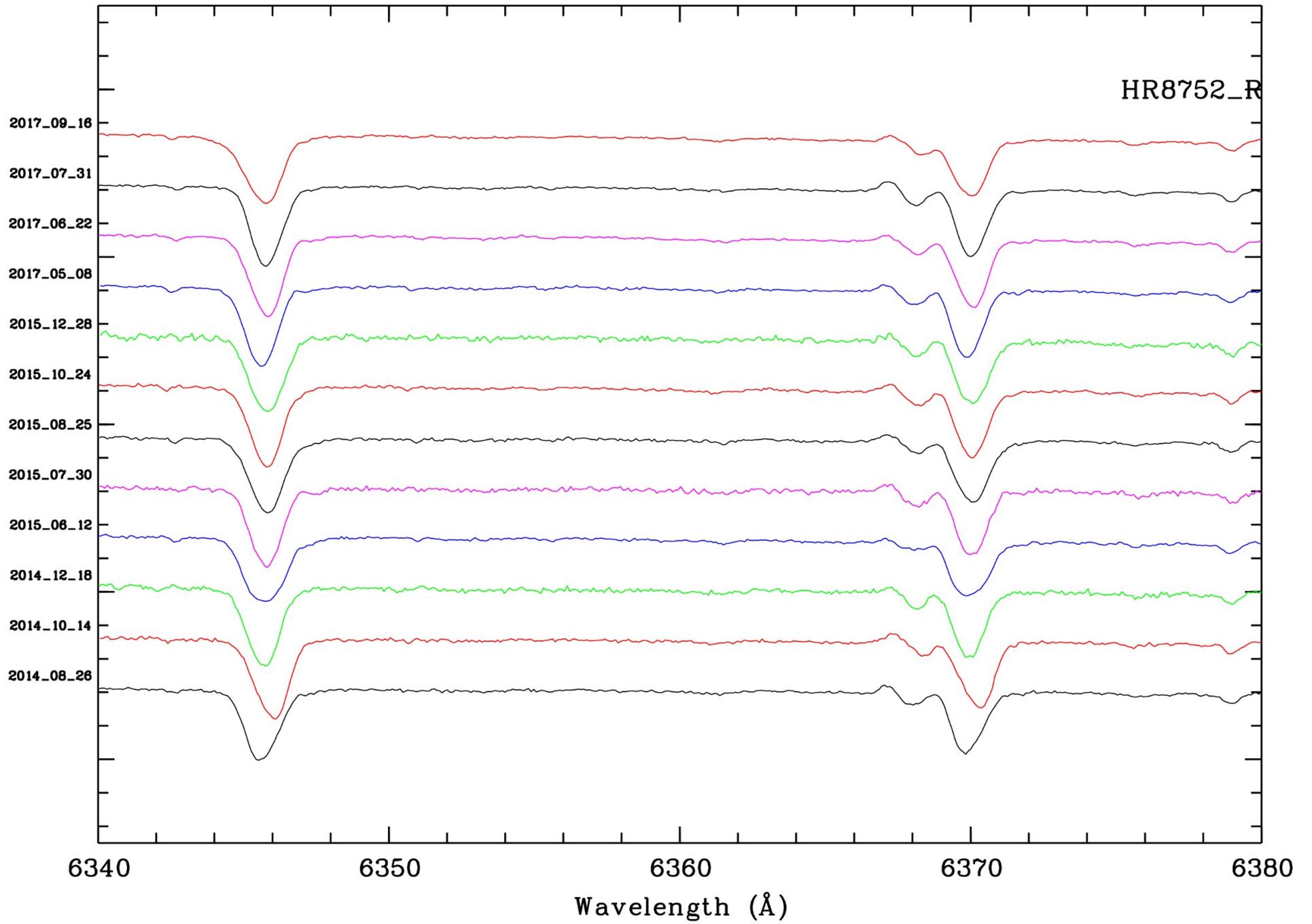
4860

4880

4900

4920

Wavelength (Å)

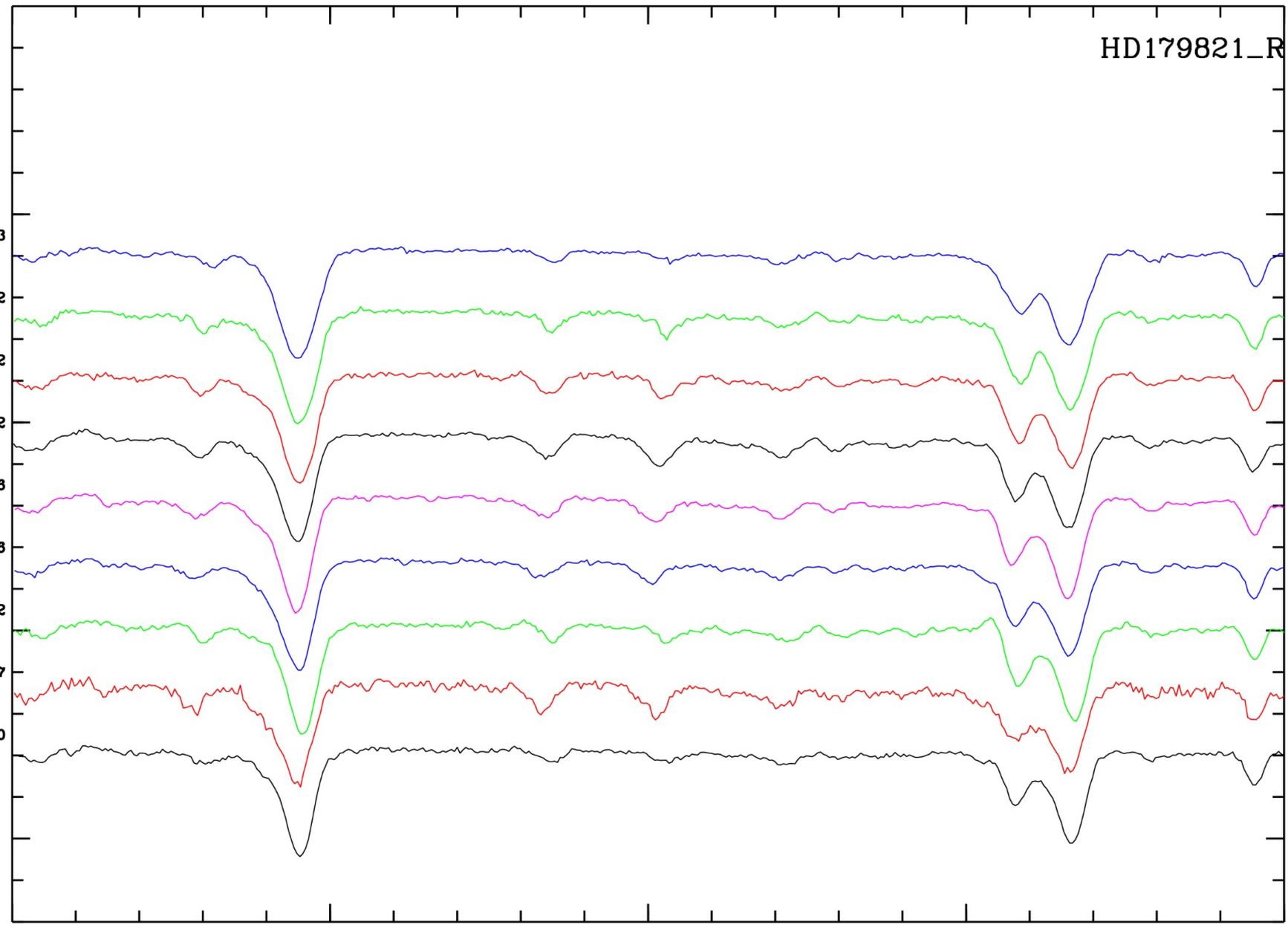


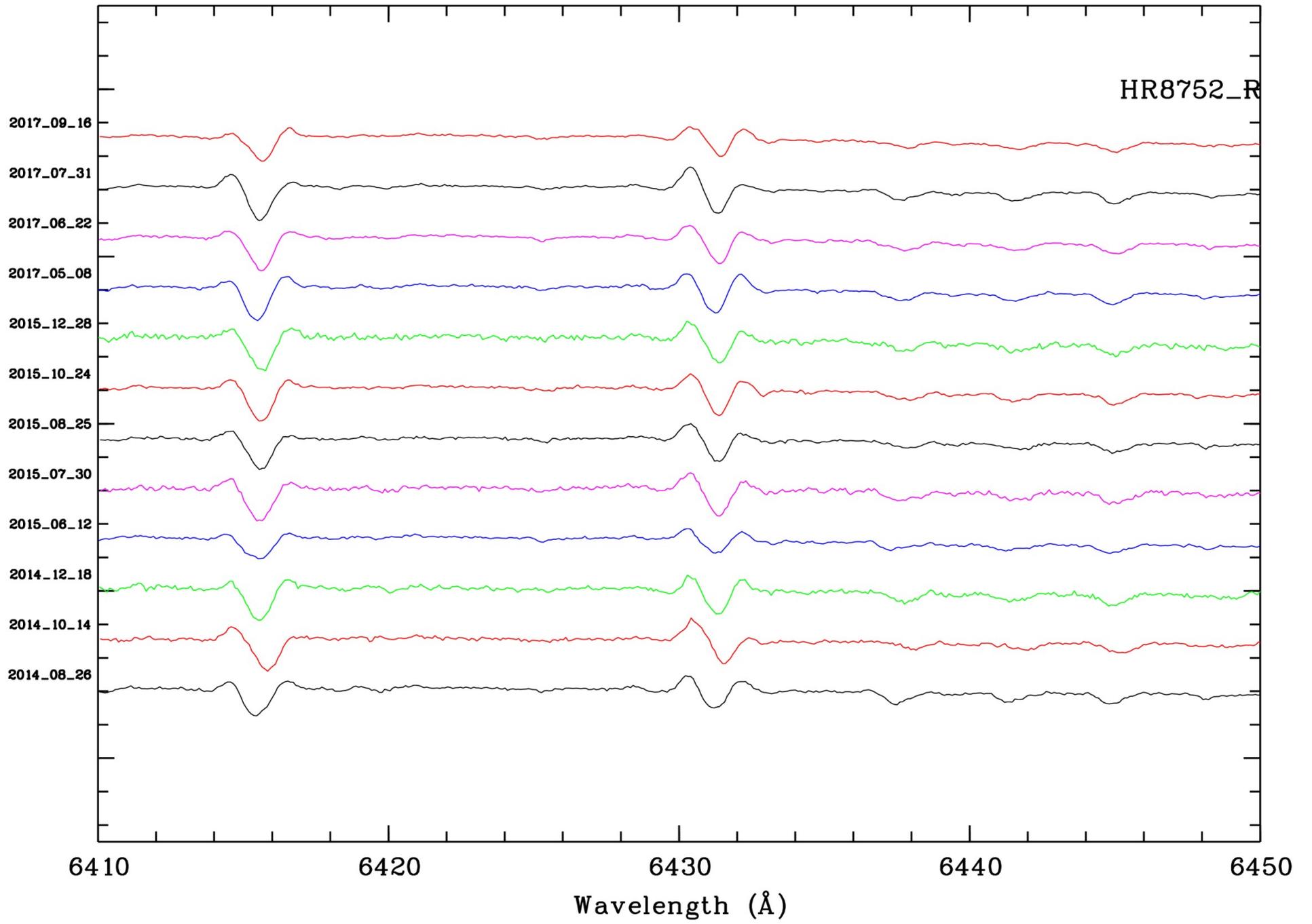
HD179821_R

2017_10_13
2017_08_02
2017_06_22
2017_05_02
2017_03_28
2016_04_28
2015_06_02
2015_03_27
2014_09_10

6340 6350 6360 6370 6380

Wavelength (Å)



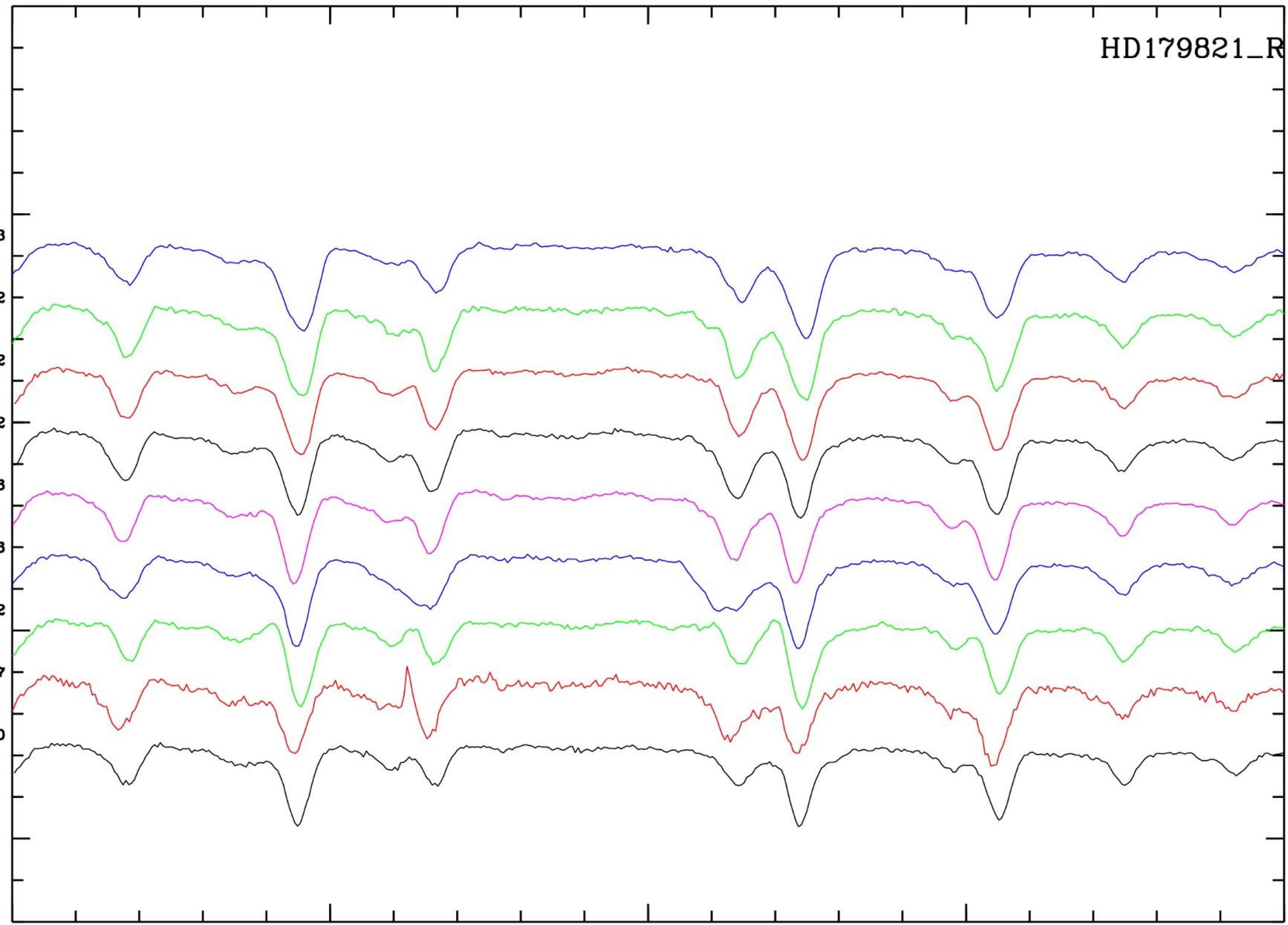


HD179821_R

2017_10_13
2017_08_02
2017_06_22
2017_05_02
2017_03_28
2016_04_28
2015_06_02
2015_03_27
2014_09_10

6410 6420 6430 6440 6450

Wavelength (Å)



RhoCas_R

2017_11_18
2017_09_21
2017_08_13
2017_07_16
2017_05_28
2015_12_13
2015_09_30
2015_08_05
2015_07_09
2014_11_17
2014_10_09
2014_08_14

6550 6555 6560 6565 6570

Wavelength (Å)

