The shape of the spectra of TIGRE

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Outline

- The blaze
- The wave
- The ghost

What is the blaze

- Intensity distribution along each order
- Corrected with flat-field images

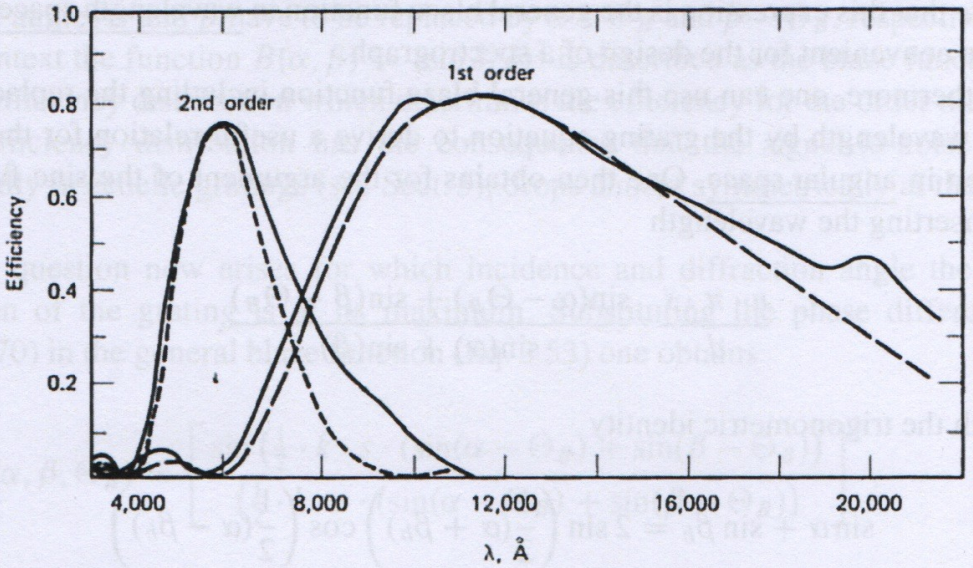
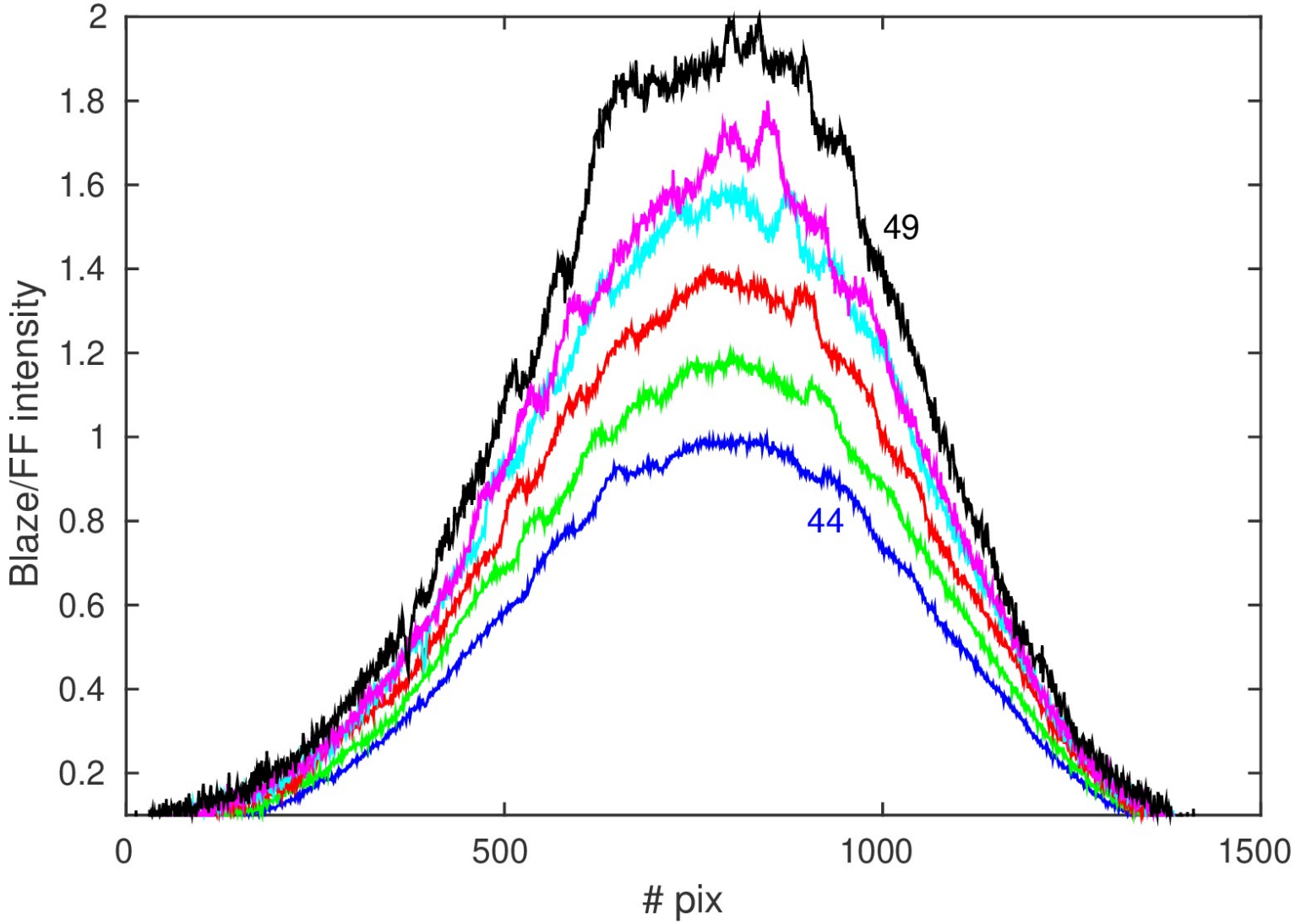
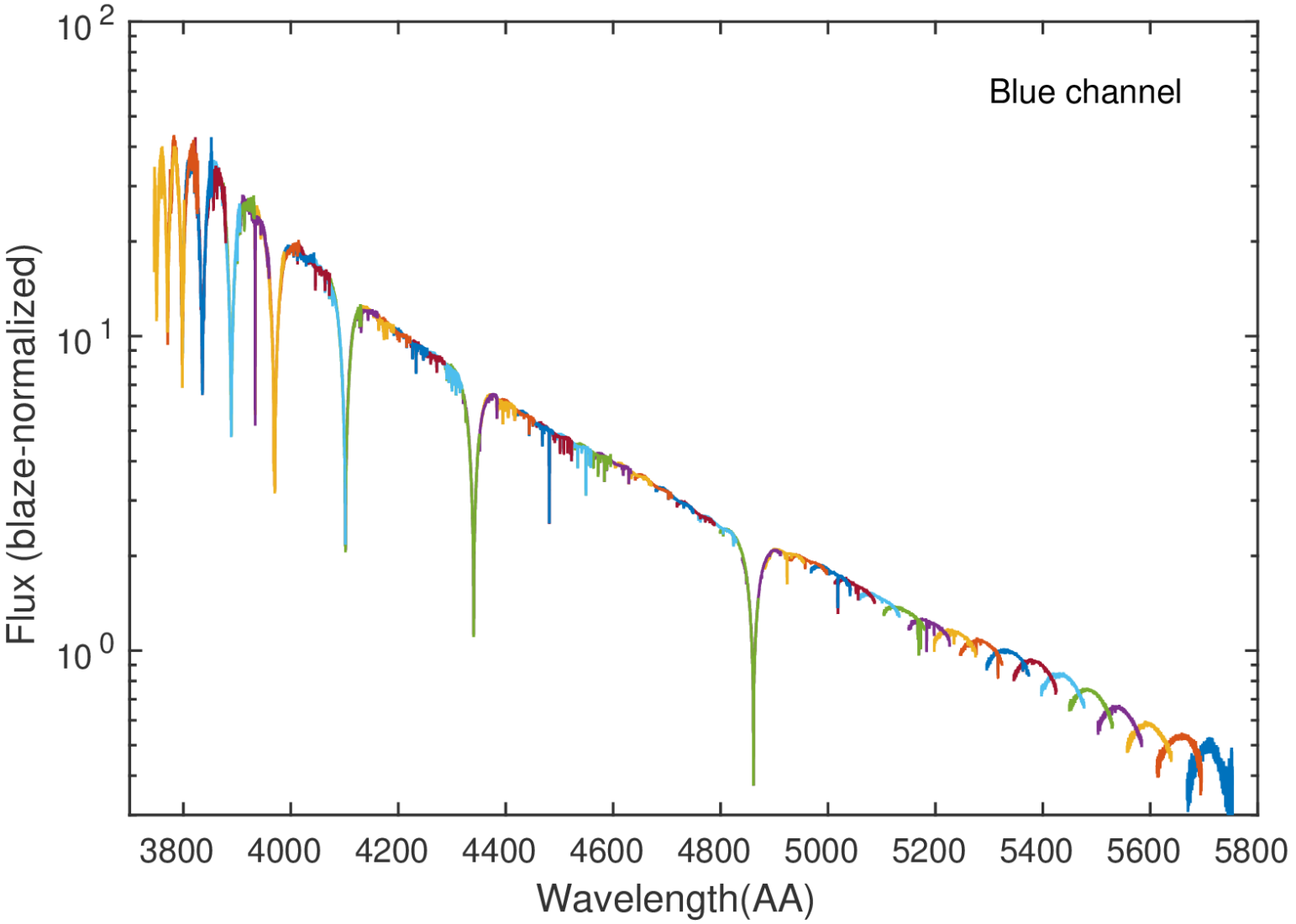


Fig. 2.26 Comparison of computed (*dashed line*) and measured blaze efficiency according Eq. 2.77 (Gray 1992)

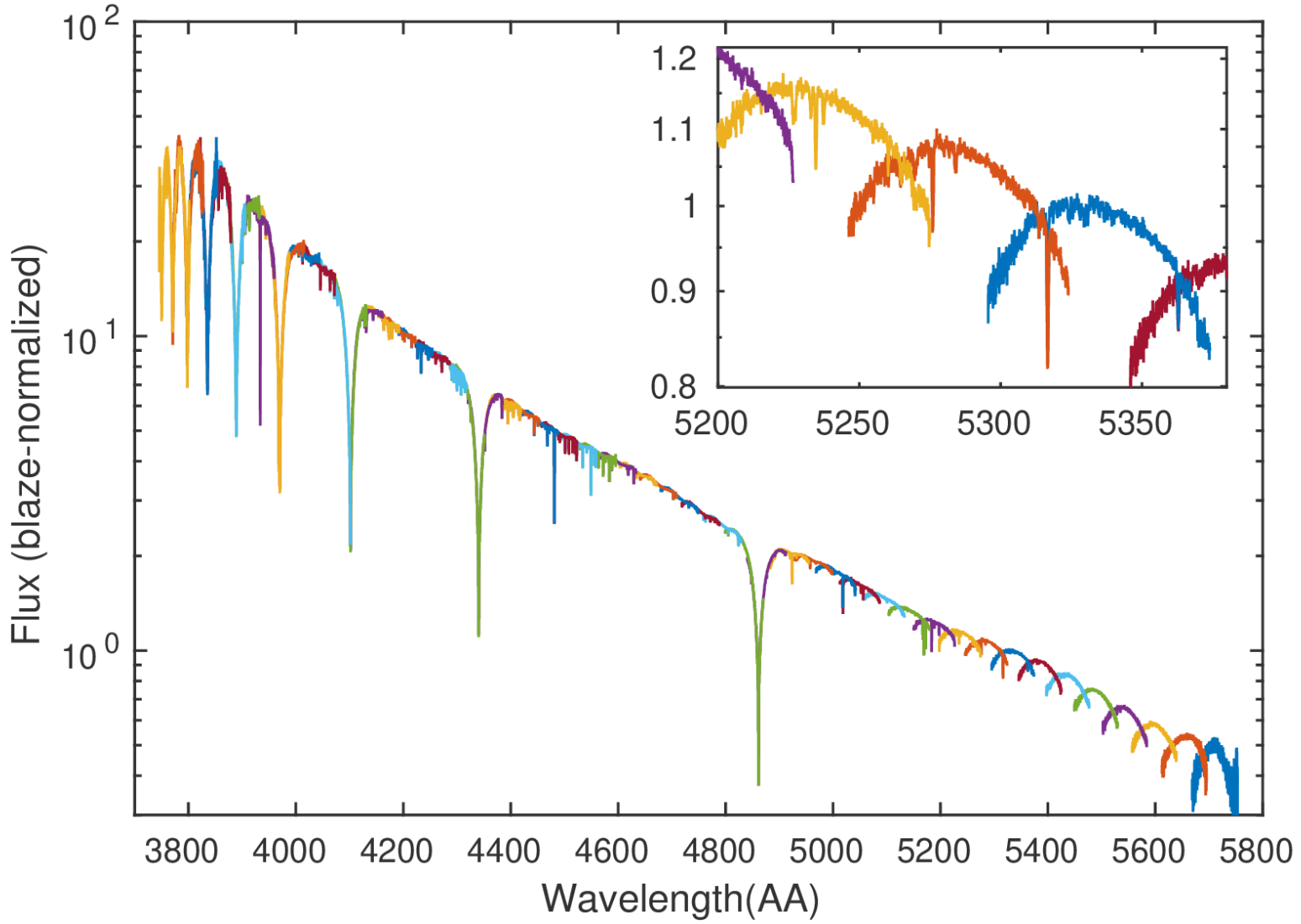
What we have


Blaze/FF intensity
pix
49
44
0
500
1000
1500
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

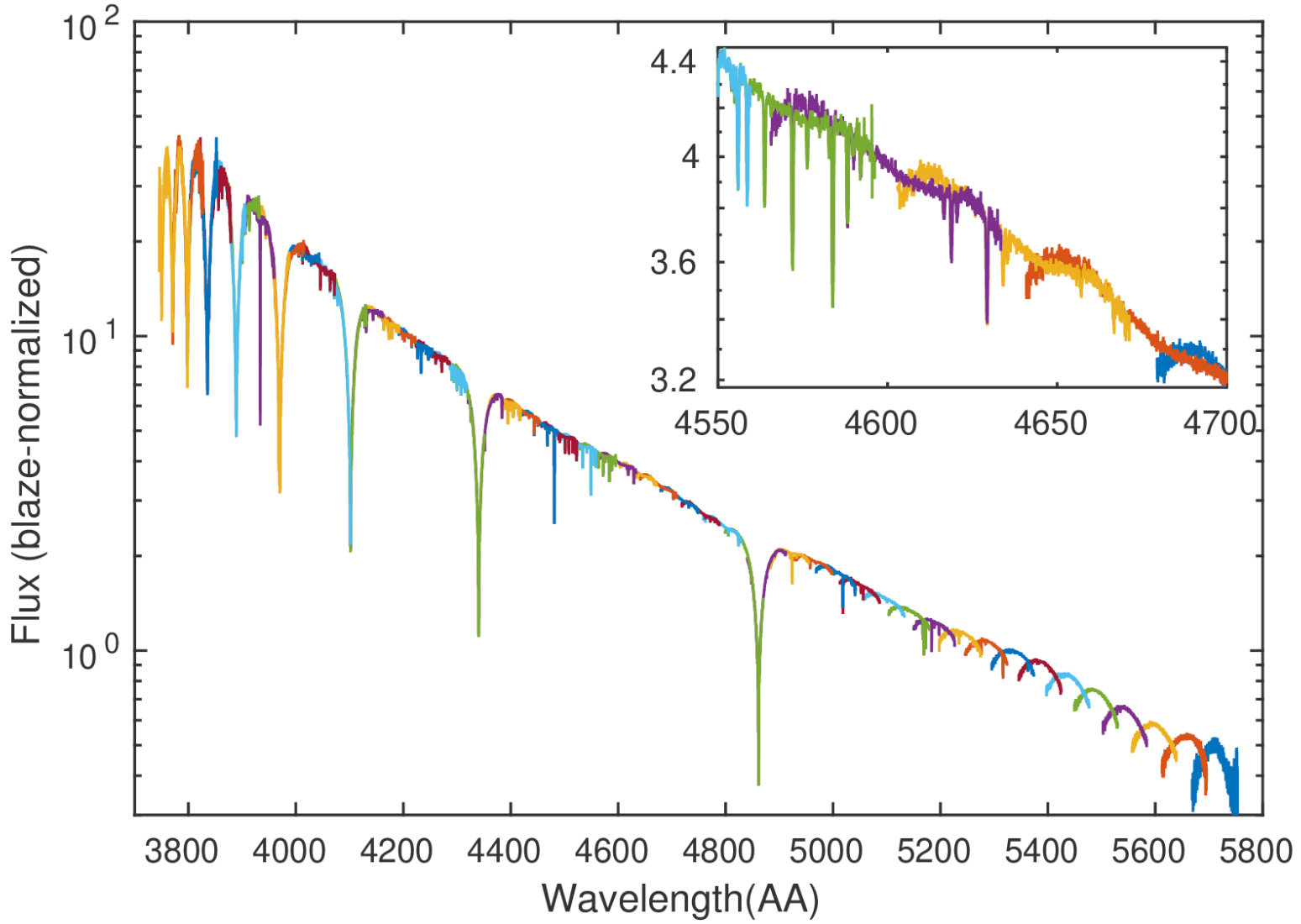
Blaze-normalized spectrum



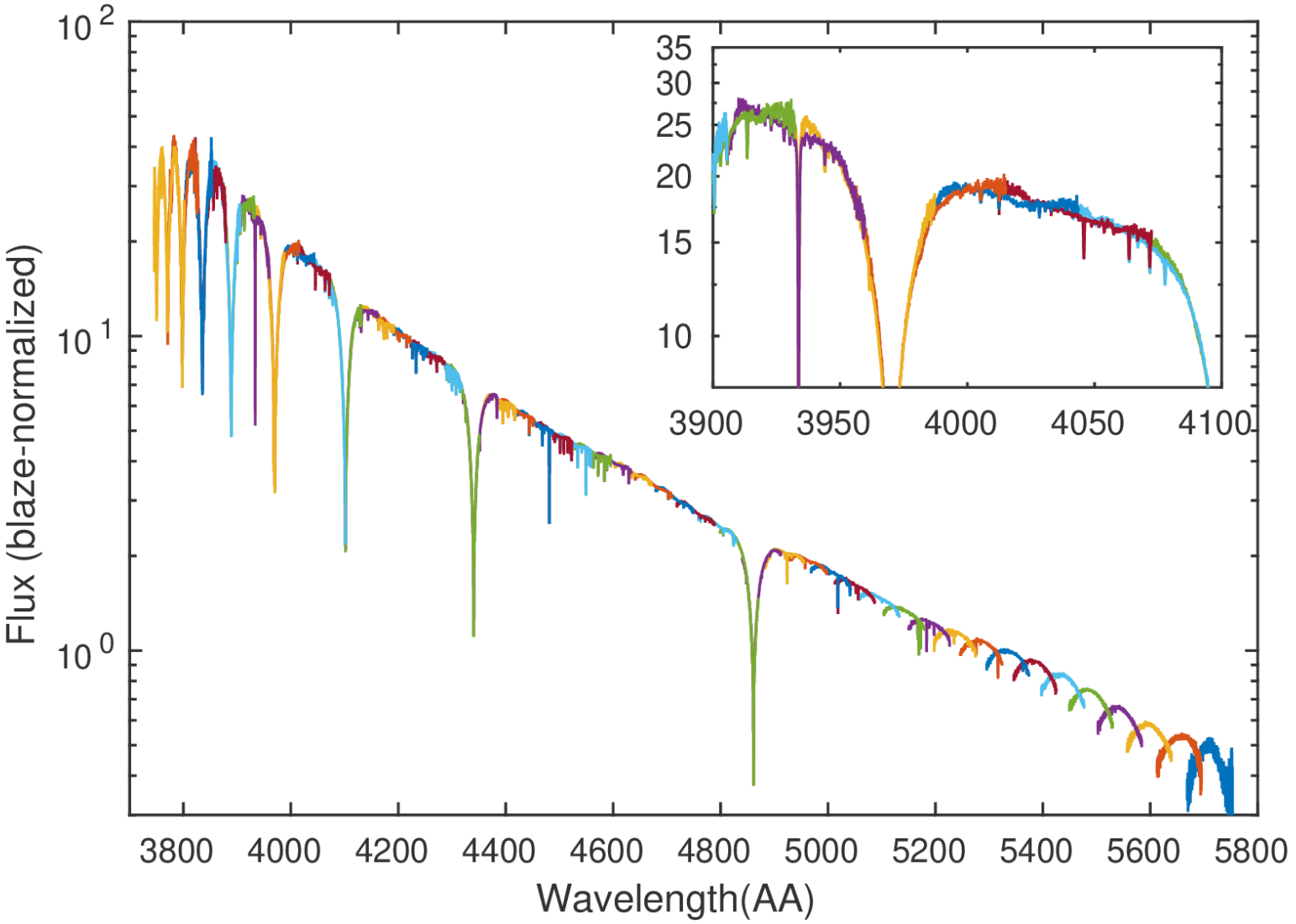
Blaze-normalized spectrum



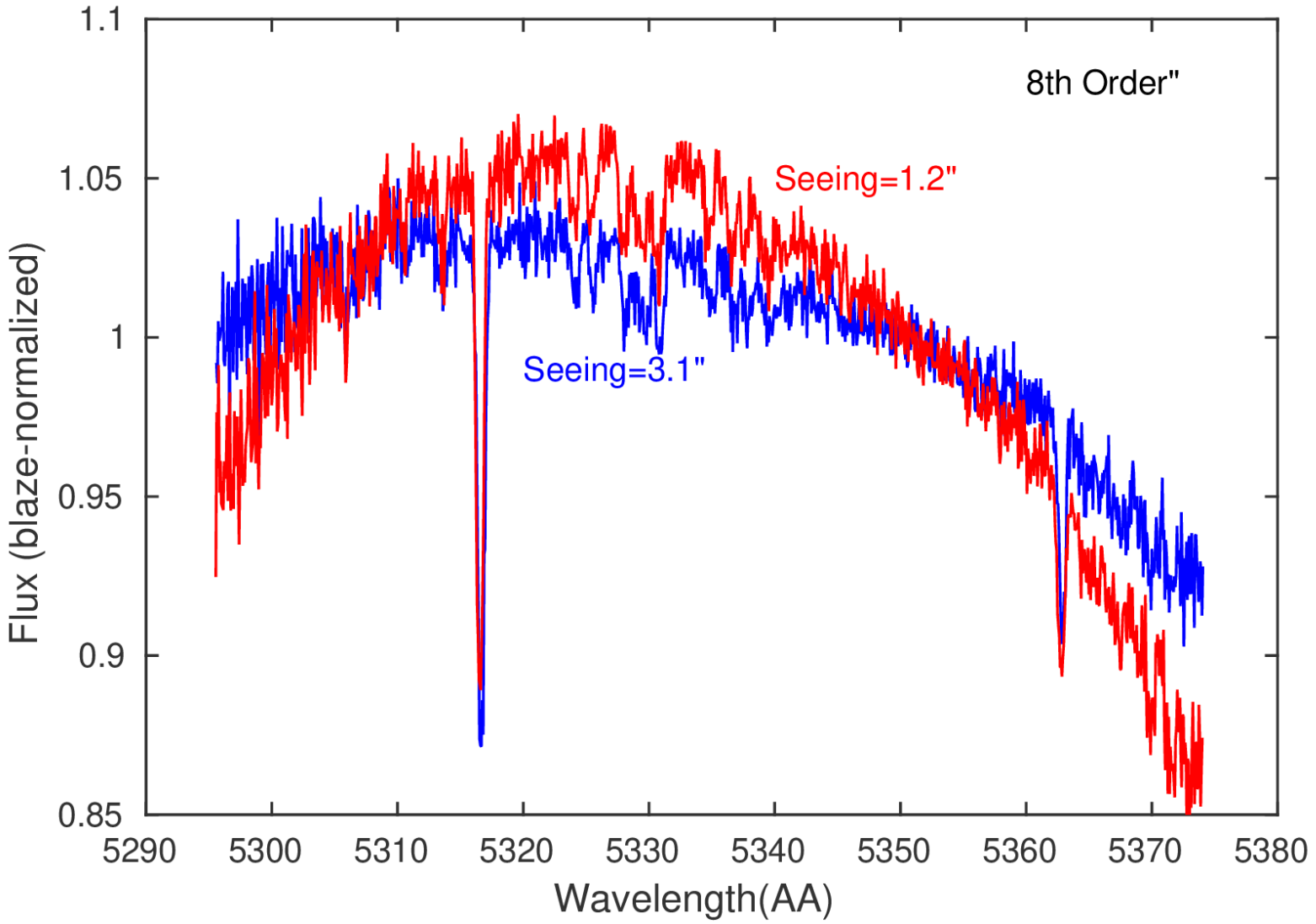
Blaze-normalized spectrum



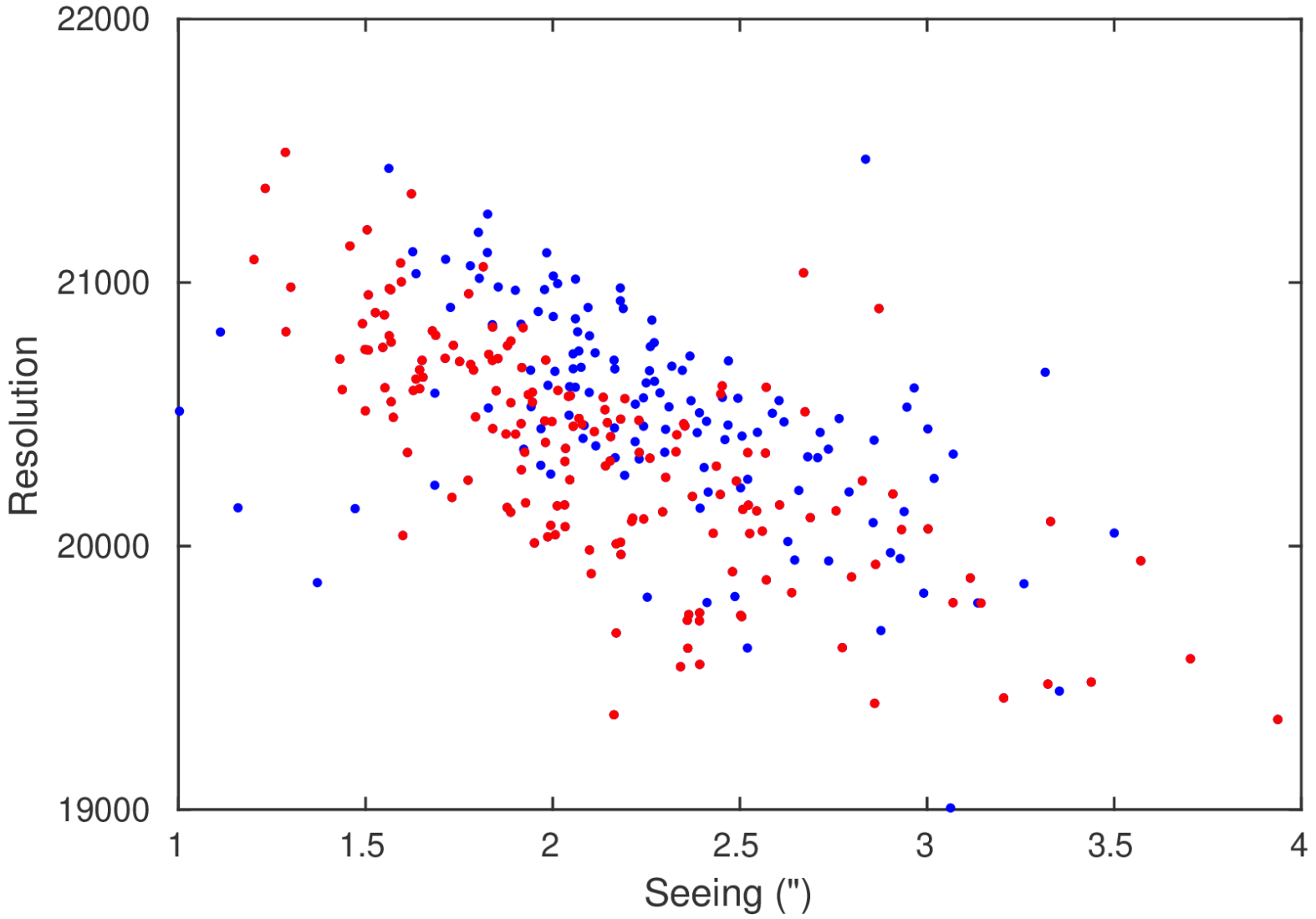
Blaze-normalized spectrum



Blaze depends on seeing



Dependence on seeing/2



Fiber scrambling

- Ability of a fiber to reduce the varying illumination at the output of a fiber relative to that at the input.
- Stars illuminate the fiber with seeing disk
- Flat-field: no optic
- Moon spectra less affected
- Circular fibers known to have imperfect scrambling

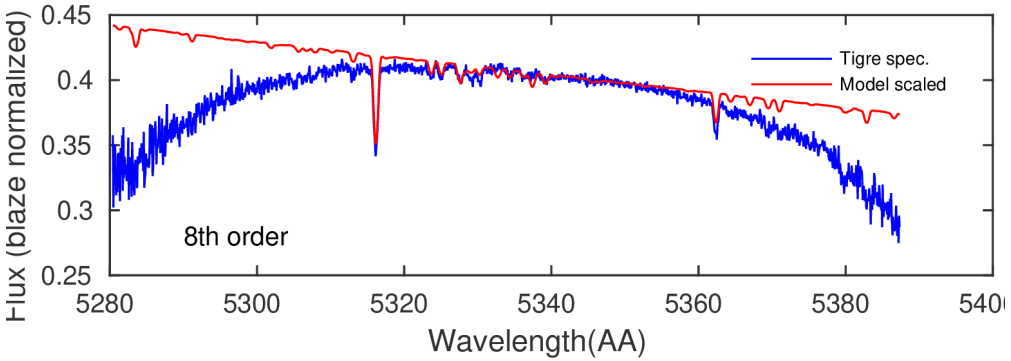
Proposed solution

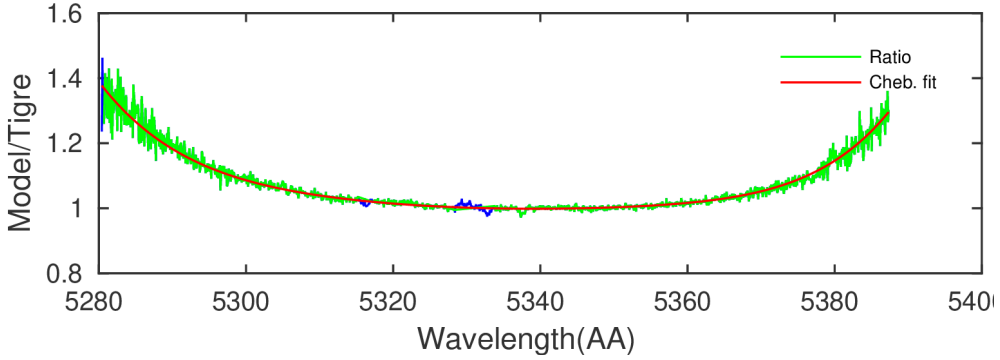
- Calculate the correction for a set of spectra: Vega
- Measure what correction is needed using only the spectrum
- Apply the correction
- HEROS overlapping regions very large
- Shape of adjacent orders are very similar
- Today only for the B channel

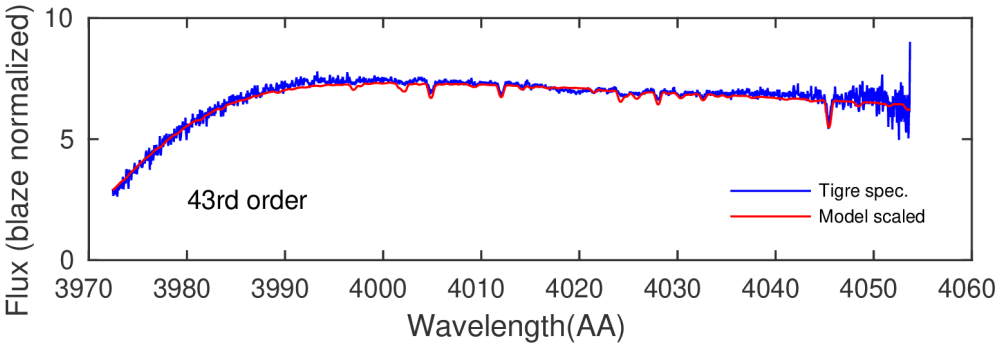
Correction

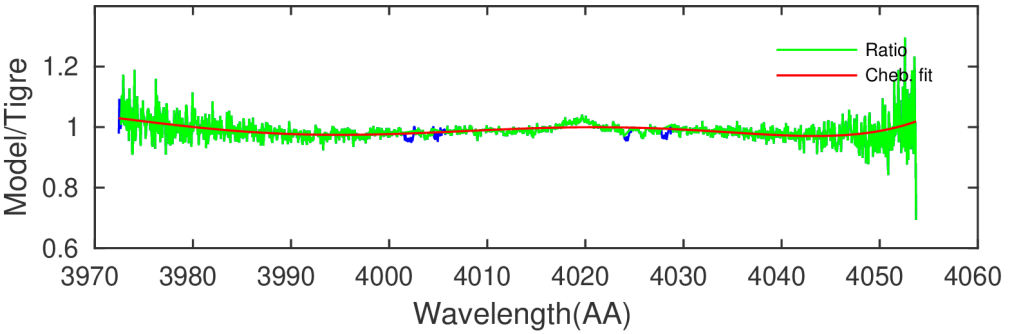
- Vega spectra
- Model of Castelli & Kurucz (1994) as comparison
  - No telluric lines
  - Good Balmer profiles
  - Cores of some lines are not good, but masked out
- Model spectrum scaled to each Tigre spectra
- Ratio fitted by a 6^{th}-order Chebyshev polynomial
- High order necessary to follow the variations

Correction

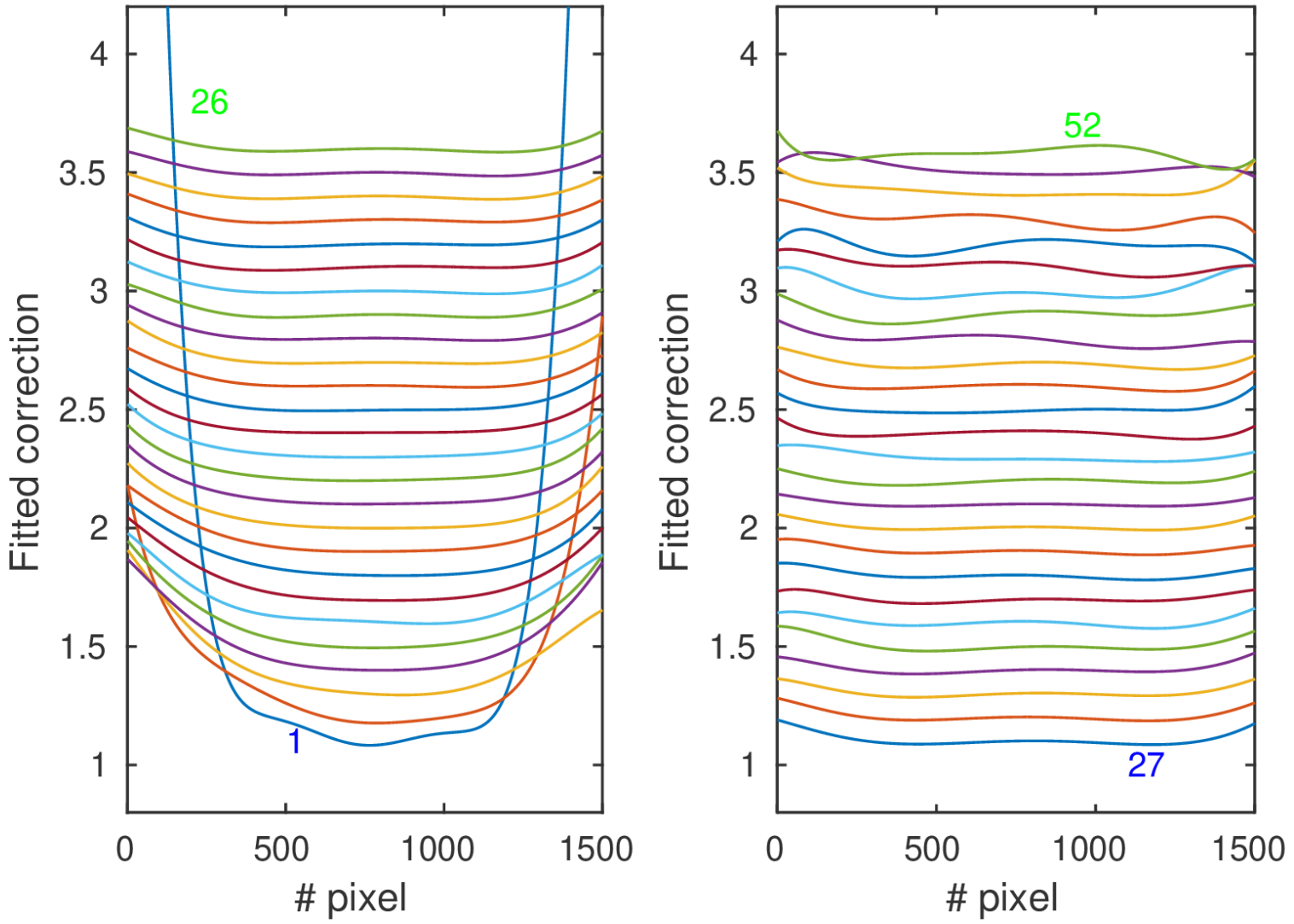

Flux (blaze normalized)
0.45
0.4
0.35
0.3
0.25
5280
5300
5320
5340
5360
5380
Wavelength(AA)
Tigre spec.
Model scaled
8th order


Model/Tigre
1.6
1.4
1.2
1
0.8
5280
5300
5320
5340
5360
5380
Wavelength(AA)
Ratio
Cheb. fit

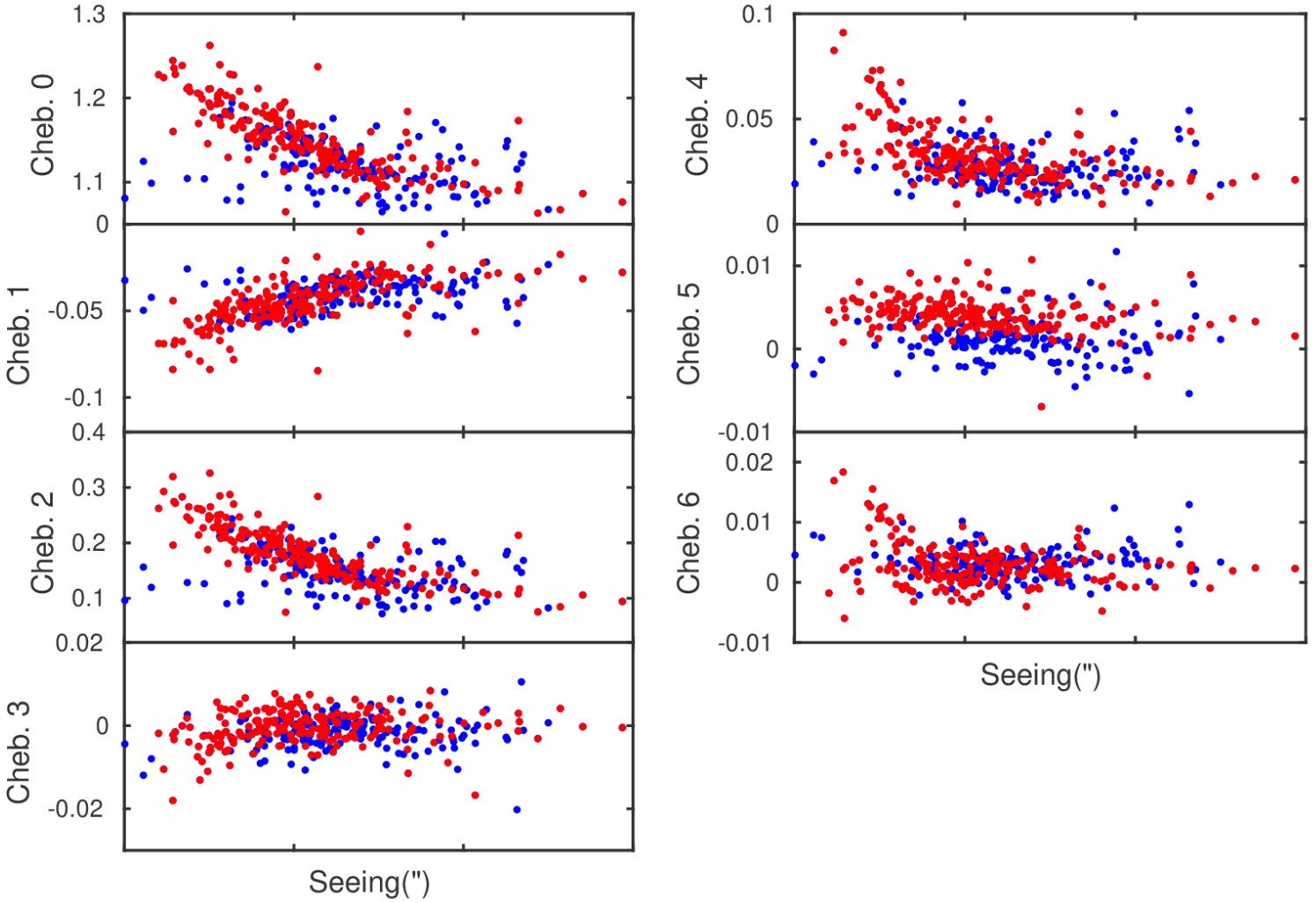

Flux (blaze normalized)
10
5
0
3970
3980
3990
4000
4010
4020
4030
4040
4050
4060
Wavelength(AA)
43rd order
Tigre spec.
Model scaled


Model/Tigre
1.2
1
0.8
0.6
3970
3980
3990
4000
4010
4020
4030
4040
4050
4060
Wavelength(AA)
Ratio
Cheb. fit

Correction


Fitted correction
pixel
26
1
52
27
0
500
1000
1500
1
1.5
2
2.5
3
3.5
4

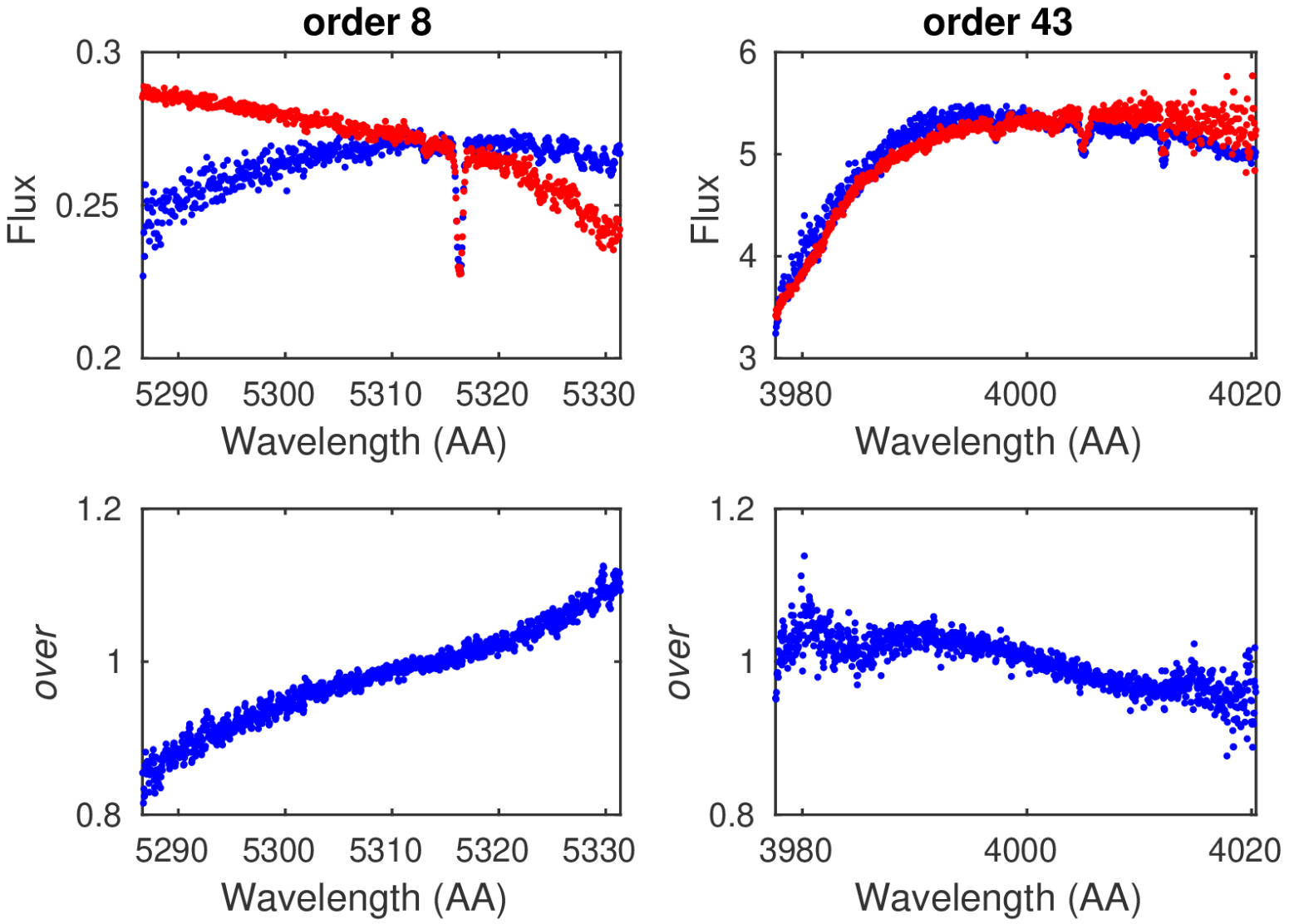
Dependence on seeing/3



How to measure the necessary correction

- Need to be robust
- The information should be in the spectrum
- Overlapping region:
- $over_i(\lambda) = 1 - F_i(\lambda)/F_{i+1}(\lambda)$
- PCA analysis of *over* (applied for each order individually)
- First four eigenvalues are used for the blaze correction
- Correlation of eigenvalues of *over* with Chebyshev parameters

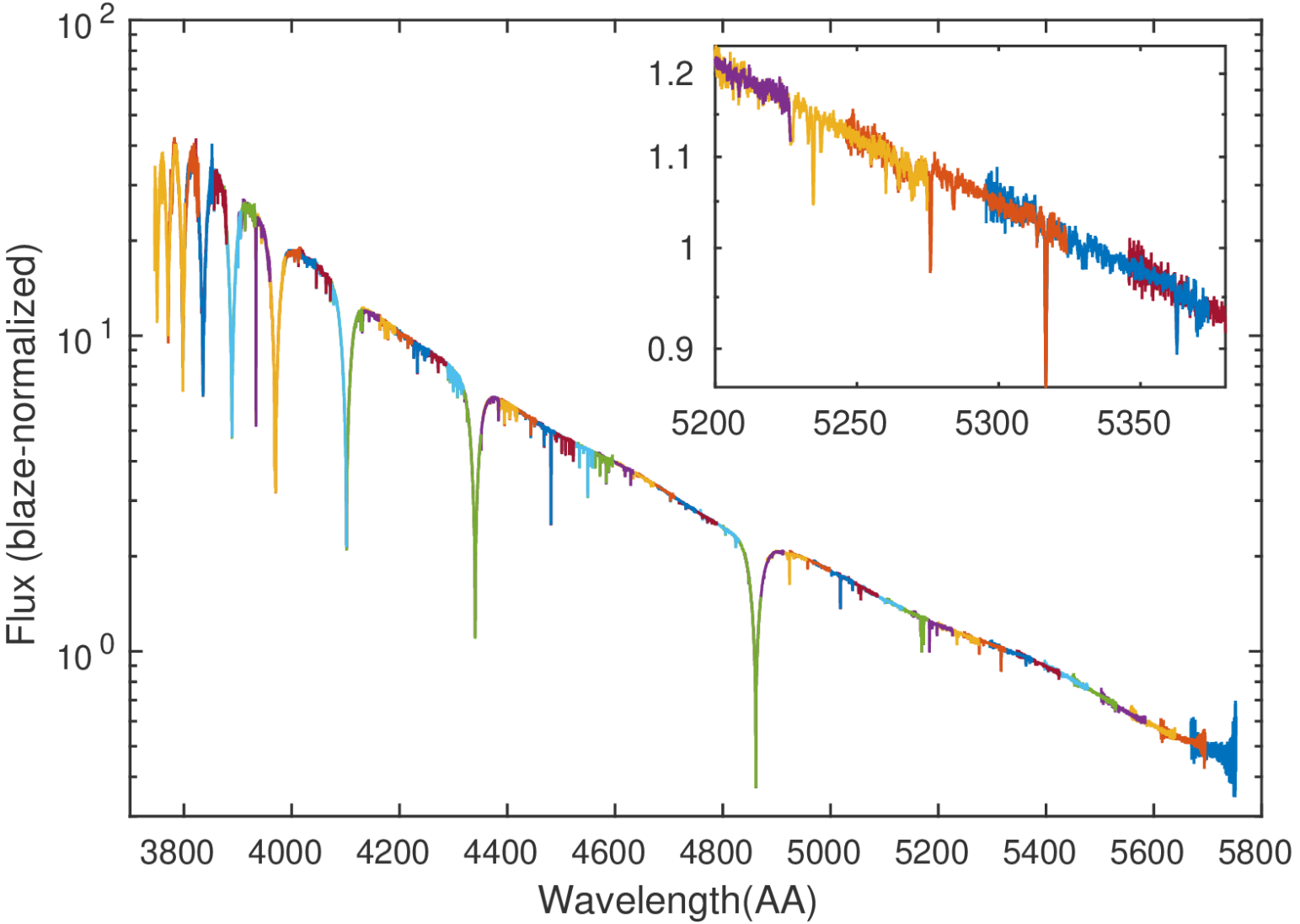
Overlapping



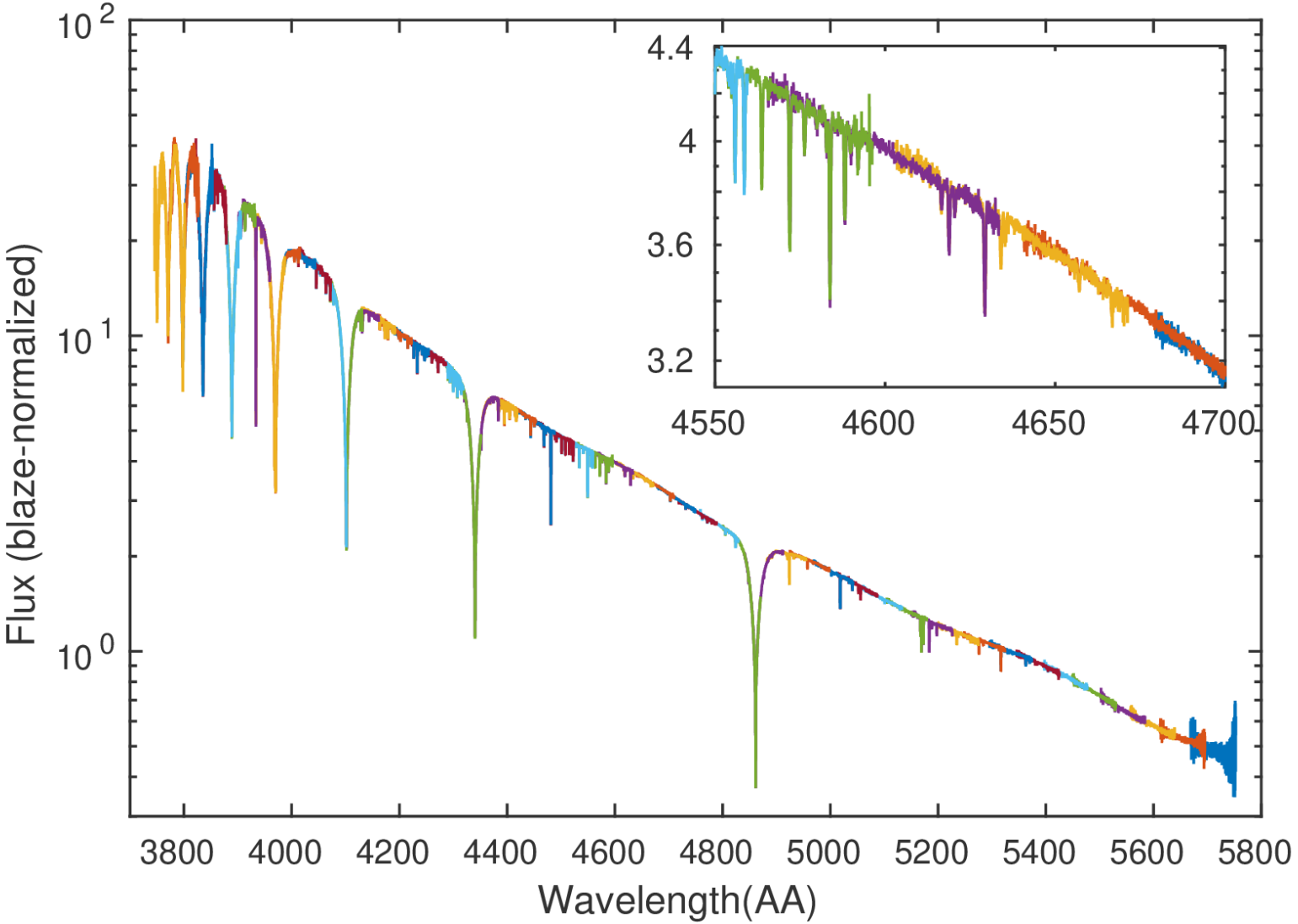
Application of the method

- Calculate the overlapping data for each order, $over_i$
- Project it to the eigenvectors of the order
- Estimate the Chebishev parameters with the eigenvectors
- Calculate the correction and apply it for the order
- Merge all order, using data of several orders for the same wavelength → improvement of SNR

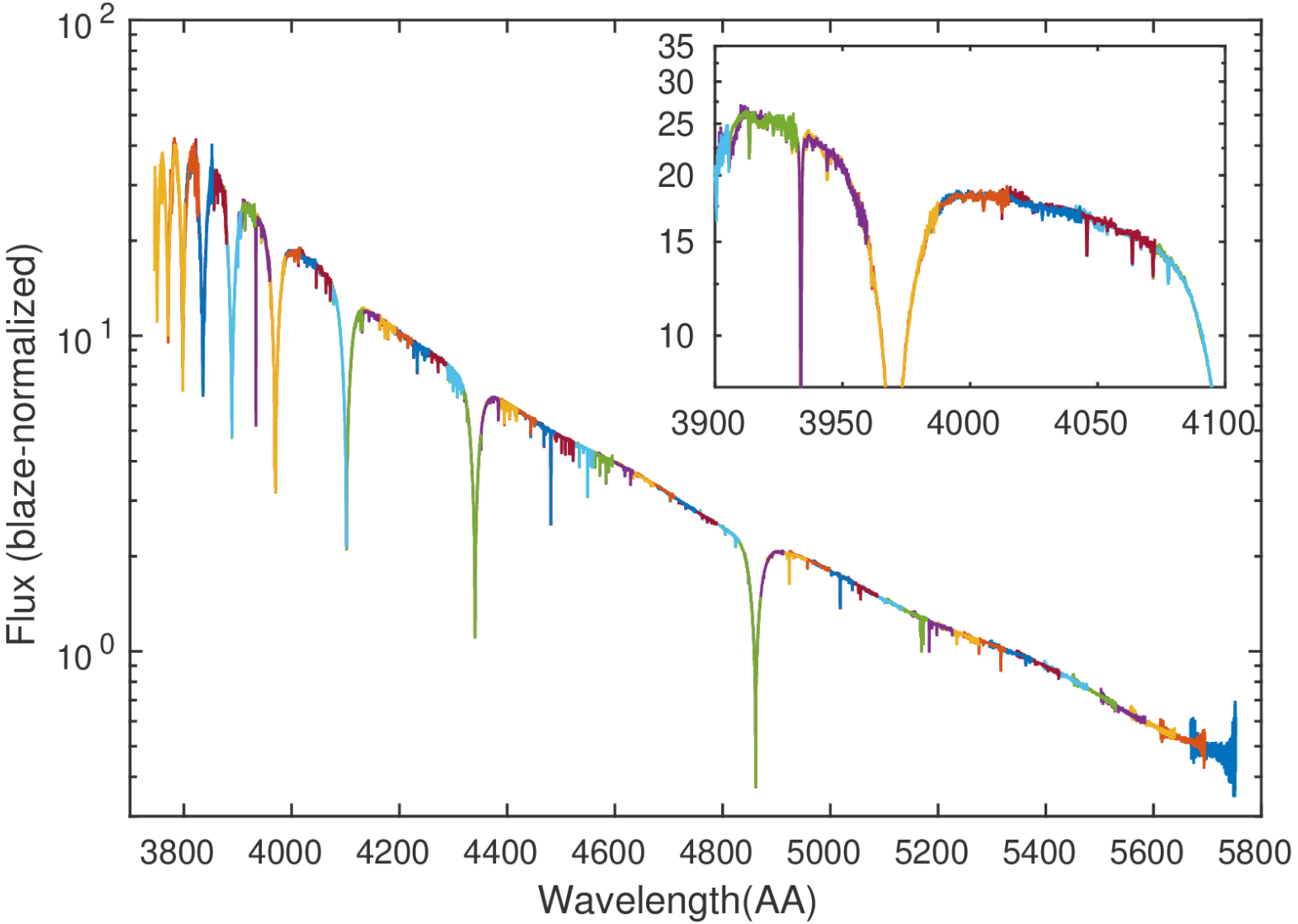
TgreExample: spectrum of Vega



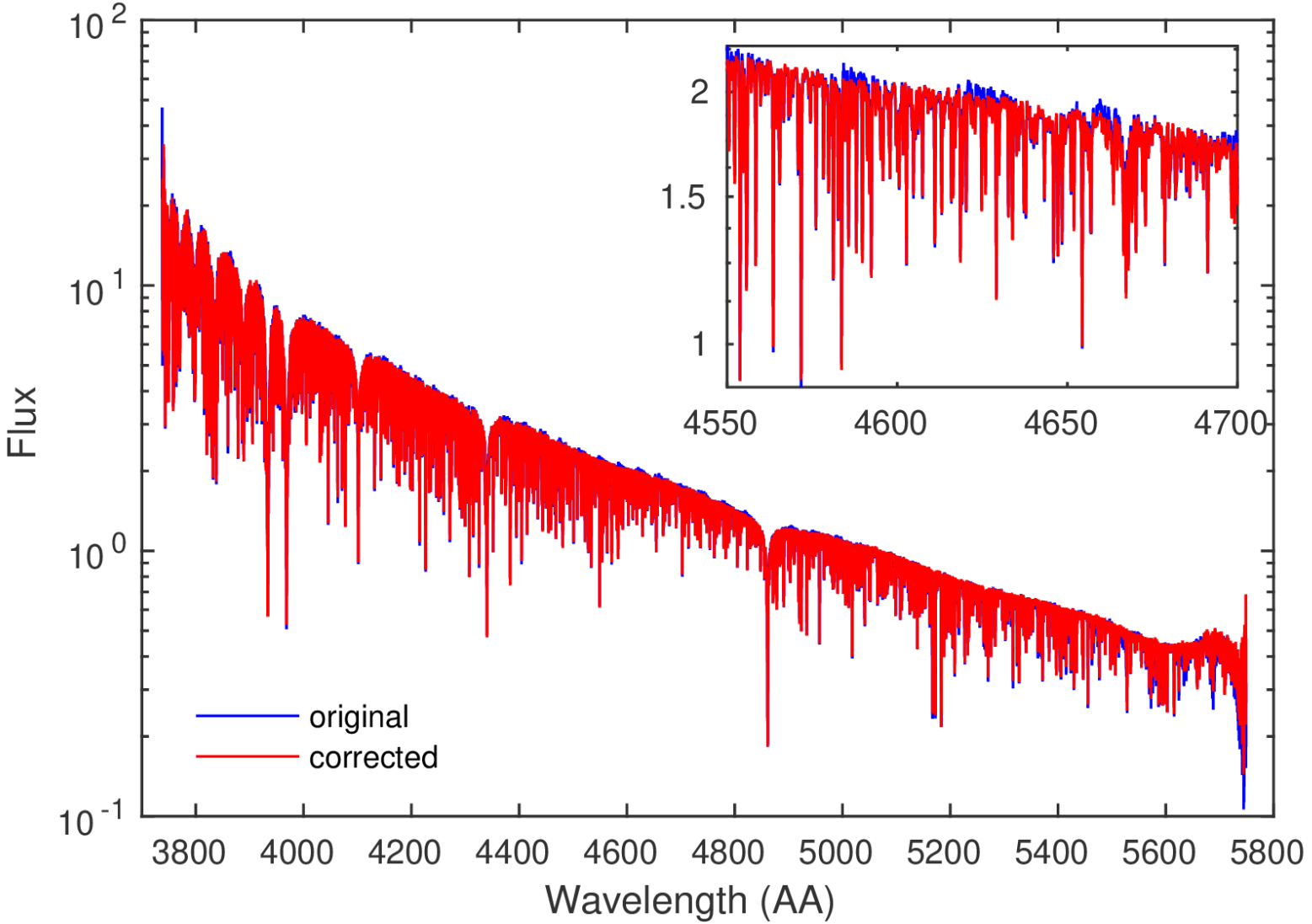
TgreExample: spectrum of Vega



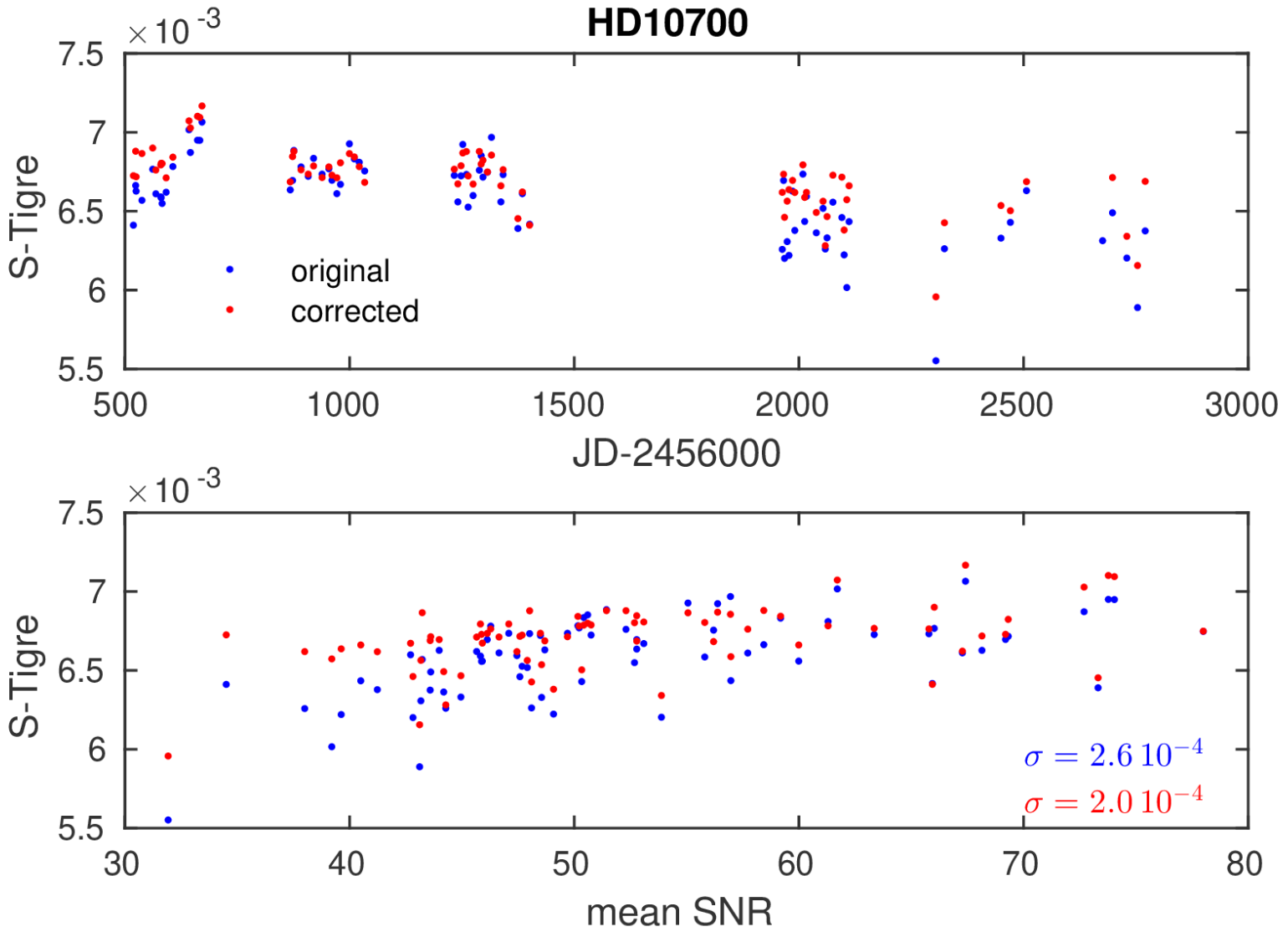
TgreExample: spectrum of Vega



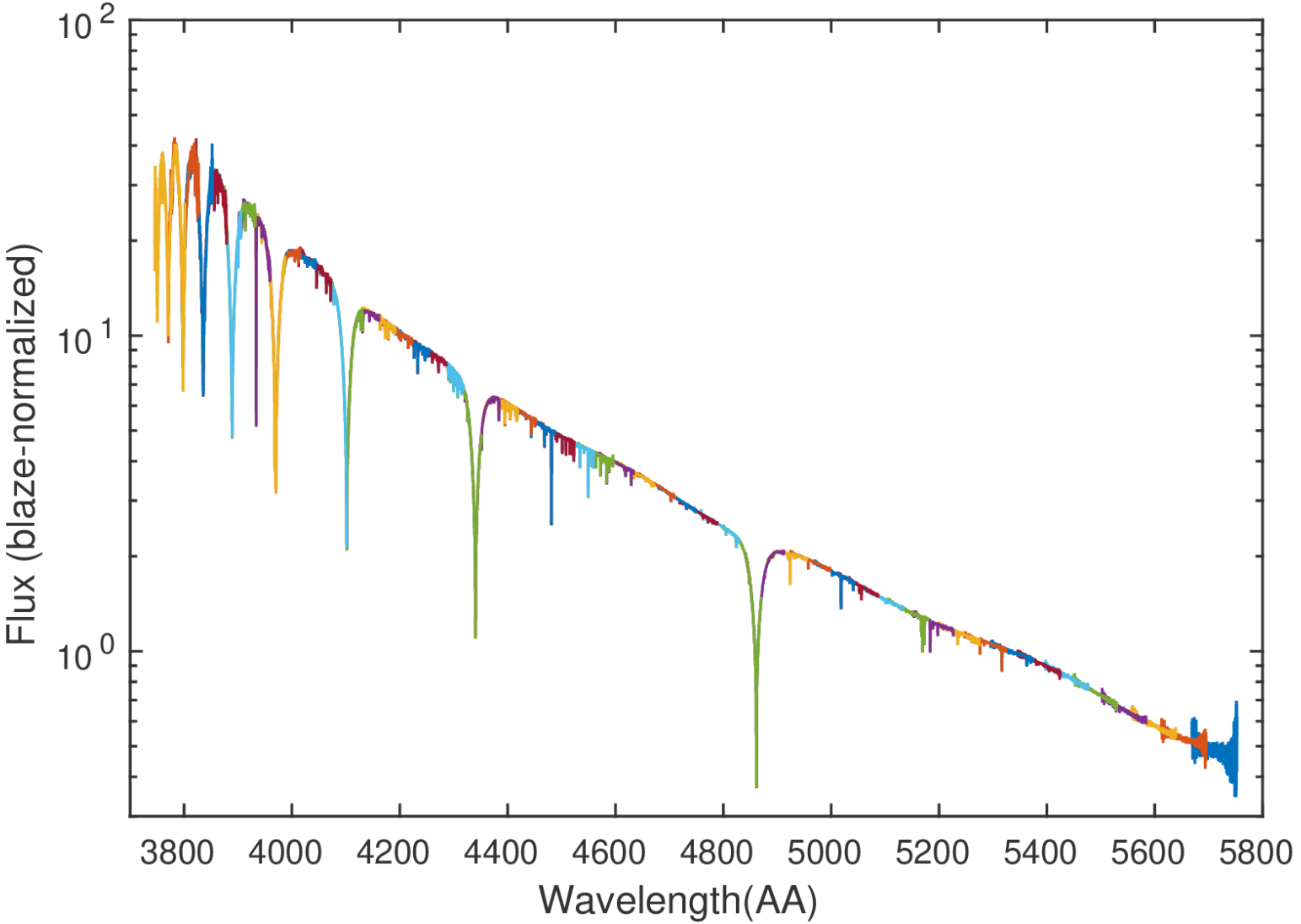
Example: spectrum of Procyon



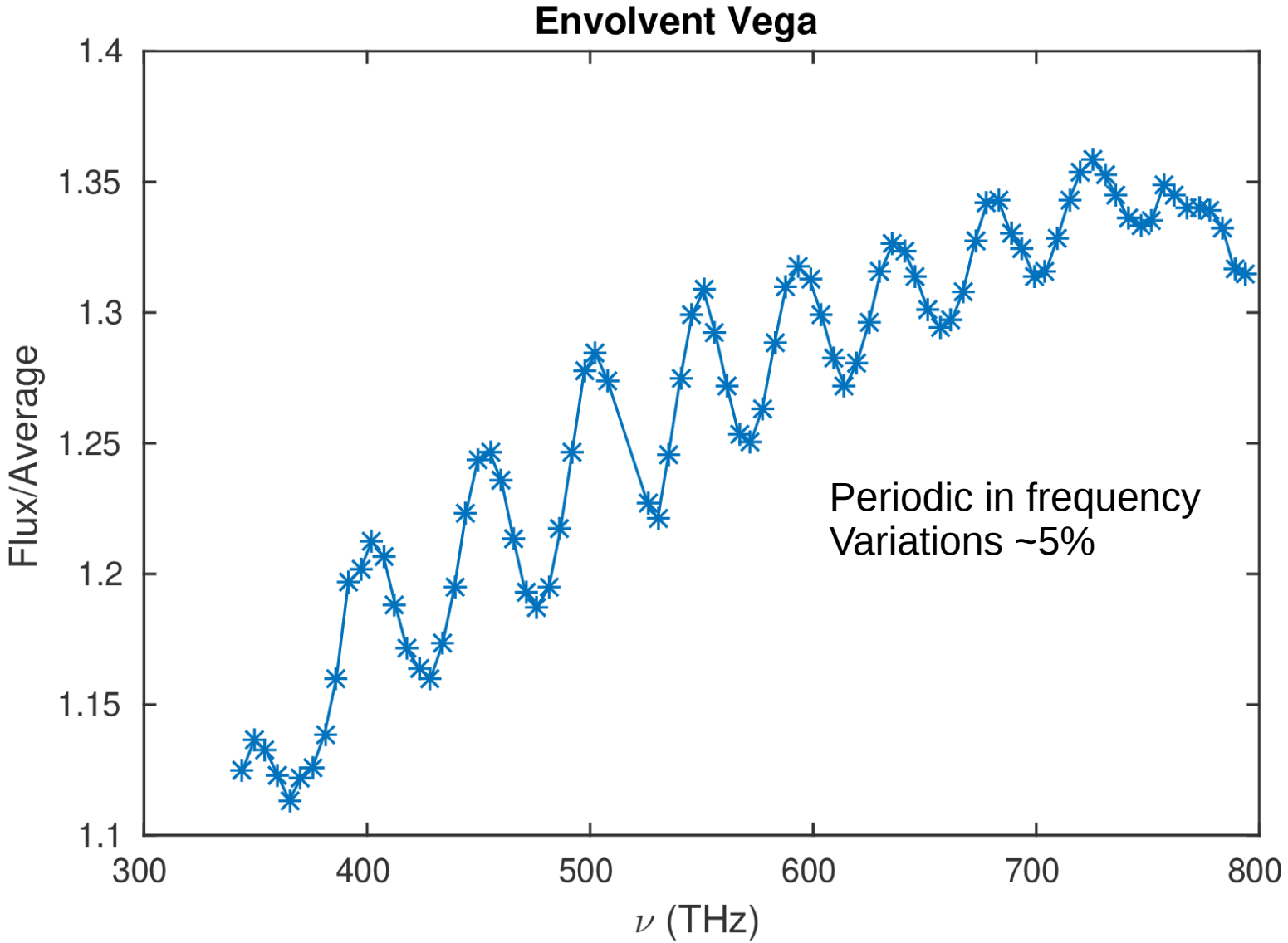
S-Tigre τ Cet


HD10700
×10 -3
7.5
7
6.5
6
5.5
S-Tigre
original
corrected
500
1000
1500
2000
2500
3000
JD-2456000
×10 -3
7.5
7
6.5
6
5.5
S-Tigre
$\sigma = 2.6\,10^{-4}$
$\sigma = 2.0\,10^{-4}$
30
40
50
60
70
80
mean SNR

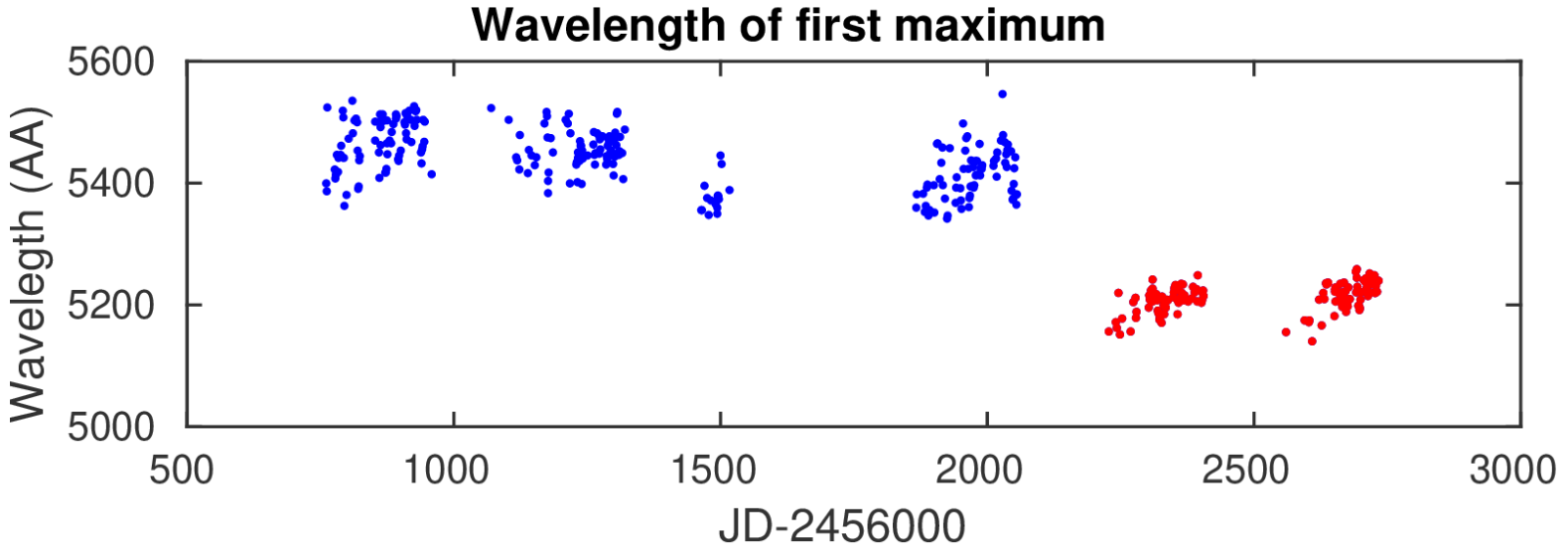
The Wave

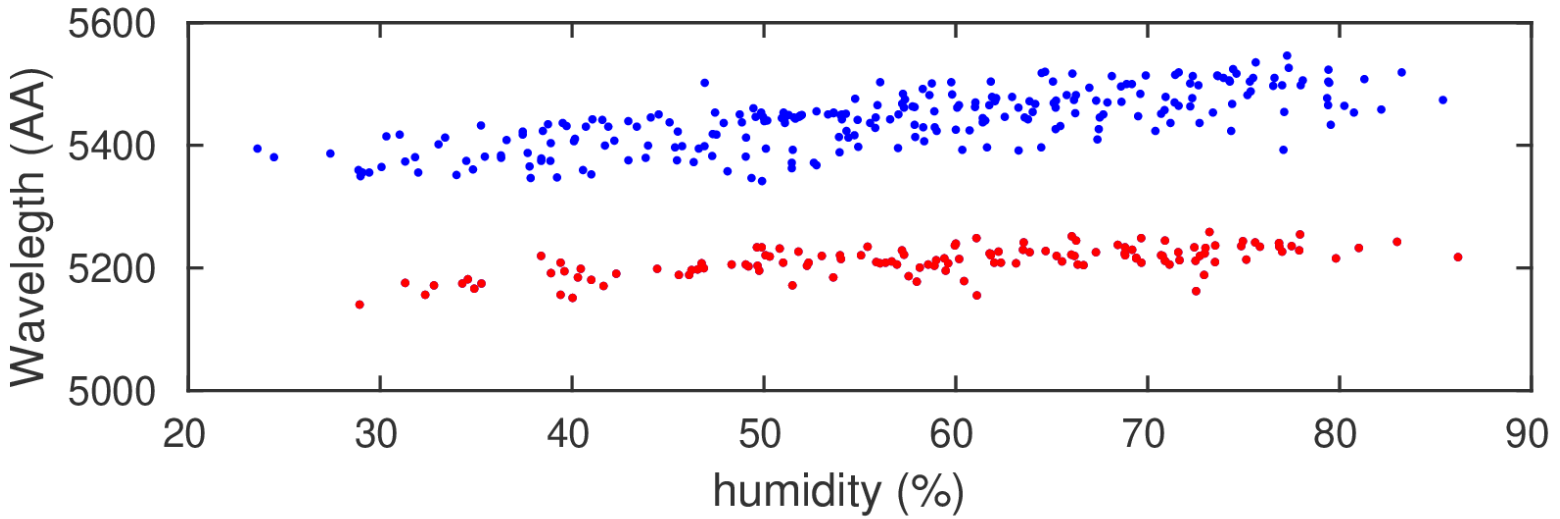

Flux (blaze-normalized)
10^2
10^1
10^0
3800
4000
4200
4400
4600
4800
5000
5200
5400
5600
5800
Wavelength(AA)

The Wave

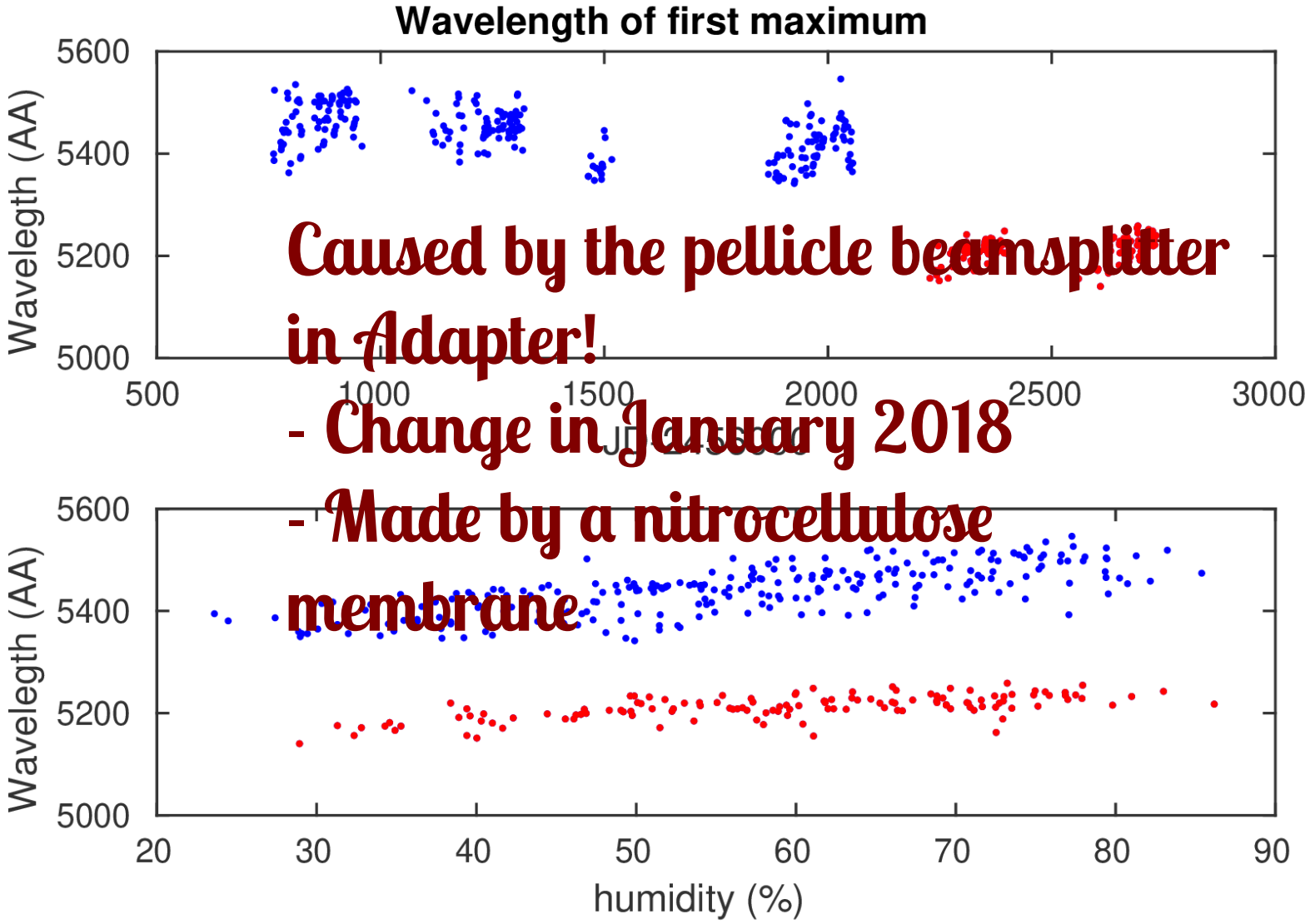

Envolvent Vega
Flux/Average
1.4
1.35
1.3
1.25
1.2
1.15
1.1
300
400
500
600
700
800
ν (THz)
Periodic in frequency
Variations ~5%

The Wave


Wavelength of first maximum
Wavelegth (AA)
5600
5400
5200
5000
500
1000
1500
2000
2500
3000
JD-2456000


Wavelegth (AA)
5600
5400
5200
5000
20
30
40
50
60
70
80
90
humidity (%)

The Wave

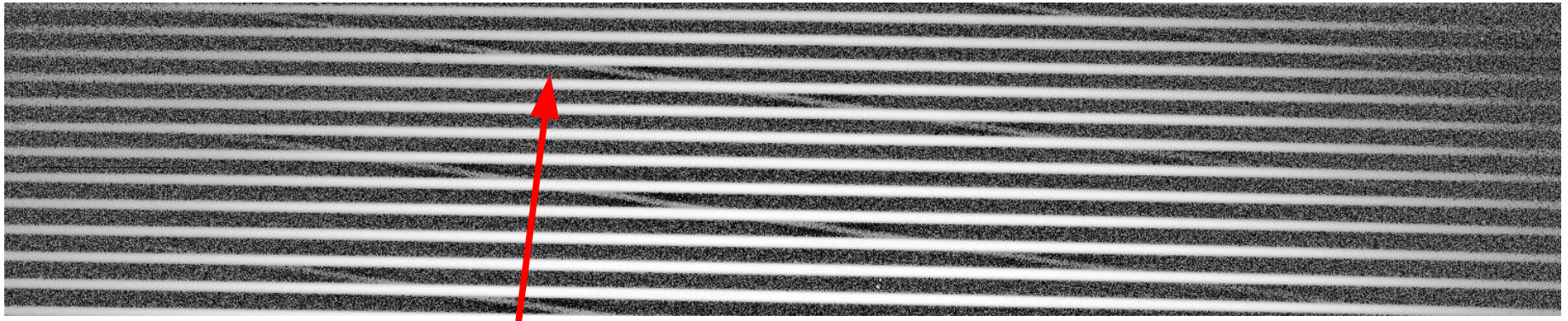


Caused by the pellicle beamsplitter in Adapter!

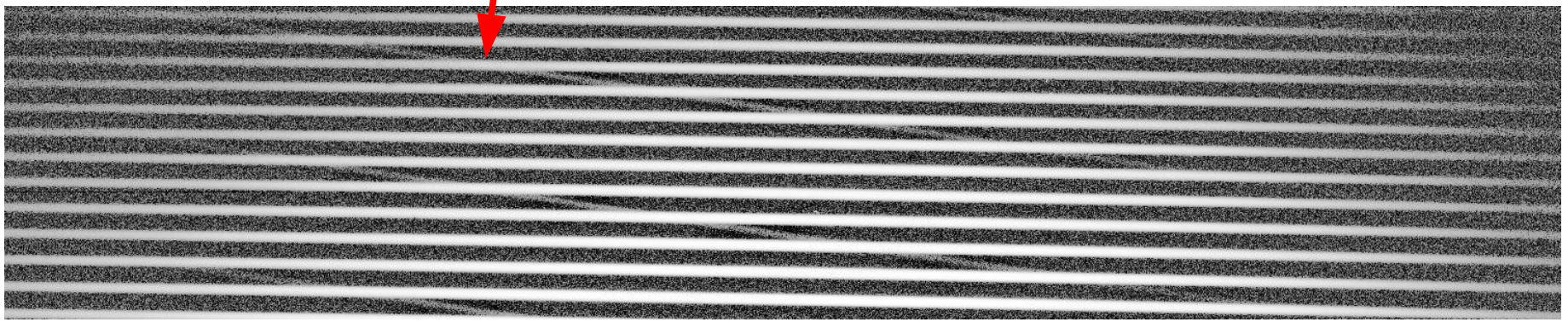
- Change in January 2018
- Made by a nitrocellulose membrane

The ghosts

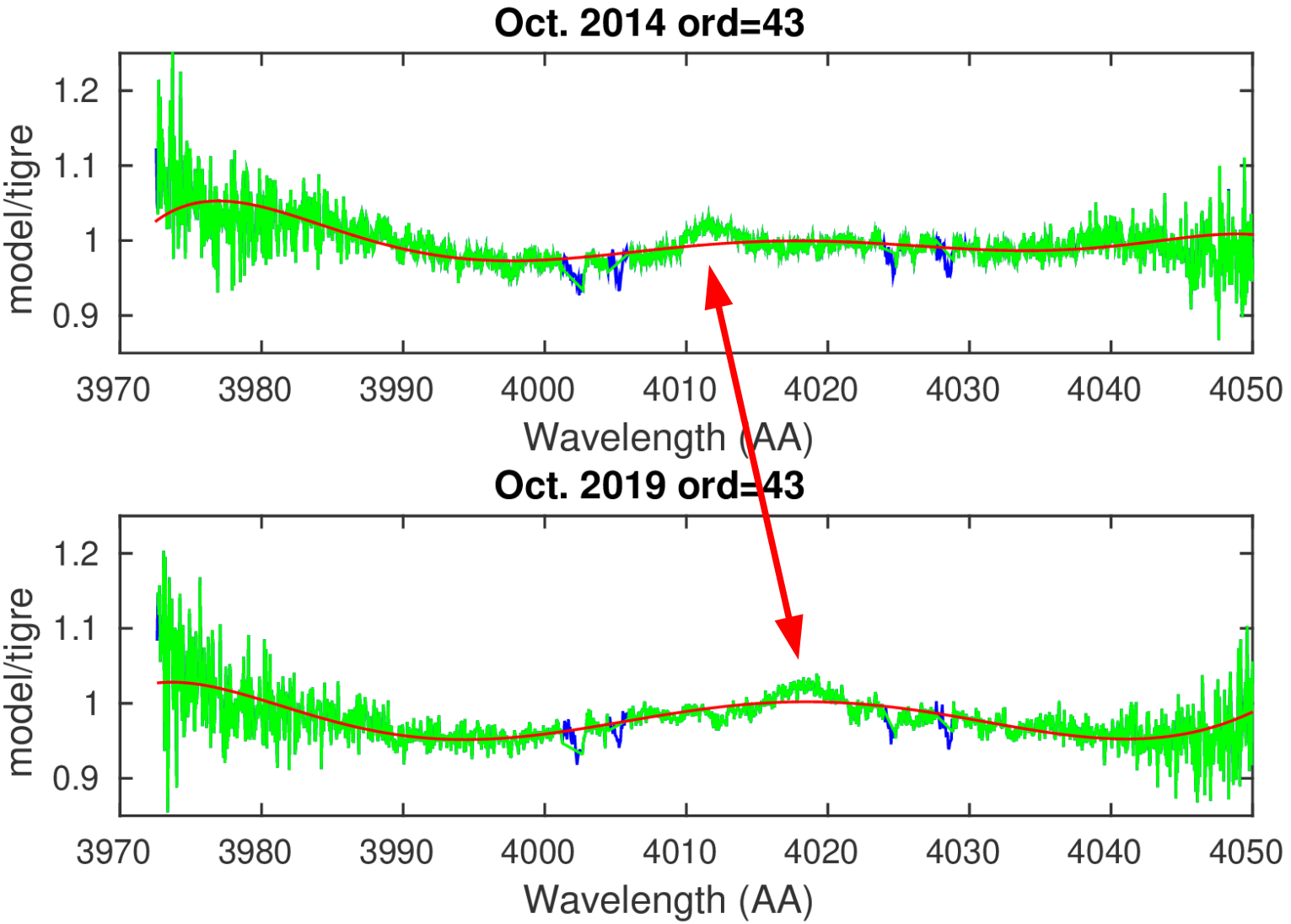
Oct. 2014



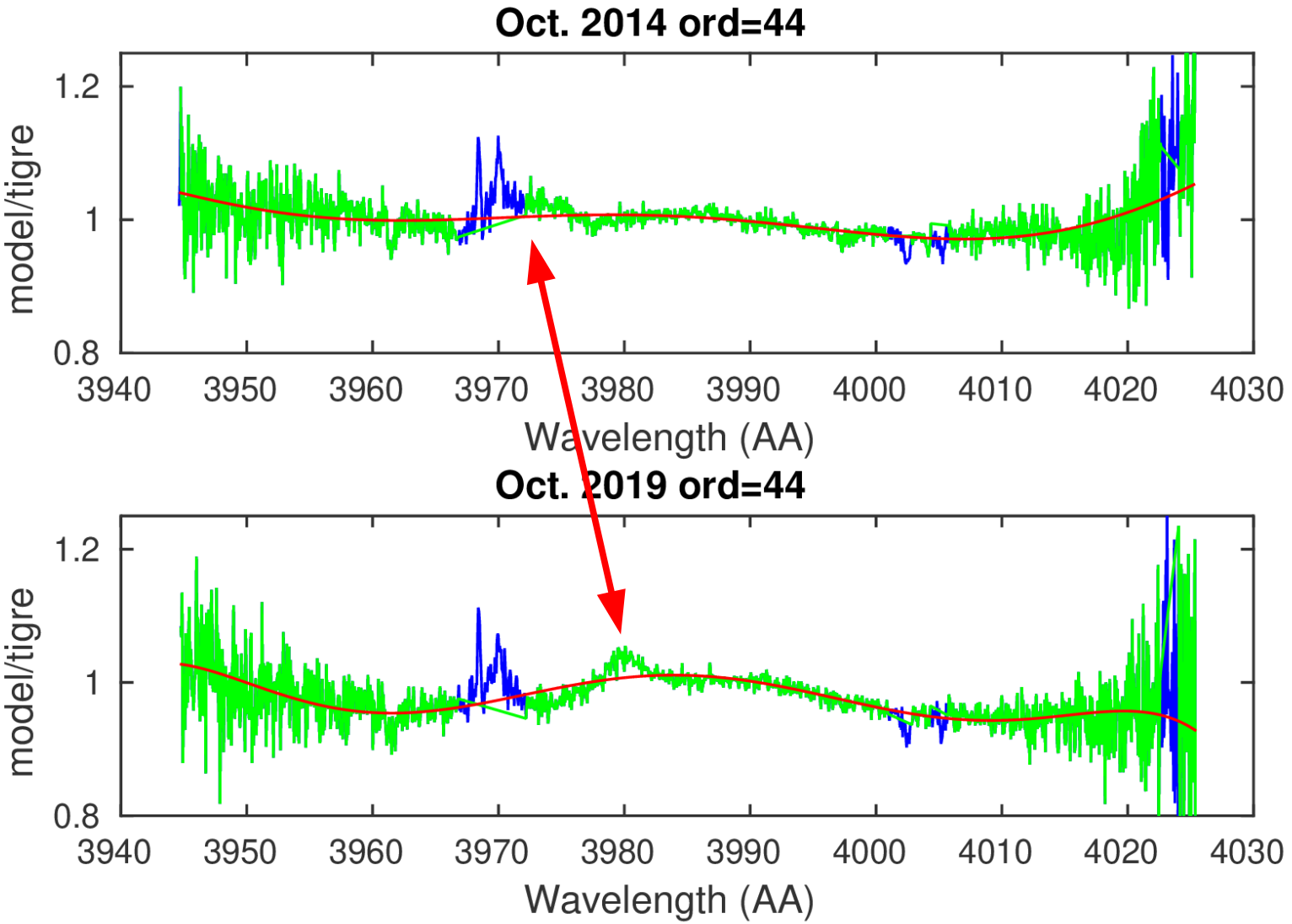
Oct. 2019



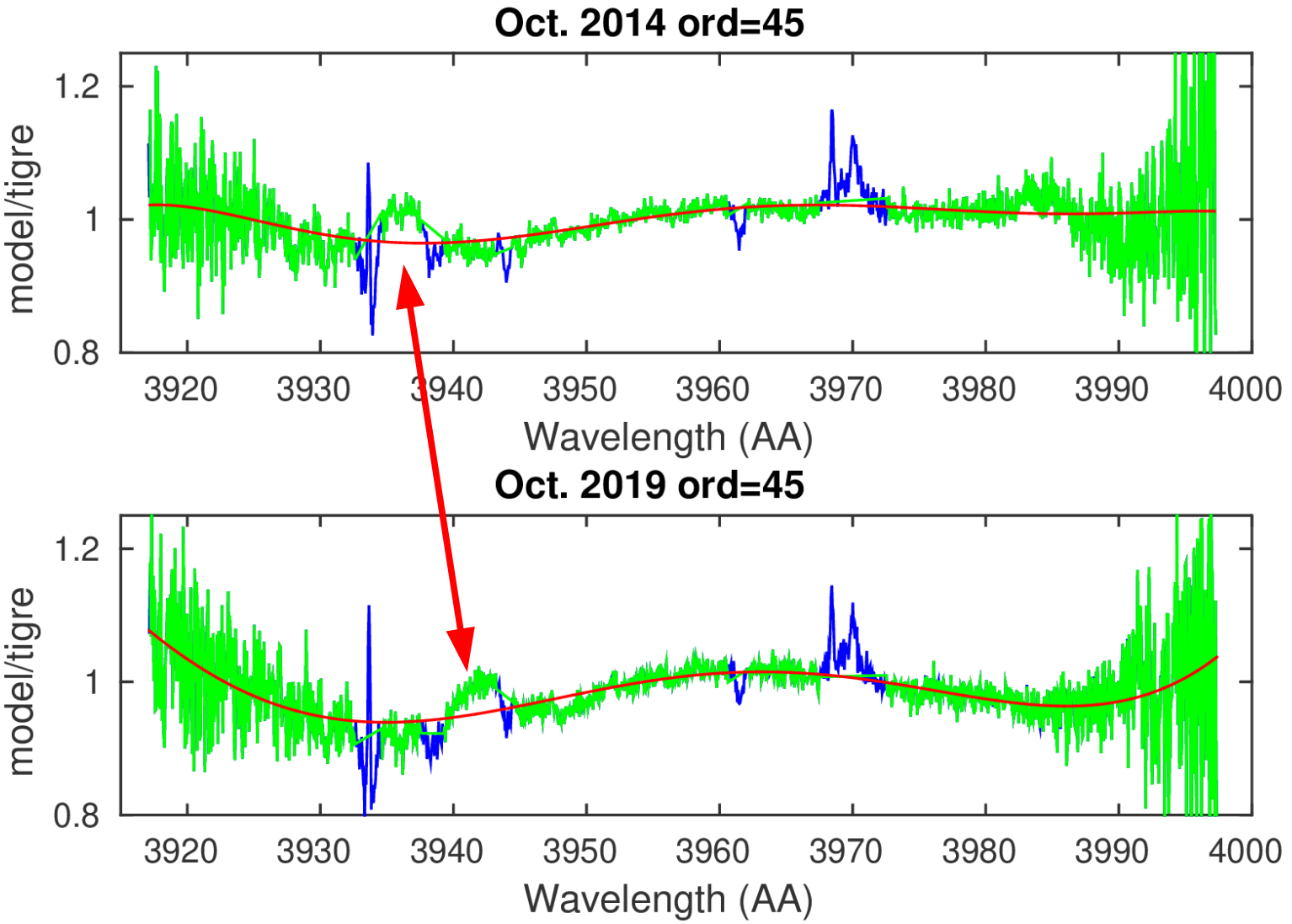
The ghosts


Oct. 2014 ord=43
model/tigre
1.2
1.1
1
0.9
3970
3980
3990
4000
4010
4020
4030
4040
4050
Wavelength (AA)
Oct. 2019 ord=43
model/tigre
1.2
1.1
1
0.9
3970
3980
3990
4000
4010
4020
4030
4040
4050
Wavelength (AA)

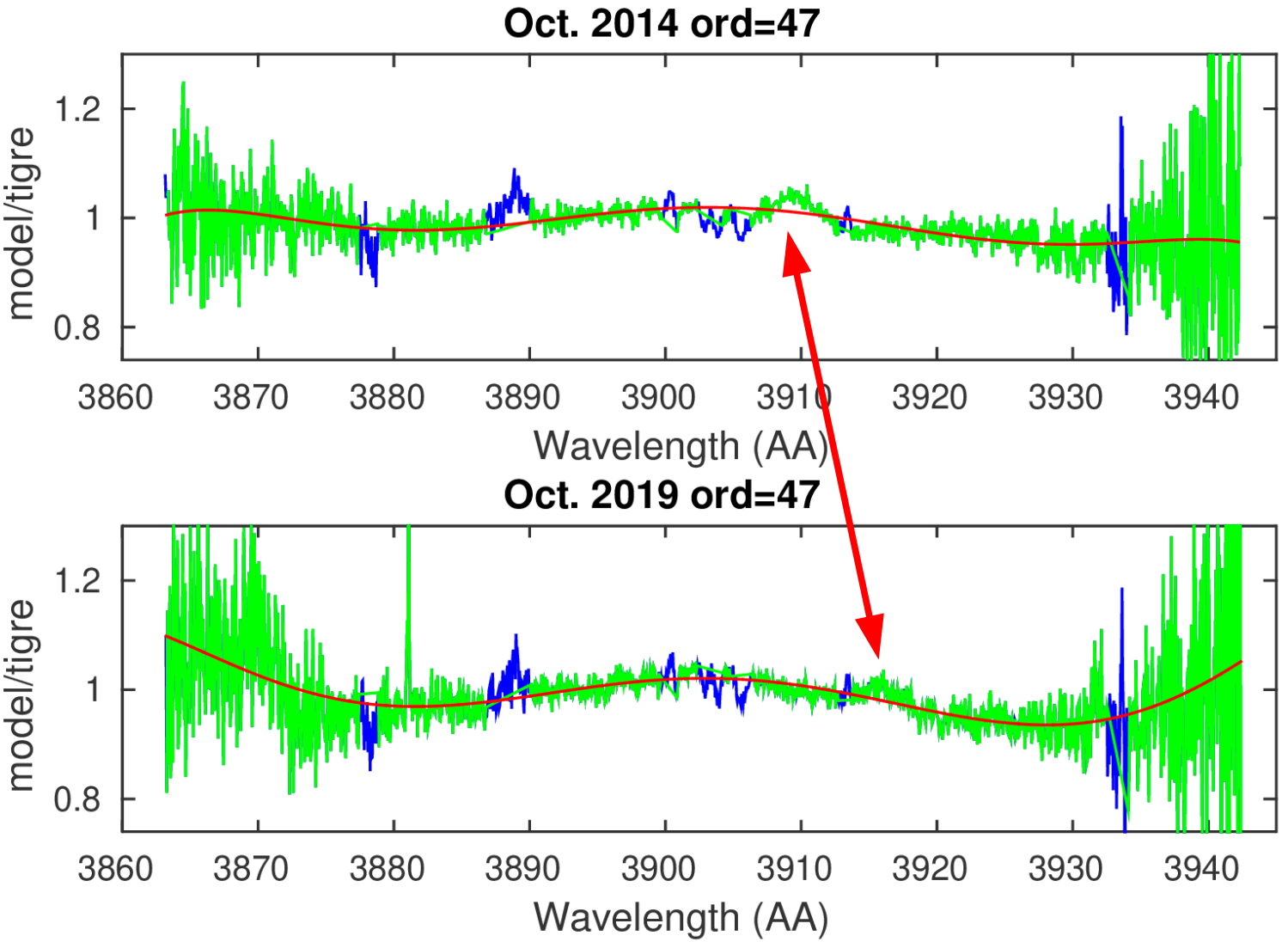
The ghosts


Oct. 2014 ord=44
model/tigre
1.2
1
0.8
3940
3950
3960
3970
3980
3990
4000
4010
4020
4030
Wavelength (AA)
Oct. 2019 ord=44
model/tigre
1.2
1
0.8
3940
3950
3960
3970
3980
3990
4000
4010
4020
4030
Wavelength (AA)

The ghosts


Oct. 2014 ord=45
model/tigre
1.2
1
0.8
3920
3930
3940
3950
3960
3970
3980
3990
4000
Wavelength (AA)
Oct. 2019 ord=45
model/tigre
1.2
1
0.8
3920
3930
3940
3950
3960
3970
3980
3990
4000
Wavelength (AA)

The ghosts


Oct. 2014 ord=47
model/tigre
1.2
1
0.8
3860
3870
3880
3890
3900
3910
3920
3930
3940
Wavelength (AA)
Oct. 2019 ord=47
model/tigre
1.2
1
0.8
3860
3870
3880
3890
3900
3910
3920
3930
3940
Wavelength (AA)

END

Correction Hbeta