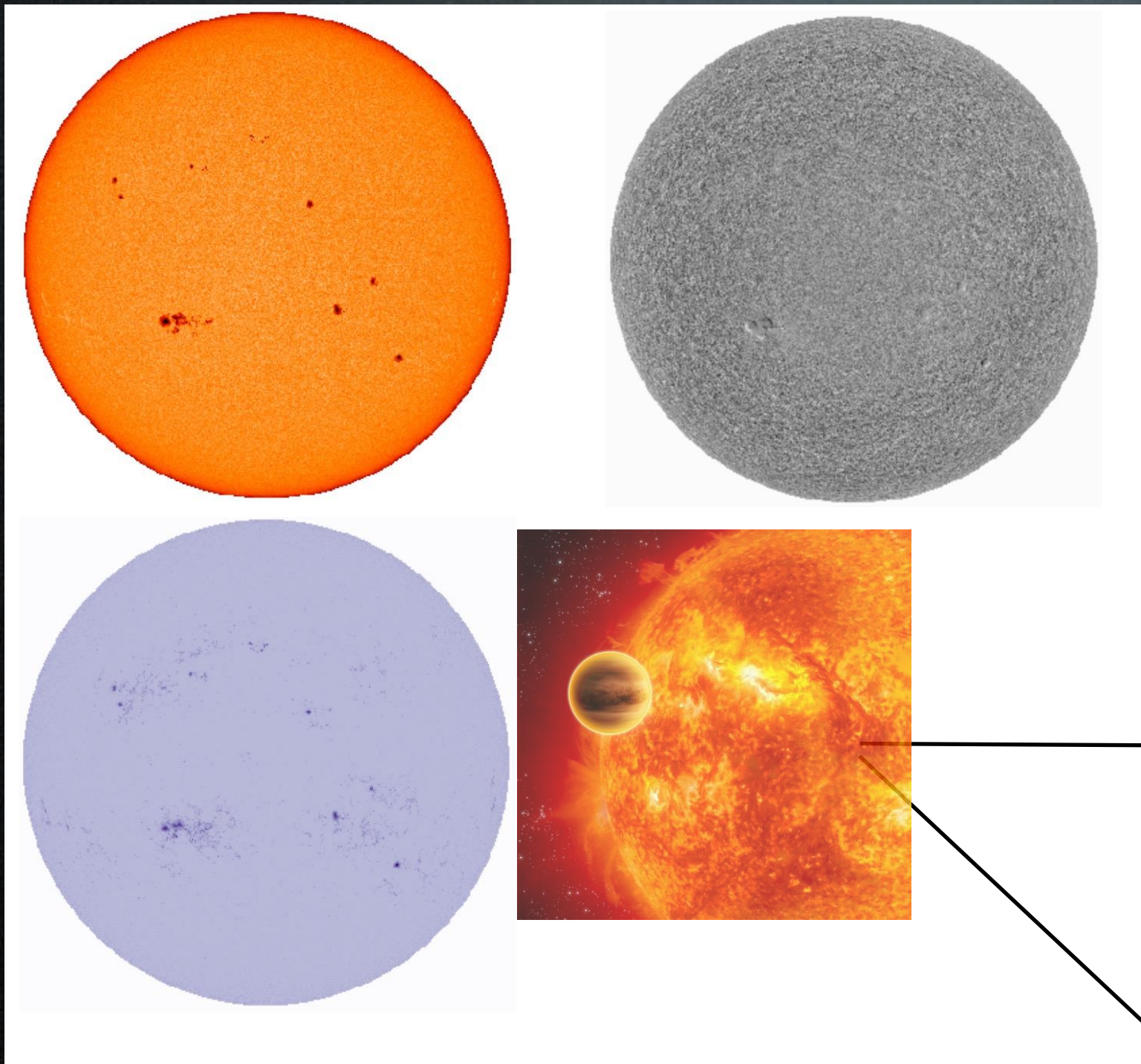




Queen's University  
Belfast

Prof. Chris Watson



David Jackson

The long-term behaviour of inactive  
cool stars.



# The stellar RV problem

Active



Inactive



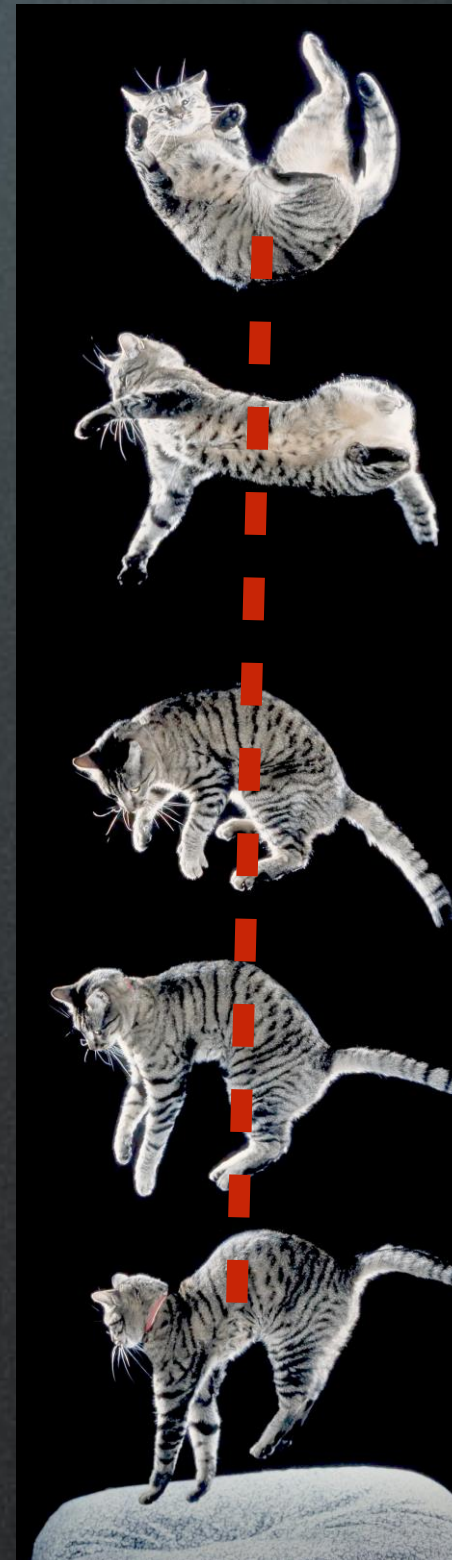


# The stellar RV problem

Active



Inactive



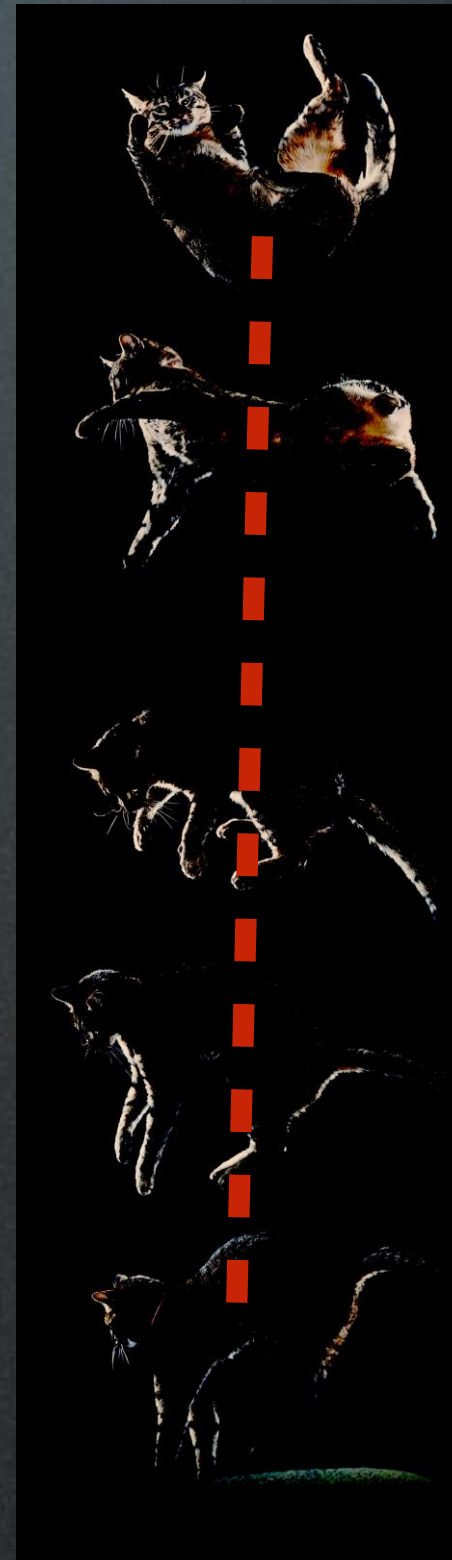


# The stellar RV problem

Active



Inactive

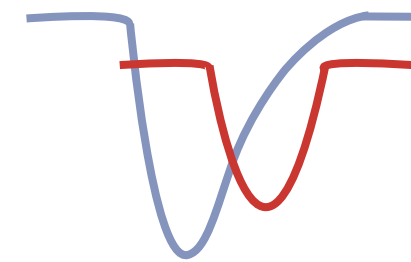
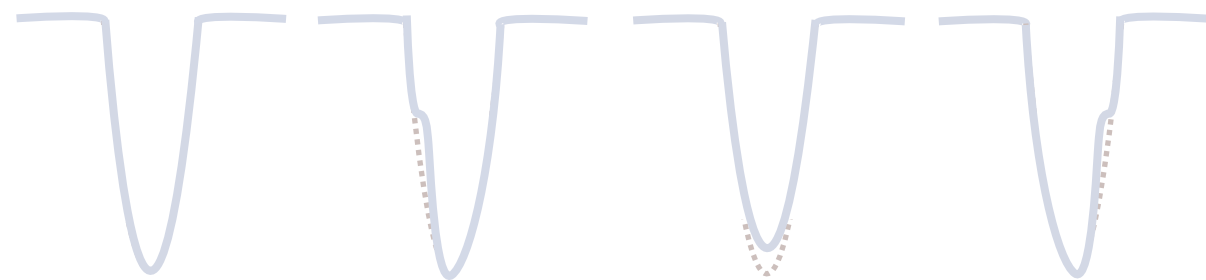
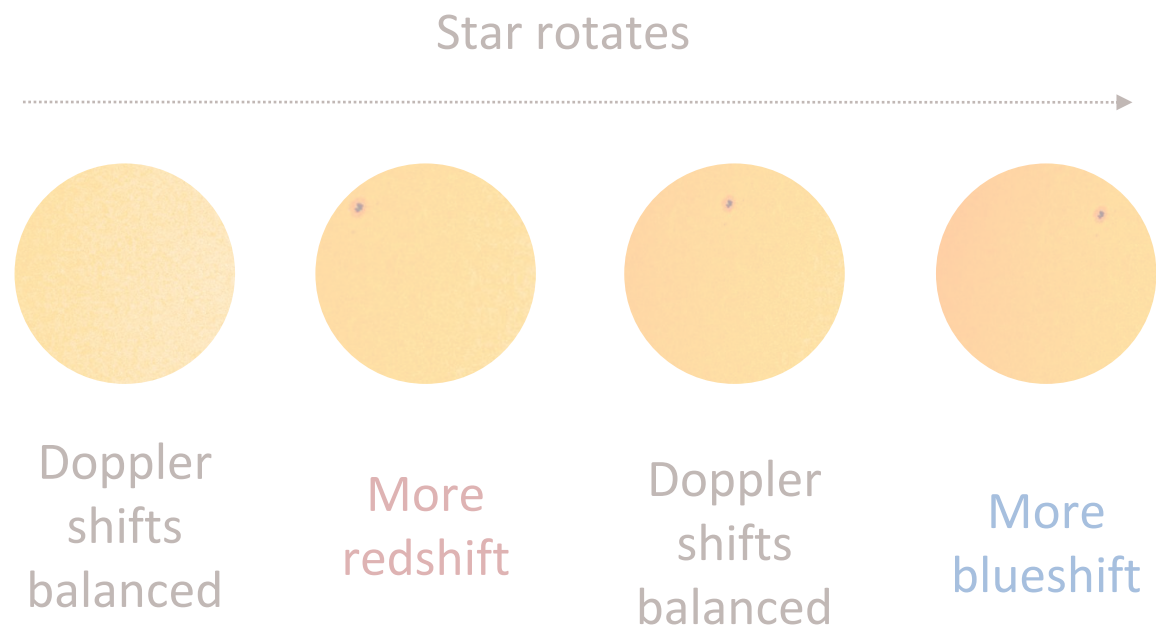




# The stellar RV problem



# Stellar RV variability

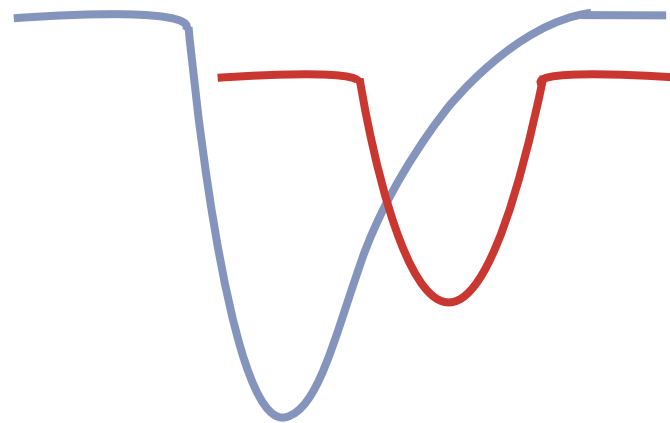


faculae, and granulation distort the shape of the spectral line

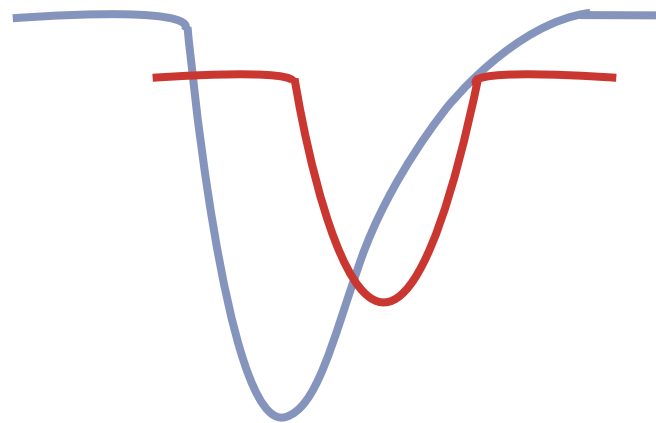
See Cegla et al. (2013)



# Convective blueshift suppression

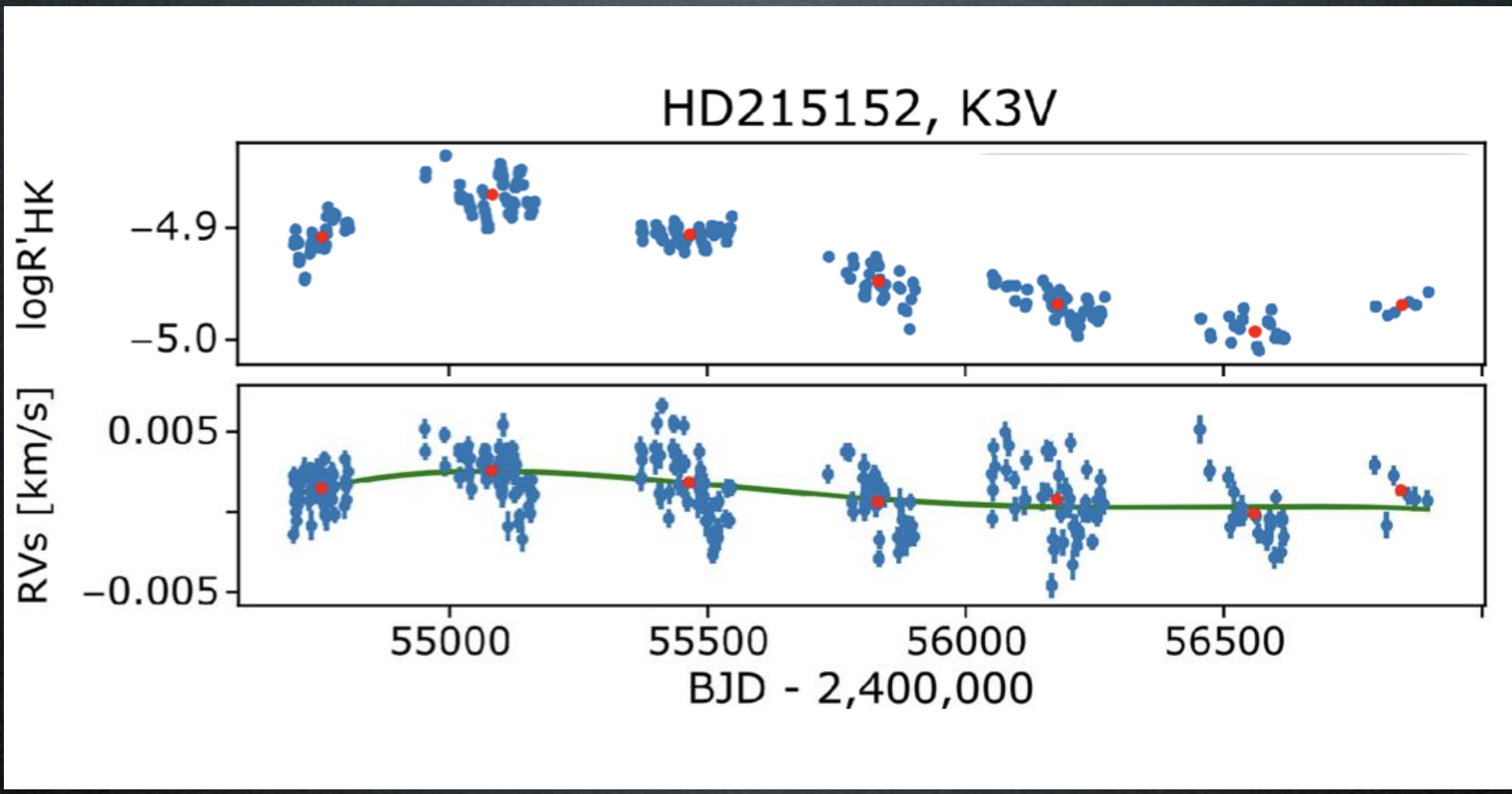


# Convective blueshift suppression

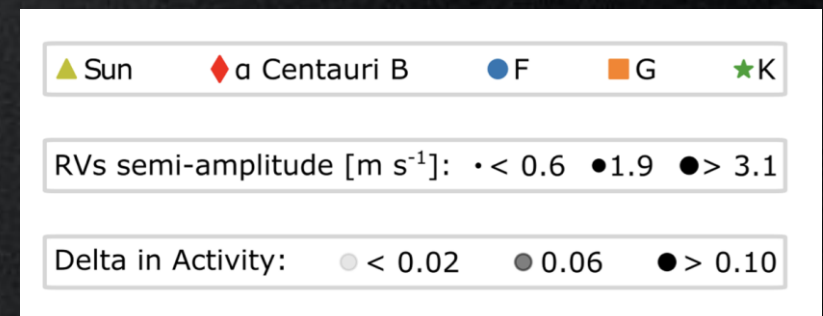
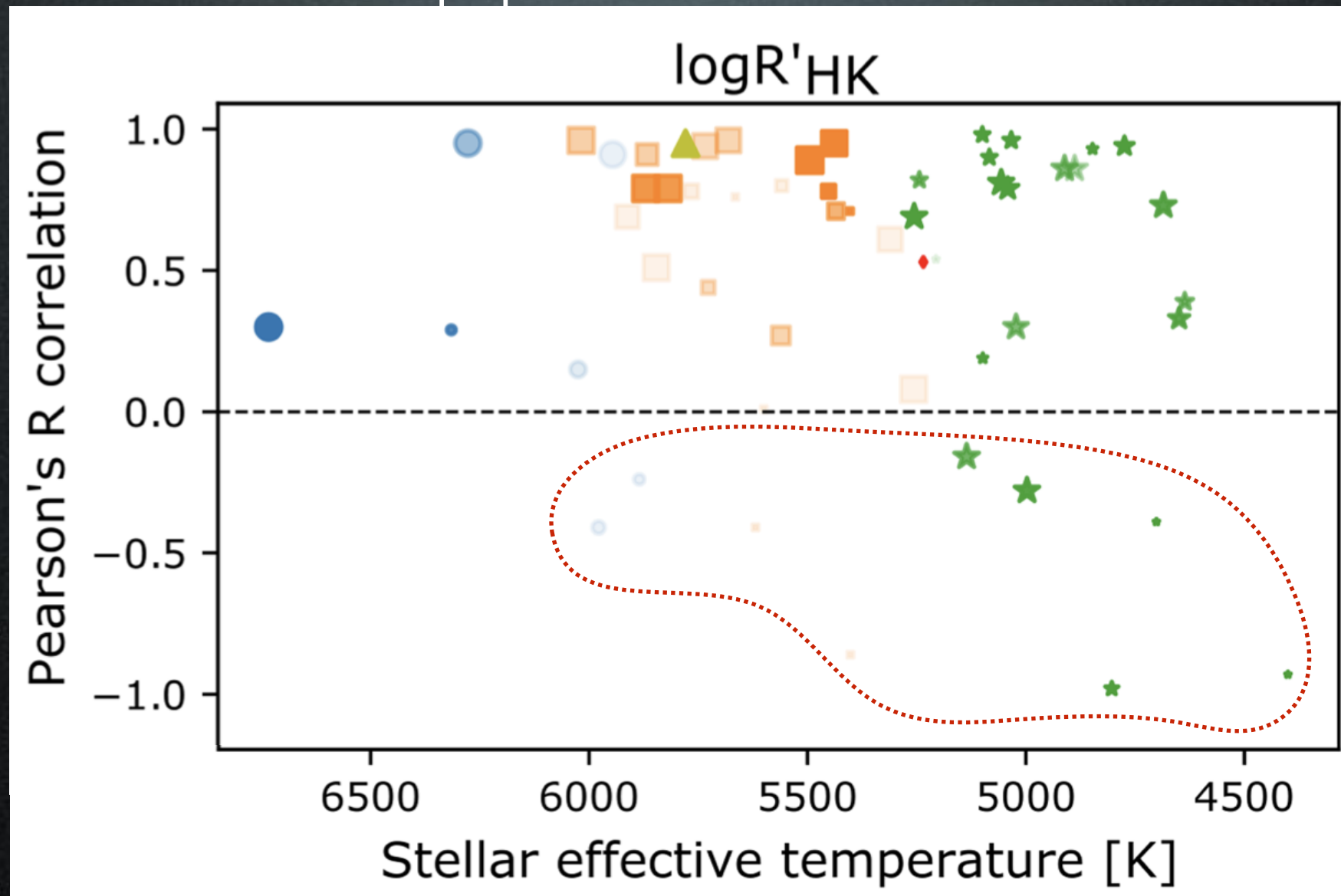




# Observations



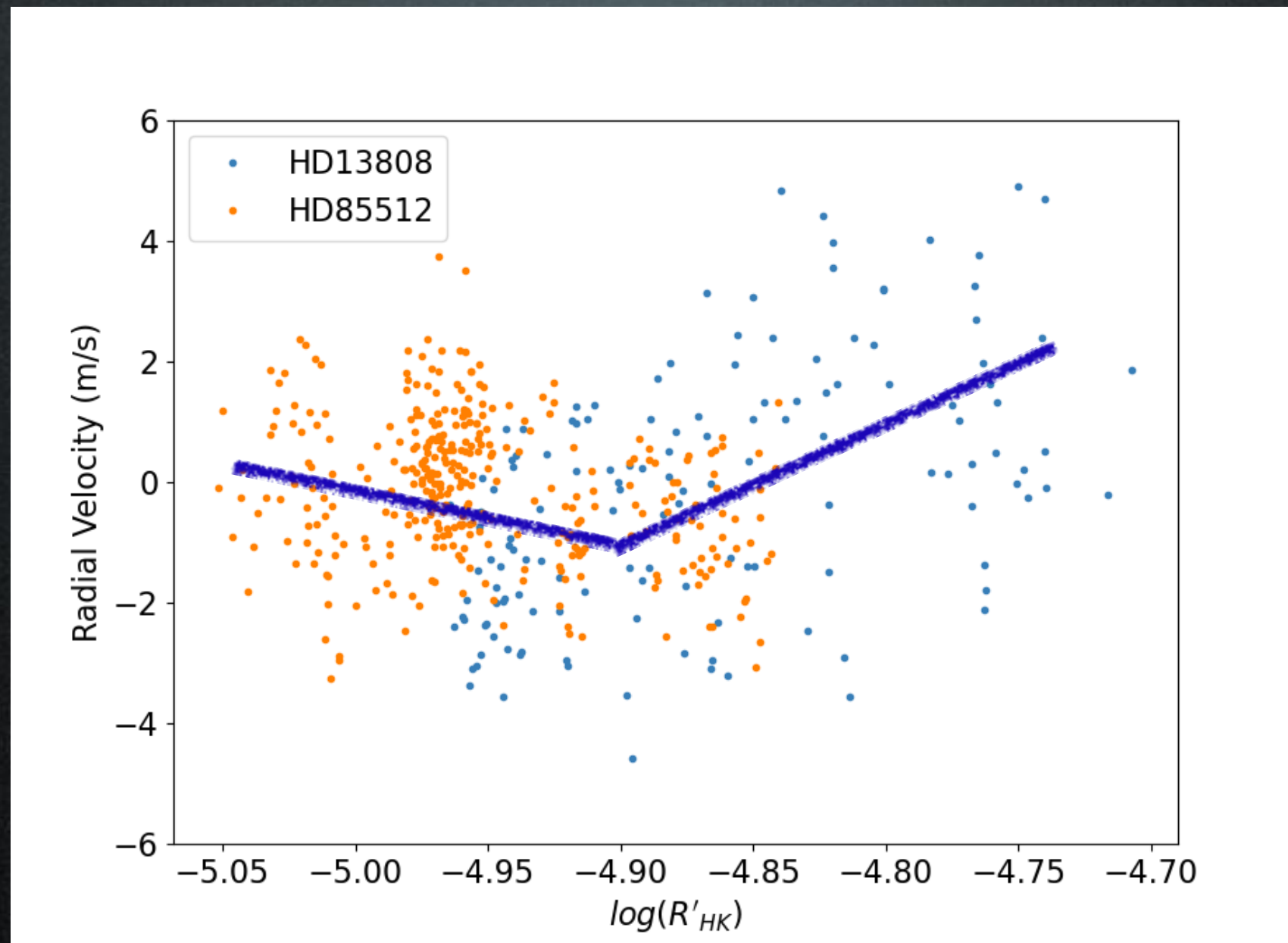
# Convective redshift suppression?



Costes et al. (2021)



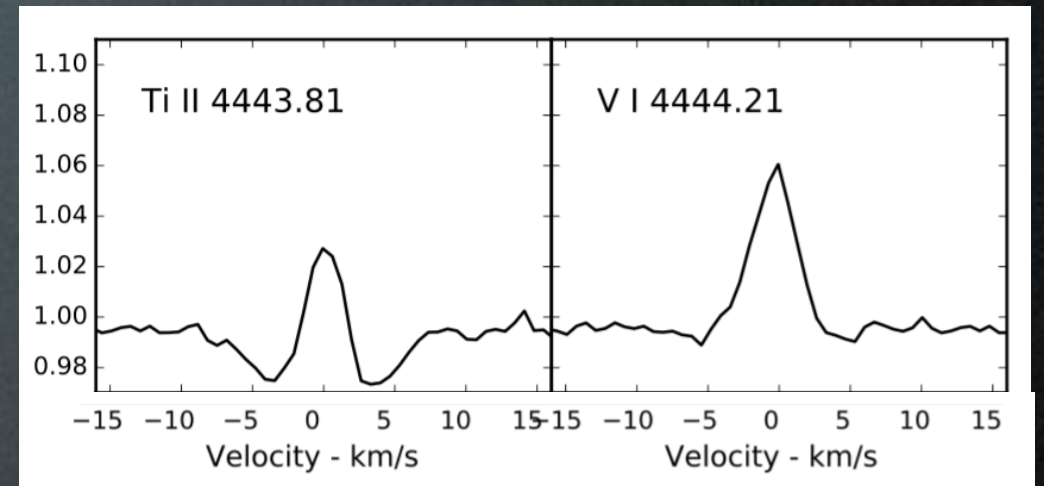
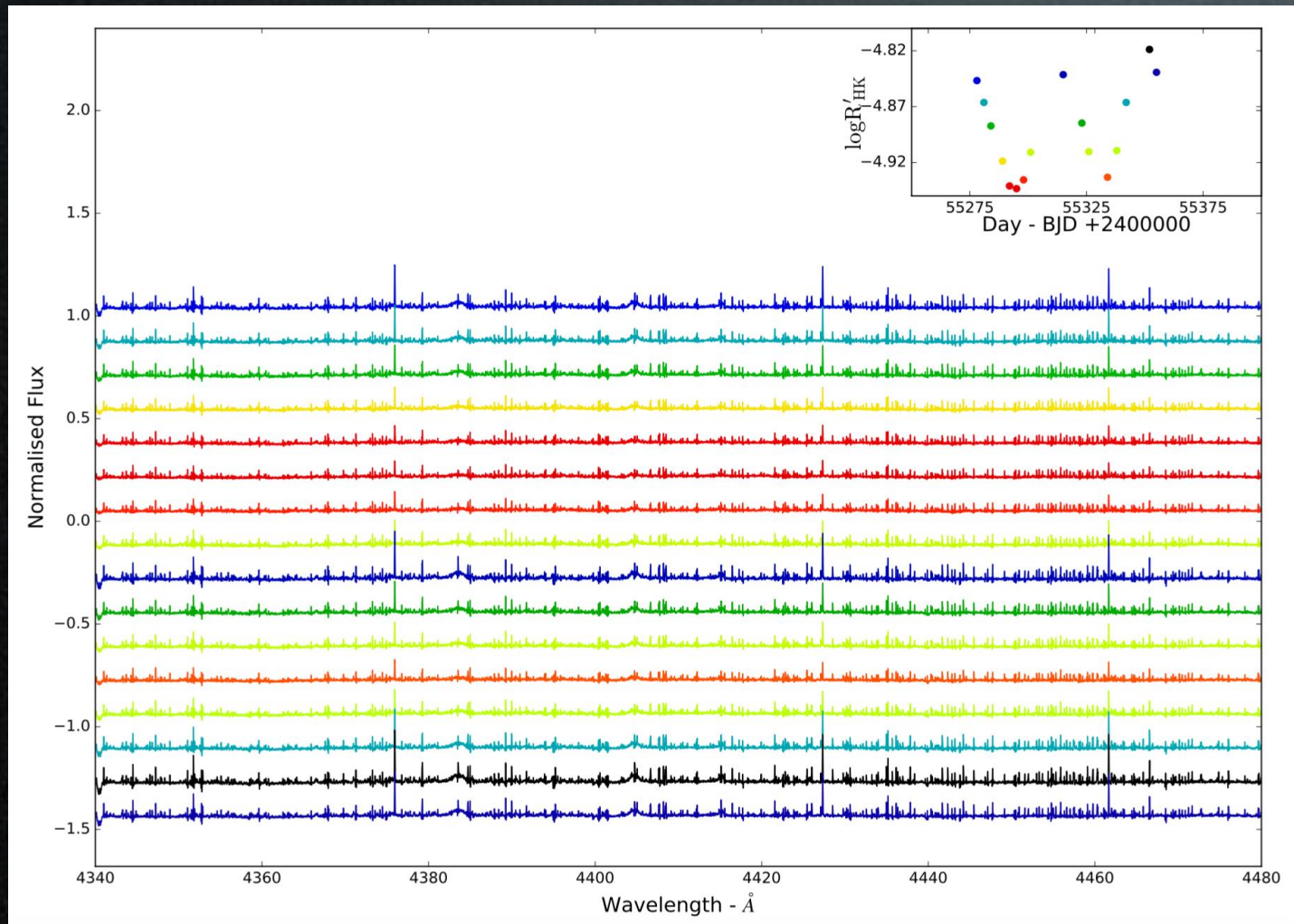
Is there a transition?



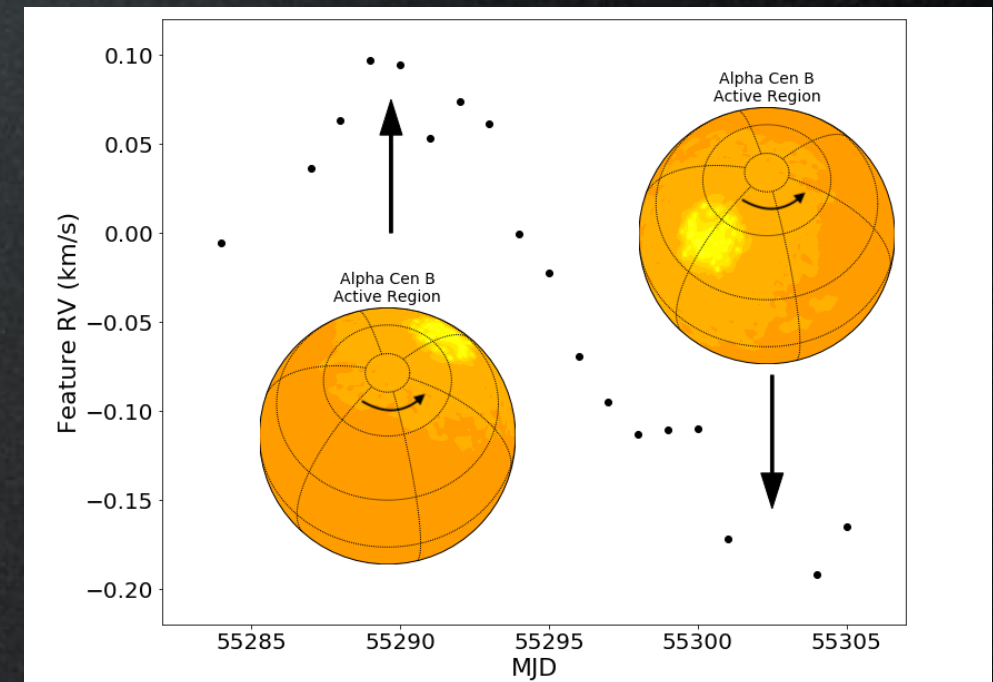
Can we explain this?



# Other constraints



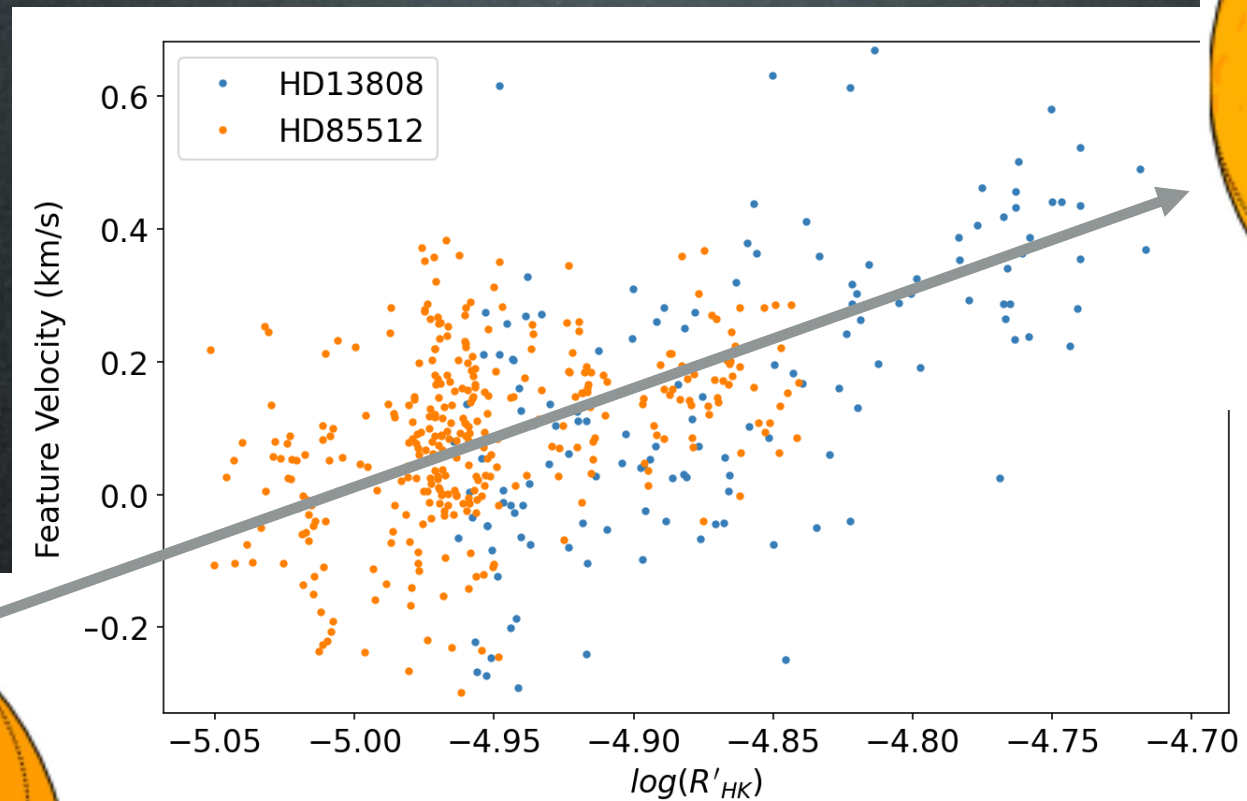
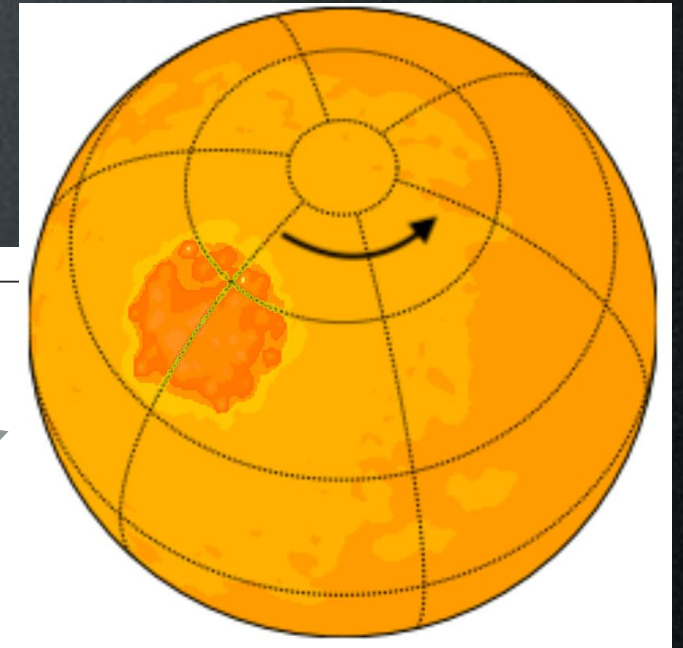
300 m/s



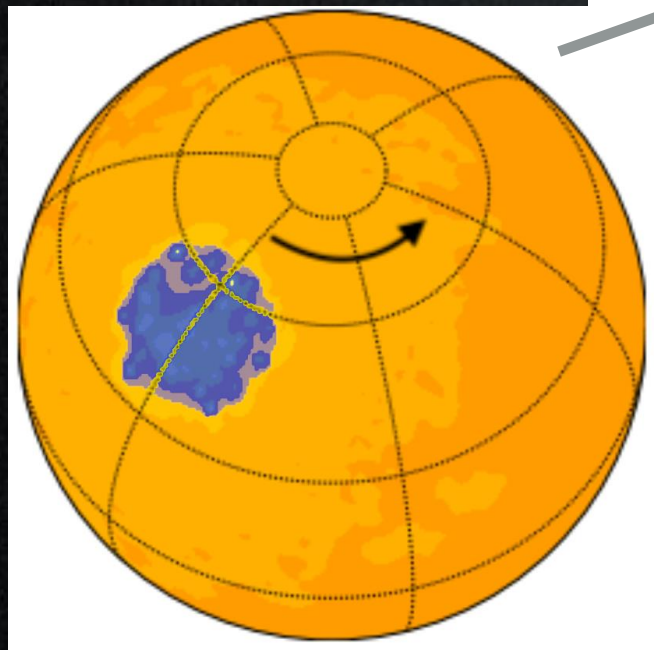
A. Thompson et al. (2017)



# ~~Convective redshift~~ ~~suppression?~~

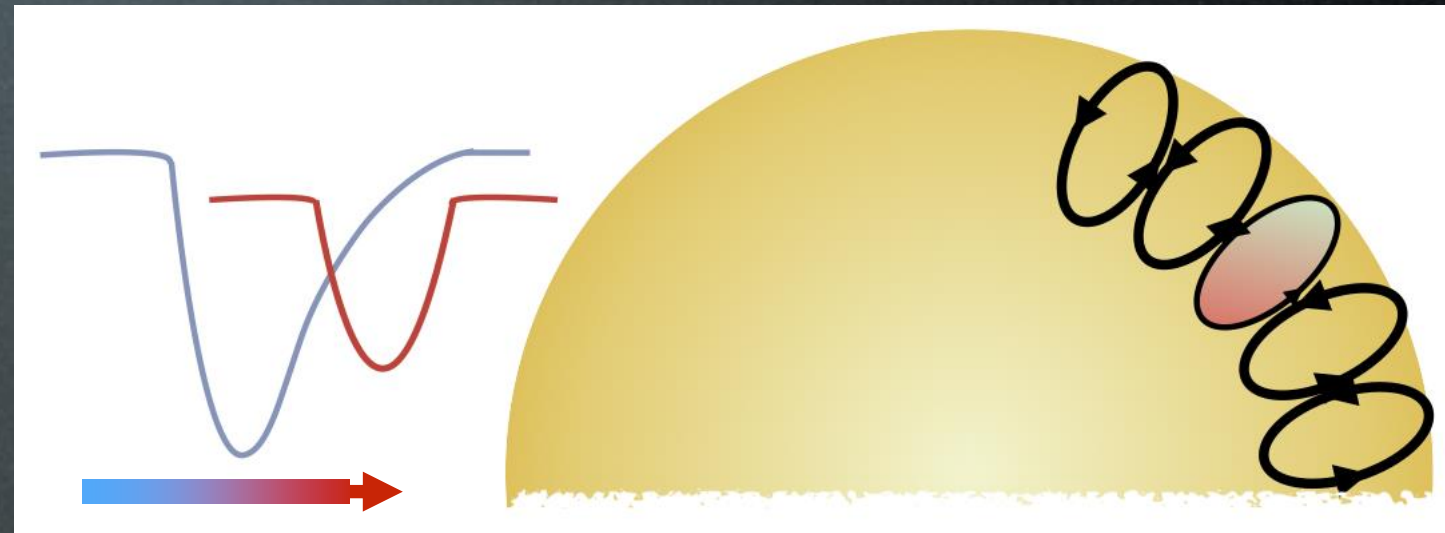
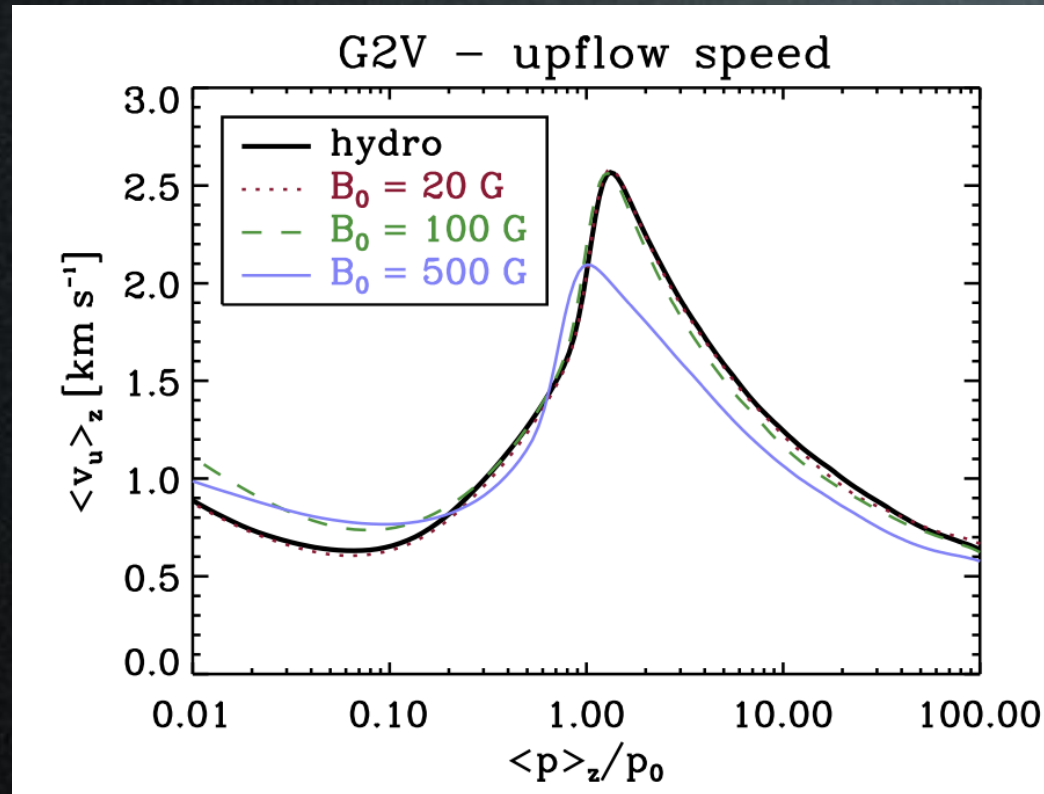


'Quiet'



'less quiet'

# Toy model: flow velocities



## Three-dimensional simulations of near-surface convection in main-sequence stars

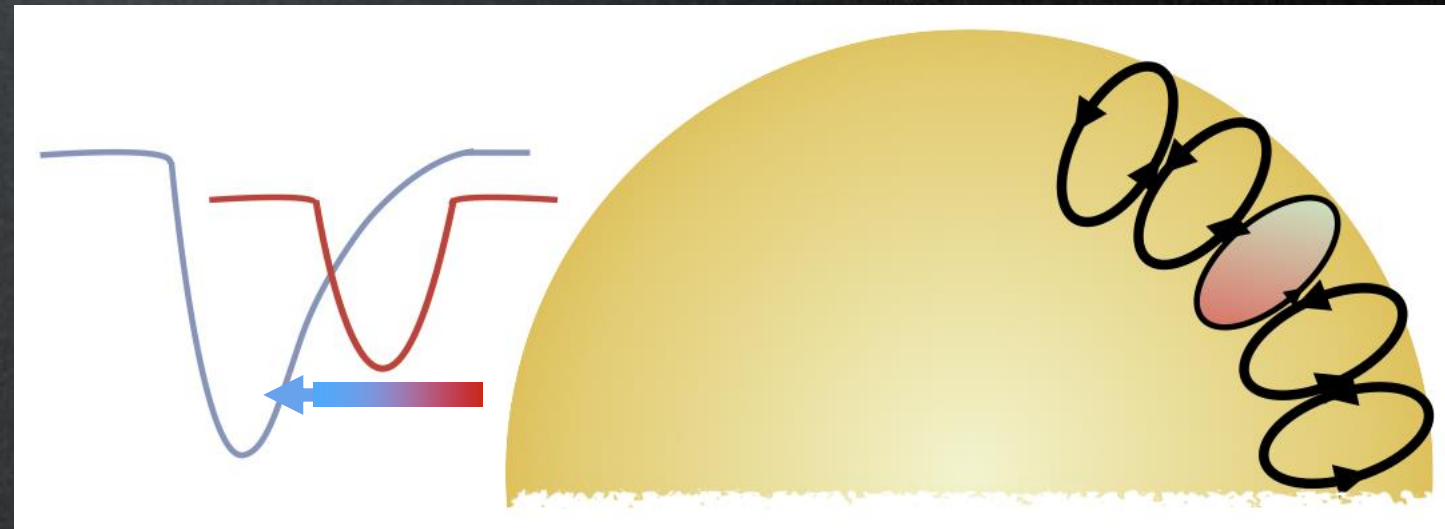
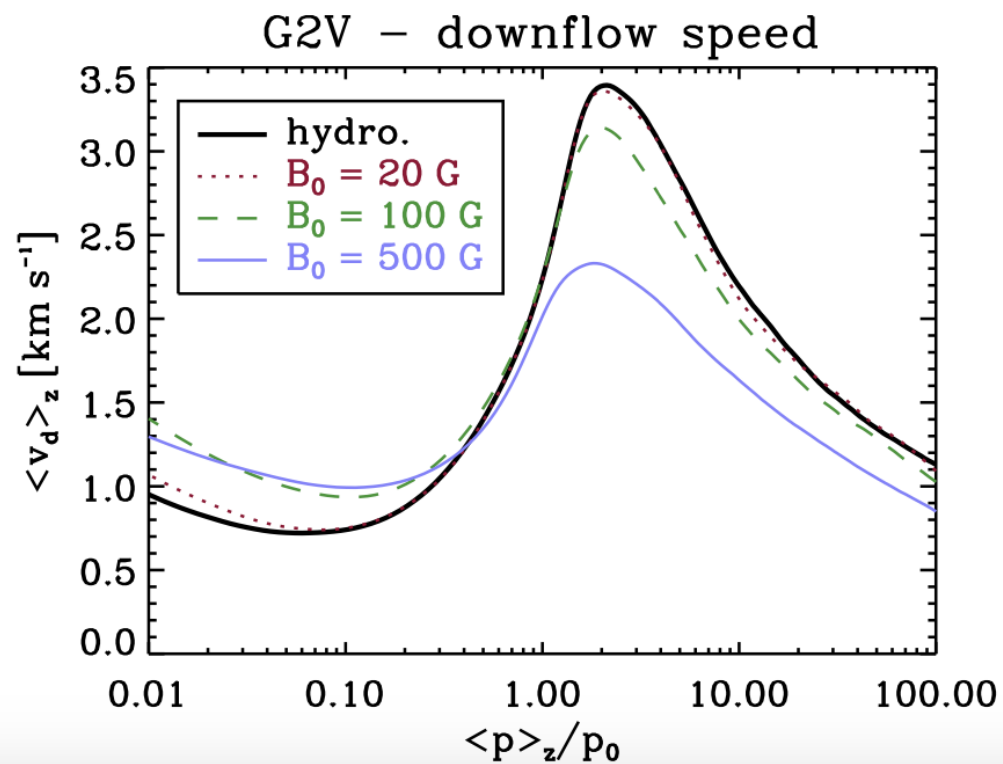
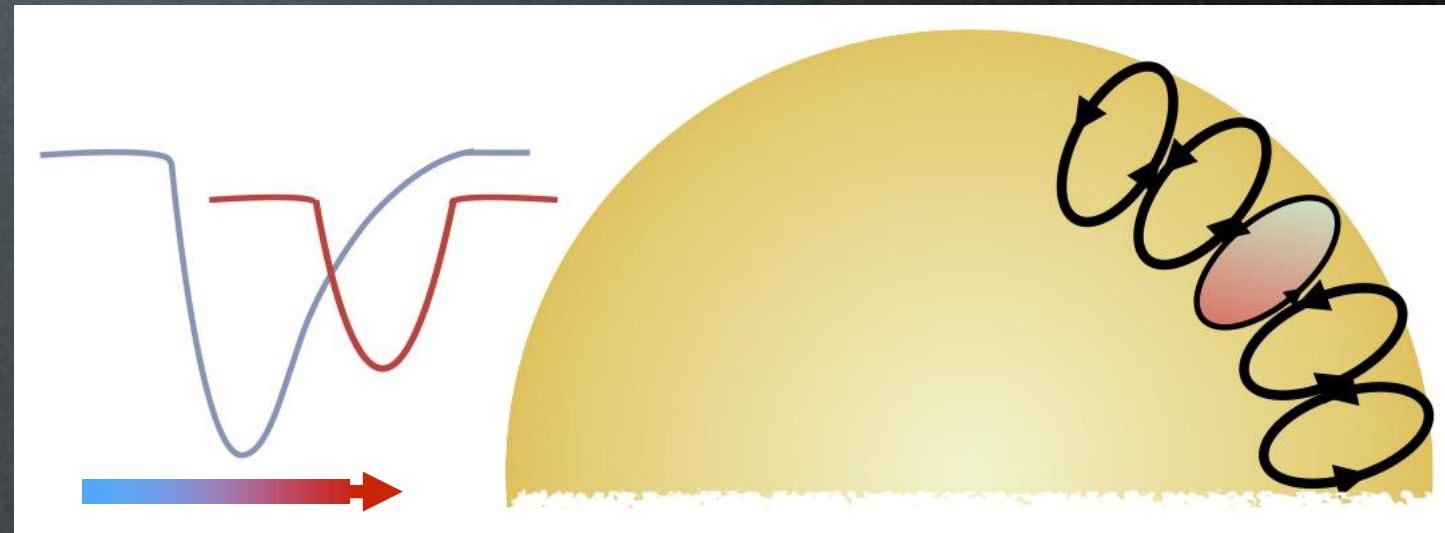
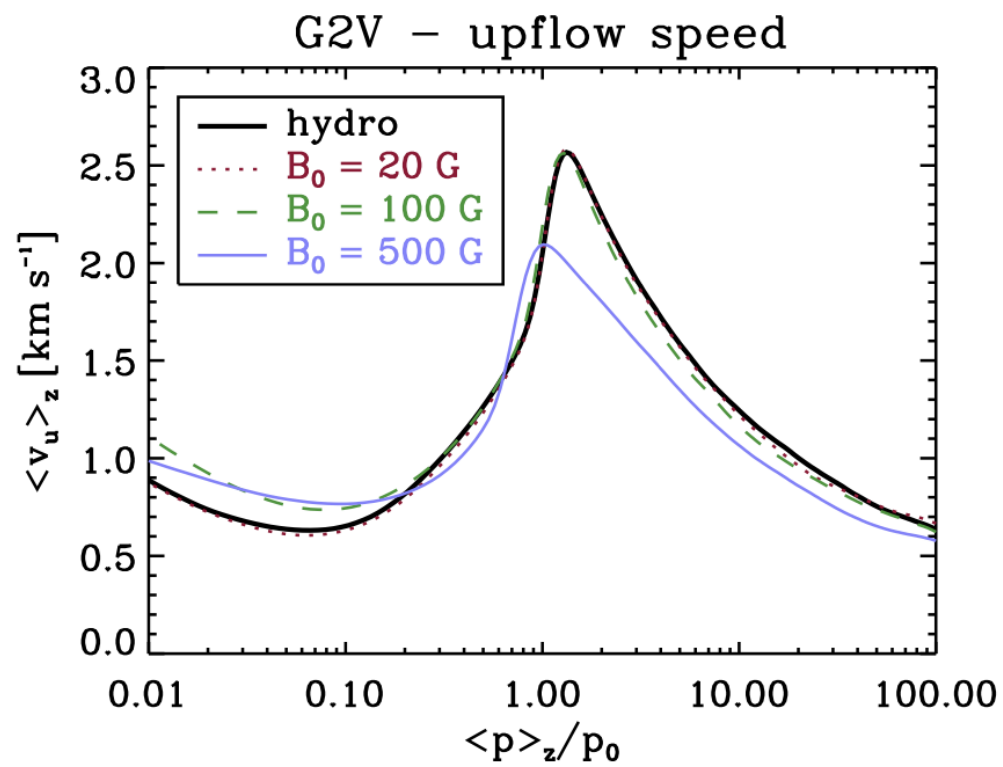
### III. The structure of small-scale magnetic flux concentrations

B. Beeck<sup>1</sup>, M. Schüssler<sup>1</sup>, R. H. Cameron<sup>1</sup>, and A. Reiners<sup>2</sup>

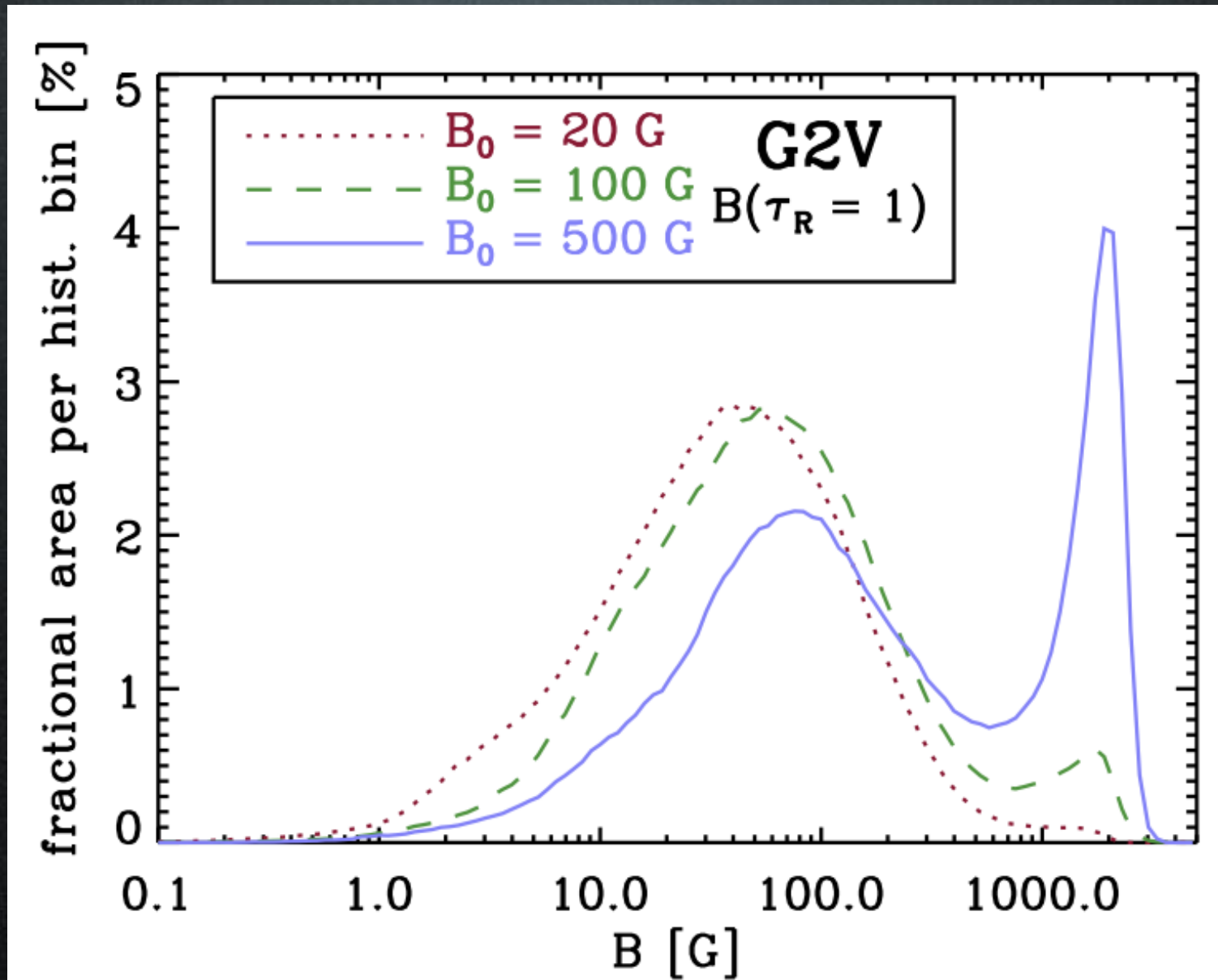
2015



# Toy model: flow velocities



# Toy model: Filling factors





# Toy model

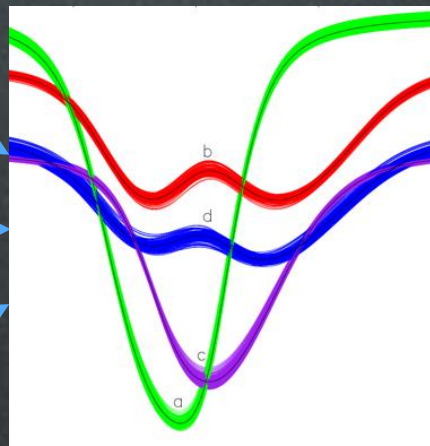
## Outputs

### Changey things

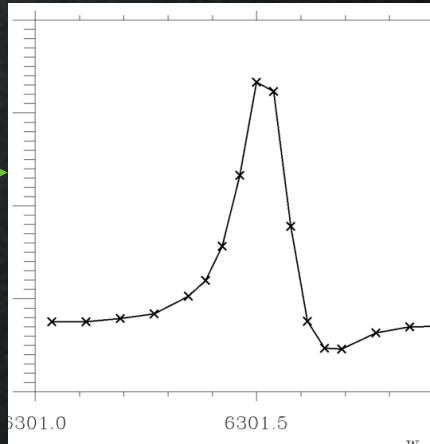
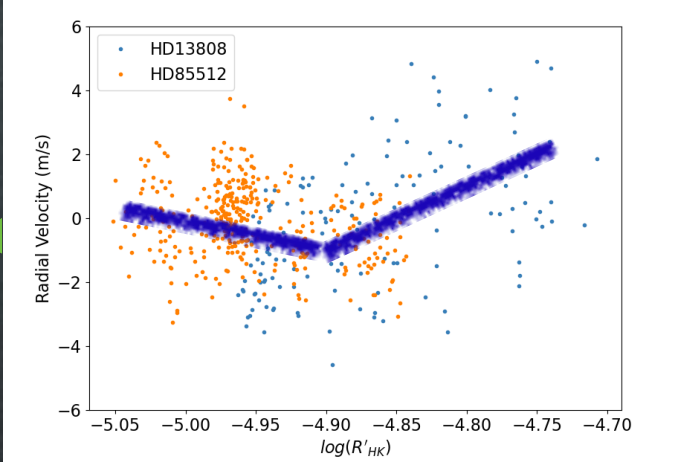
1: Flow velocities

2: Filling factors

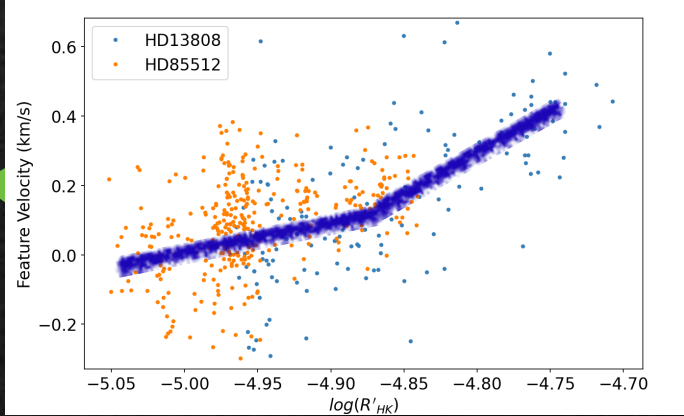
3: Both (MHD led)



RVs



line shape





# Toy model

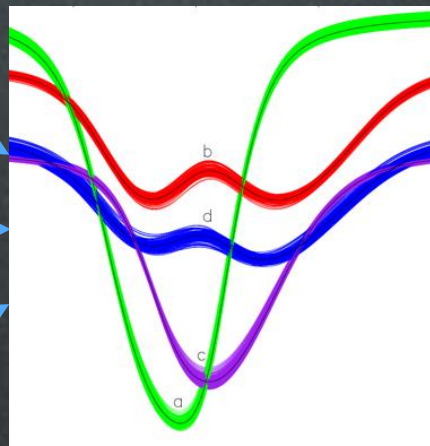
## Outputs

### Changey things

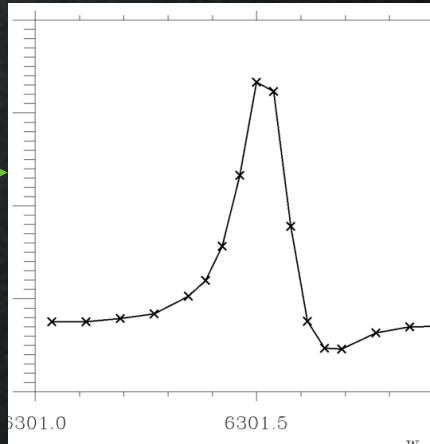
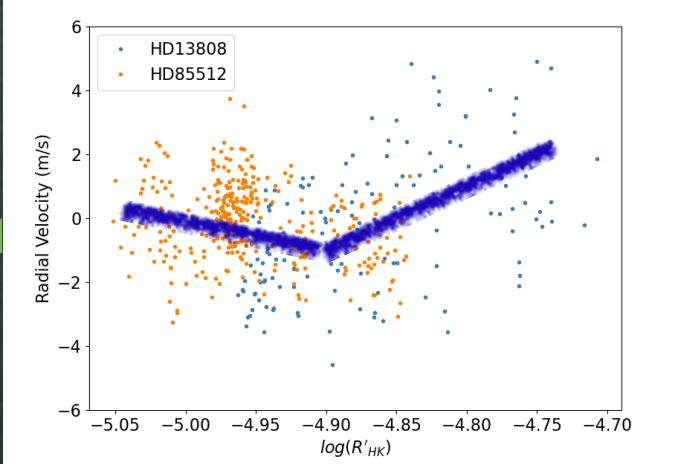
1: Flow velocities

2: Filling factors

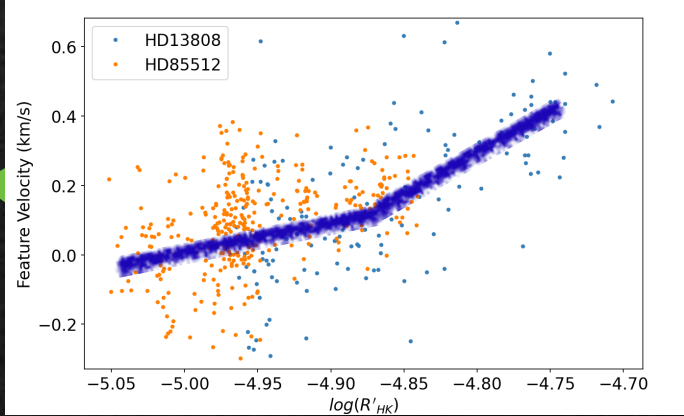
3: Both (MHD led)



RVs



line shape





# Toy model

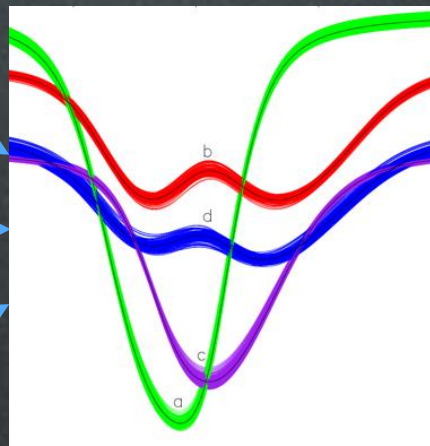
## Outputs

### Changey things

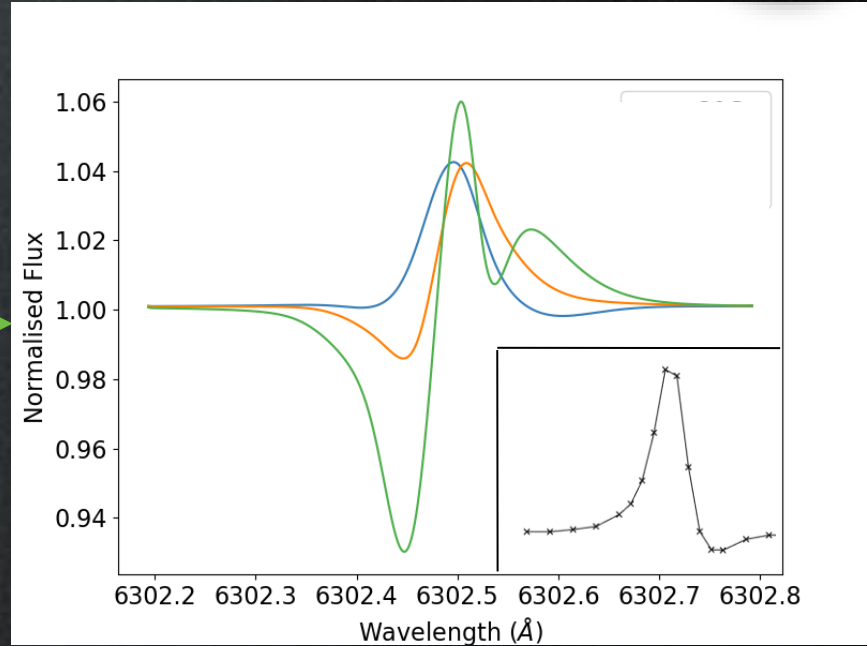
1: Flow velocities

2: Filling factors

3: Both (MHD led)



1: RVs 



2: Line shapes 



# Toy model

## Outputs

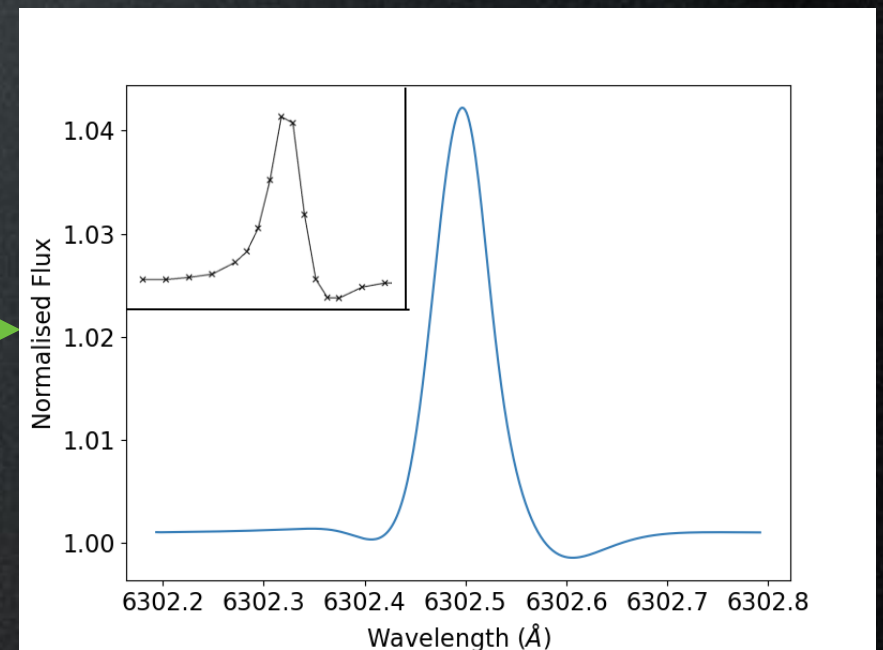
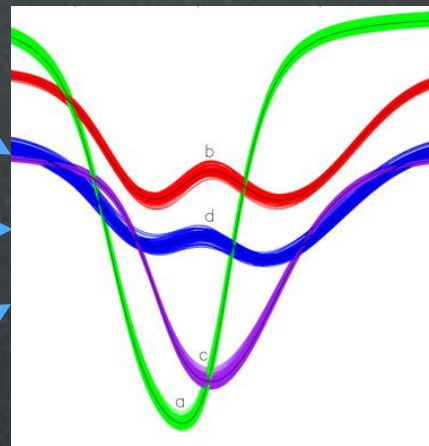
### Changey things

1: RVs 

1: Flow velocities

2: Filling factors

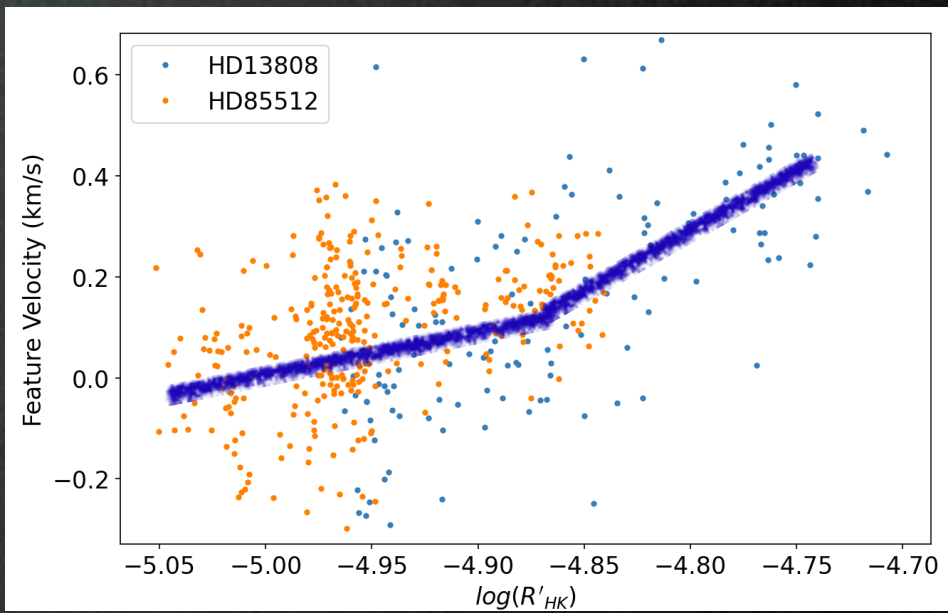
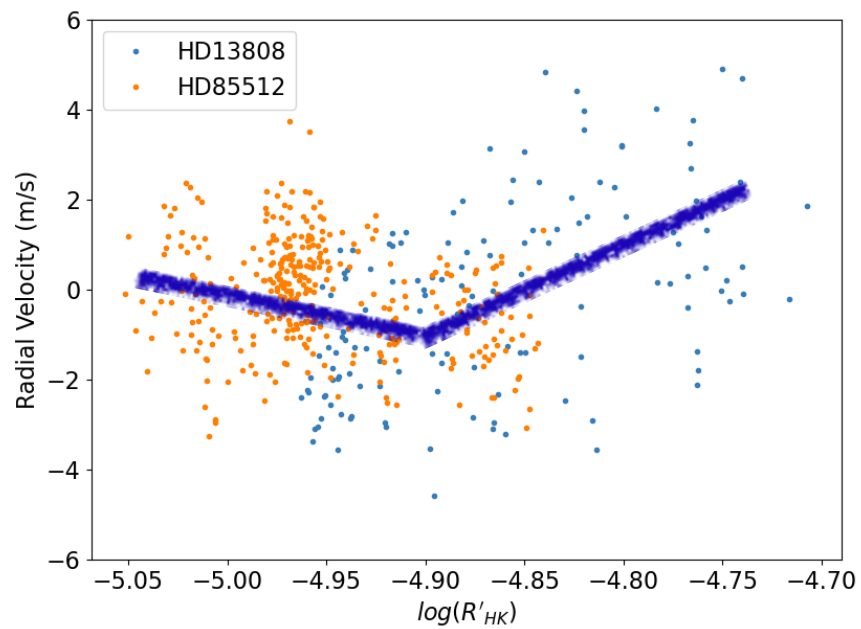
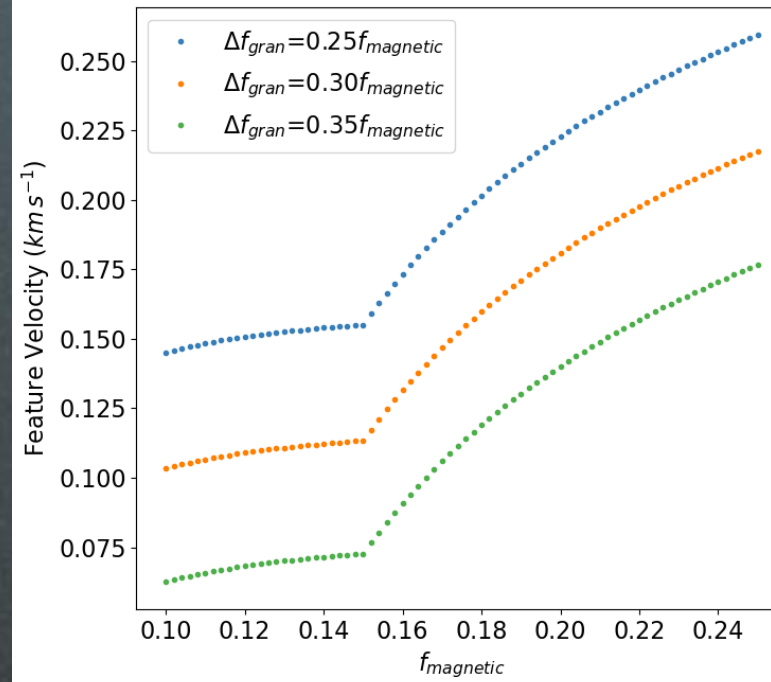
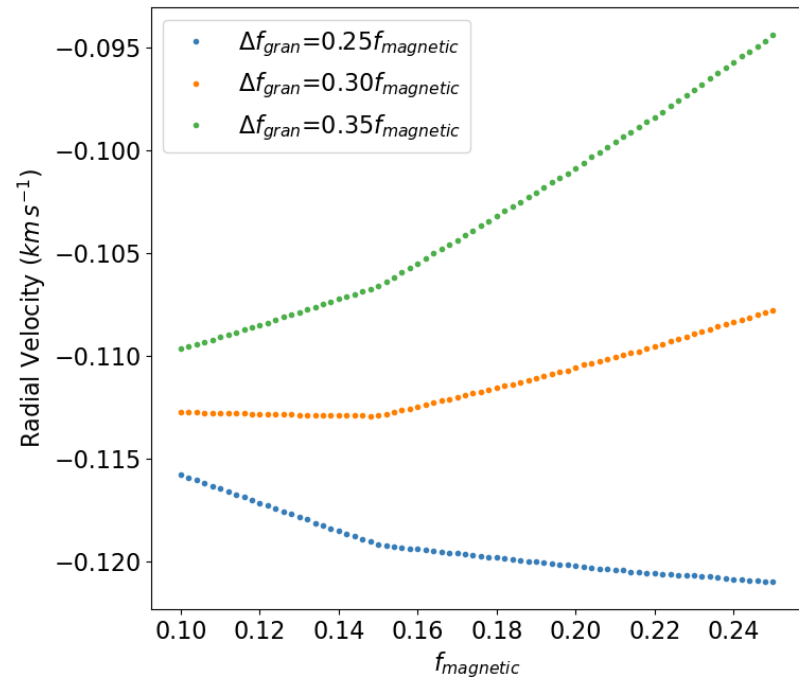
3: Both (MHD led)



2: Line shapes 



# Preliminary results



# Conclusions

evidence for 'convective redshift suppression' like eff

entative evidence for behaviour transition in quiet s

3. Could be explained by...

ially, enhanced mag field primarily alters filling fa

activity increases, then convective blueshift affect

Caveat:

MHD models may be critical here!

This could all be total rubbish...

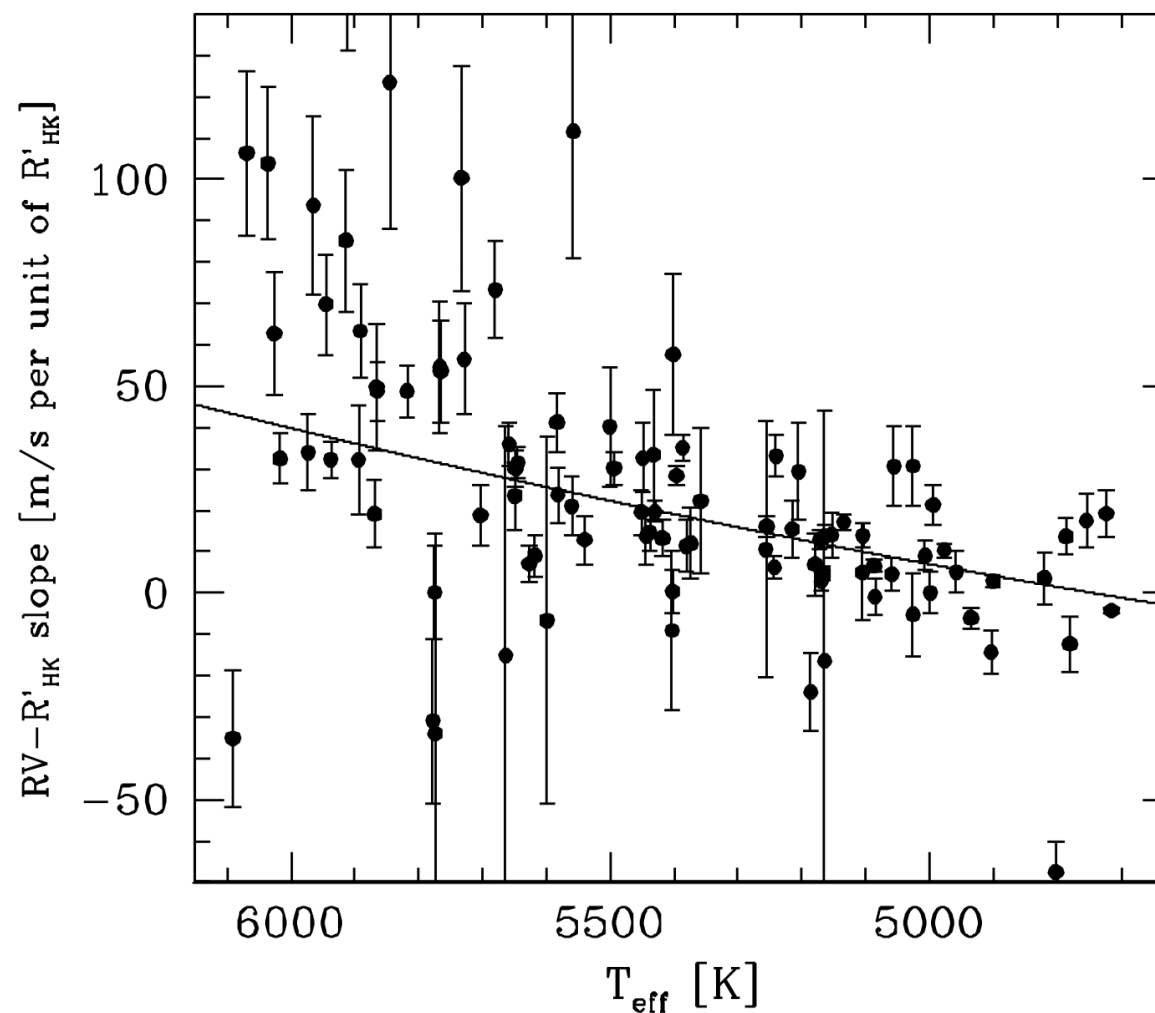


# Signs of convective redshift?

## The HARPS search for southern extra-solar planets<sup>★</sup>

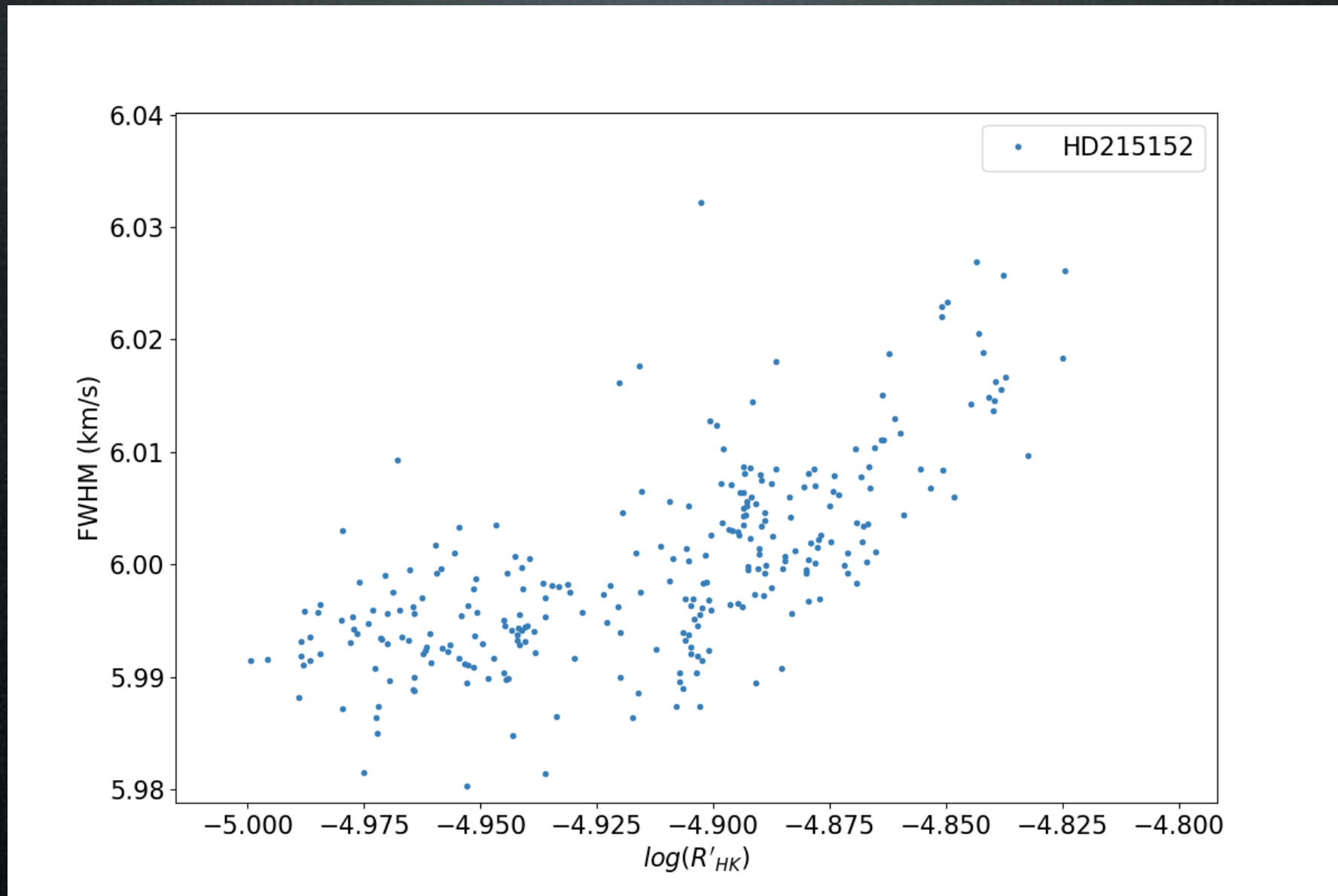
### XXXI. Magnetic activity cycles in solar-type stars: statistics and impact on precise radial velocities

C. Lovis<sup>1</sup>, X. Dumusque<sup>1,2</sup>, N. C. Santos<sup>2,3,1</sup>, F. Bouchy<sup>4,5</sup>, M. Mayor<sup>1</sup>, F. Pepe<sup>1</sup>, D. Queloz<sup>1</sup>,  
D. Ségransan<sup>1</sup>, and S. Udry<sup>1</sup>



astro-ph (2011)

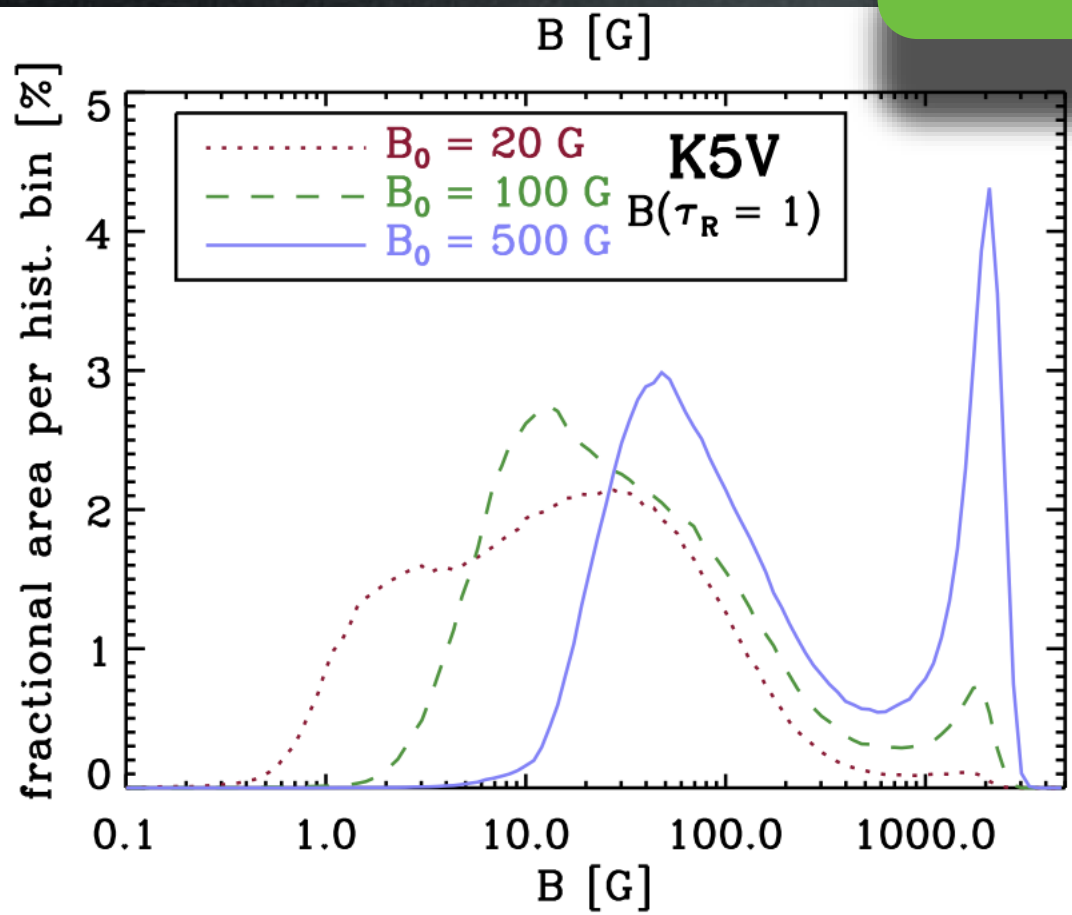
# Other evidence for 'transitions'





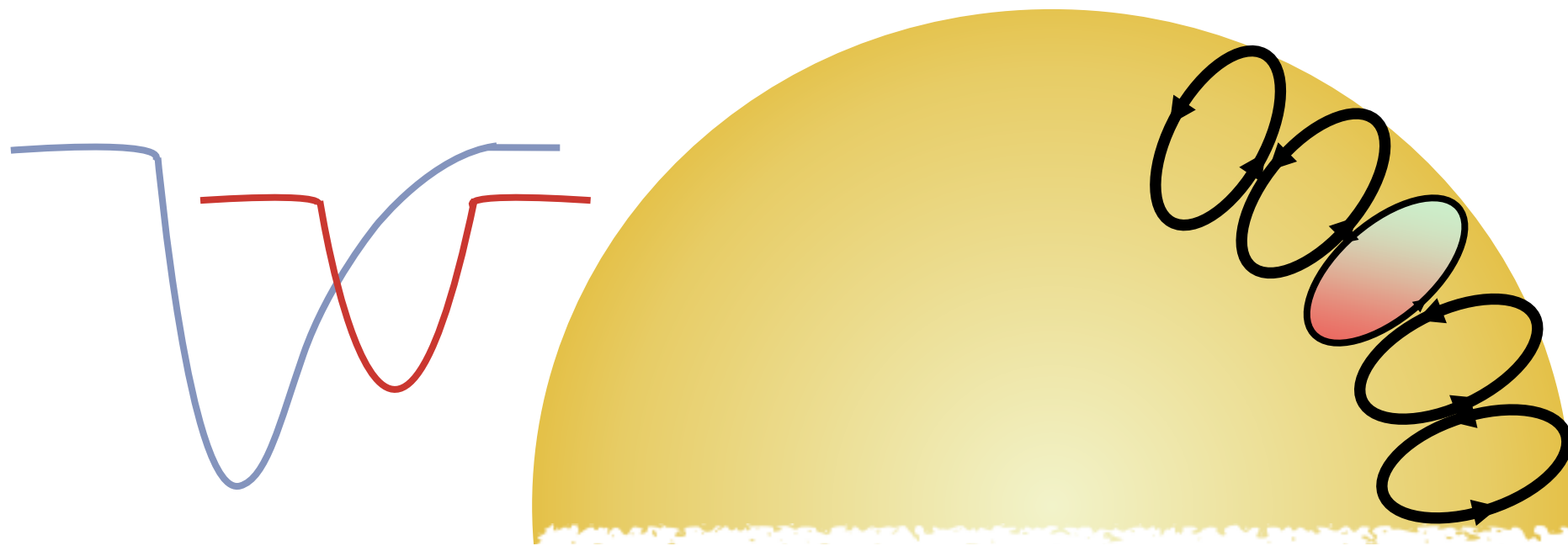
# Some title

1: RVs



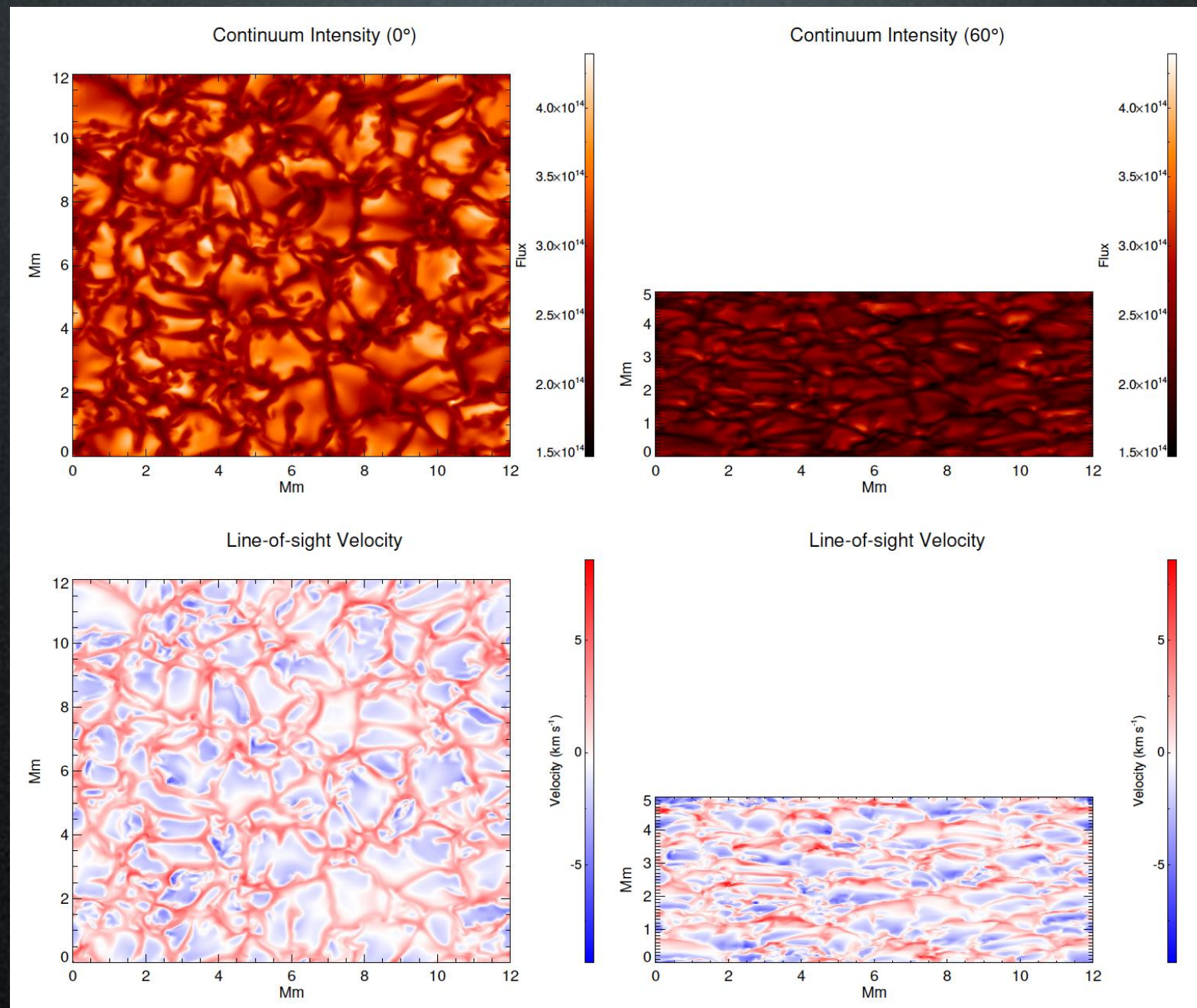
2: Line shapes

# Template





# Stellar lines are complex





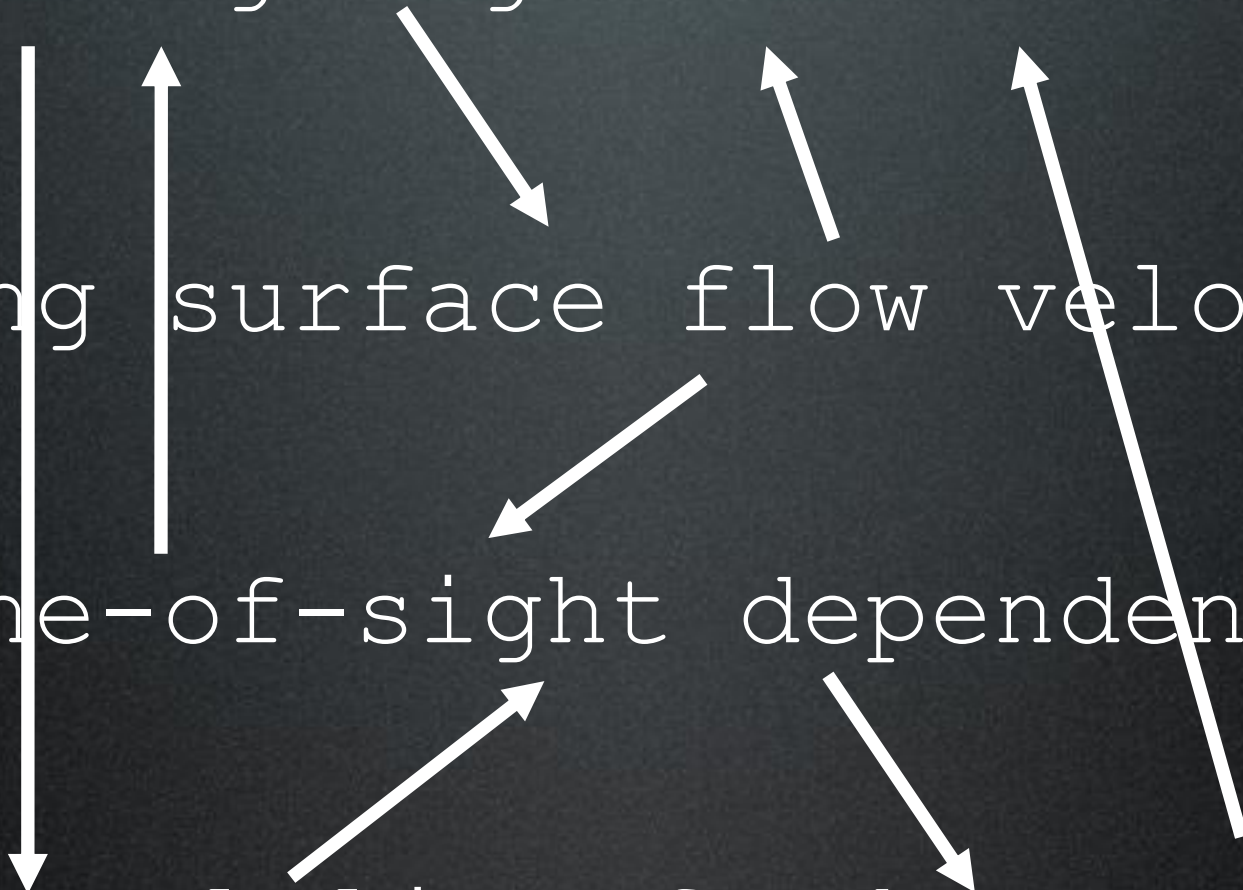
Everything is  
related!

Evolving magnetic fields

Varying surface flow velocities

Line-of-sight dependencies

Varying spectral line fundamental parameters





# Everything is related!



Evolving magnetic field

Varying surface flow velocities

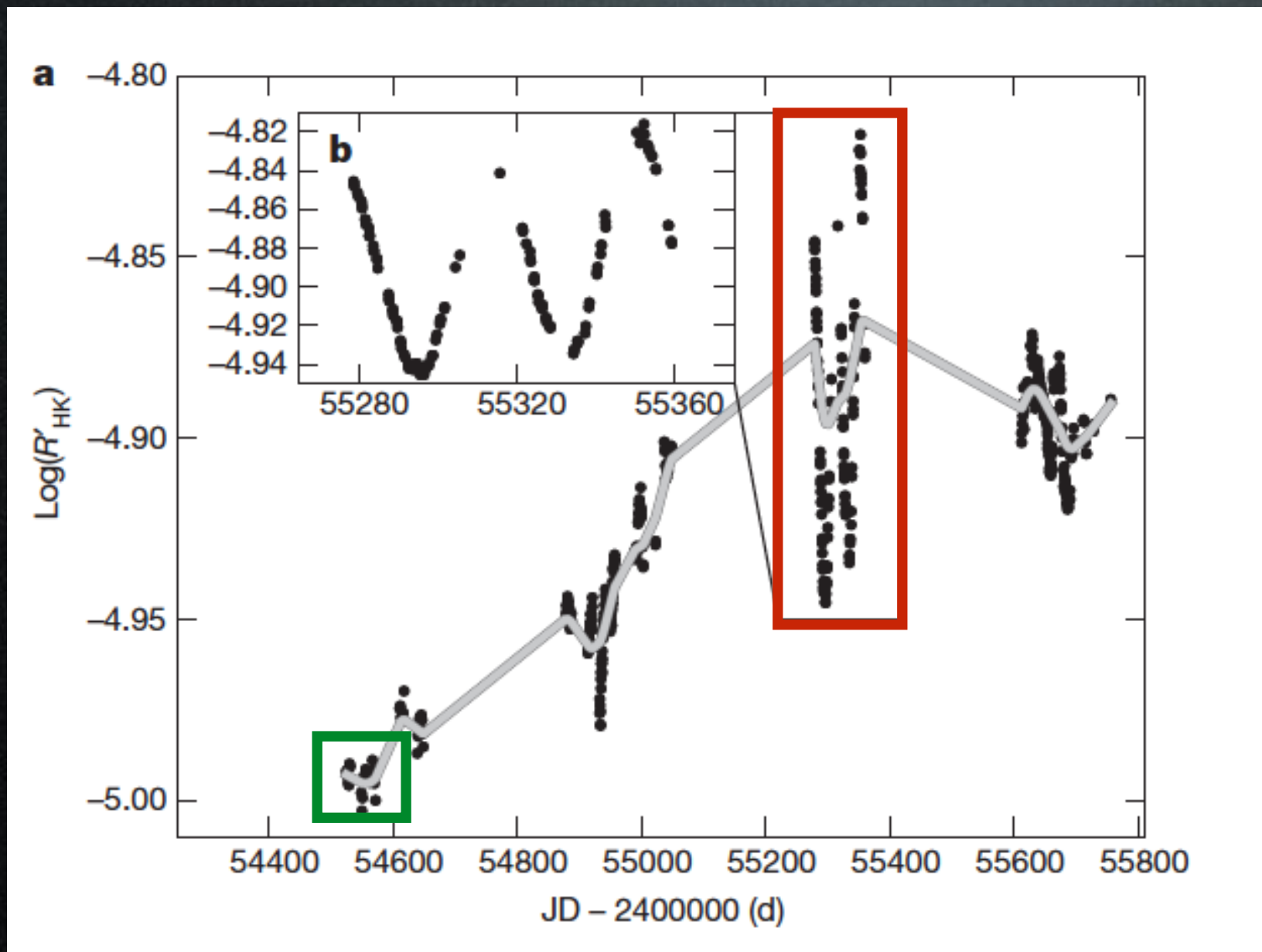
Line-of-sight dependencies

Varying spectral line fundamental parameters

Then set it all spinning.



# alpha Centauri B



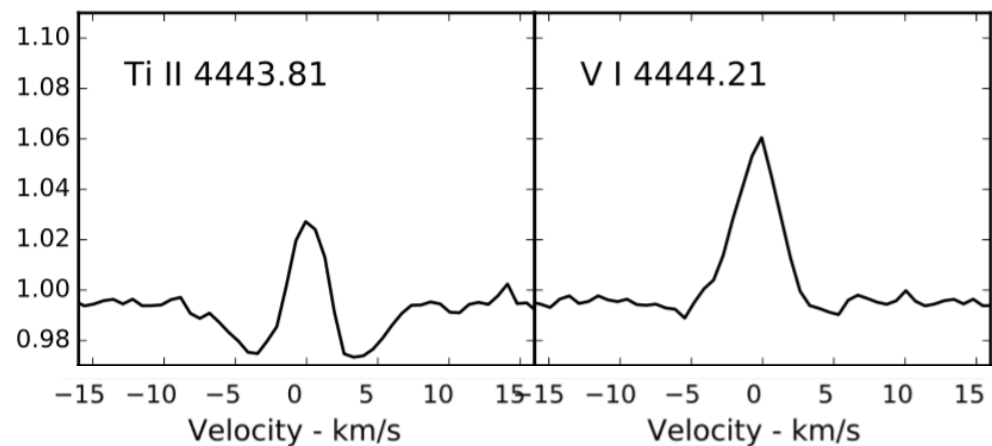
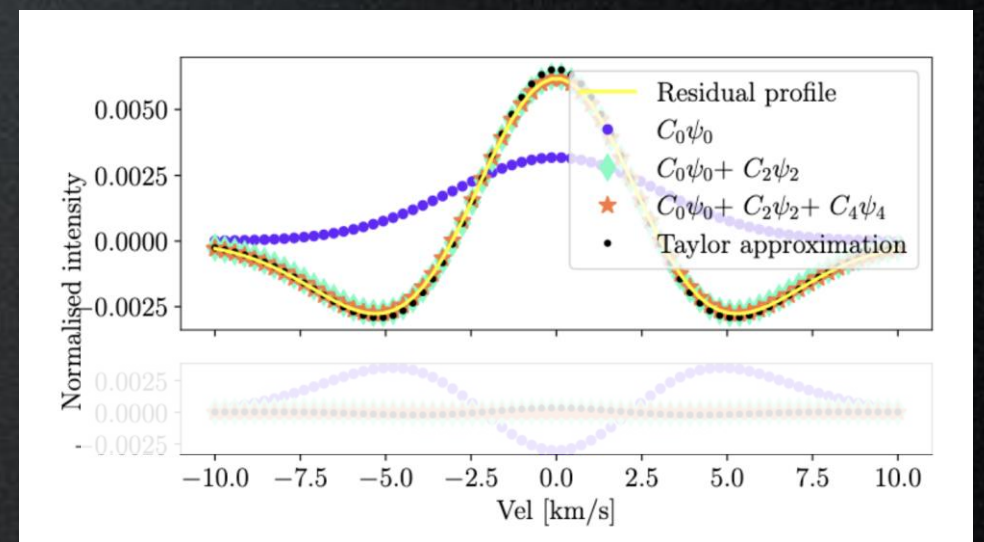
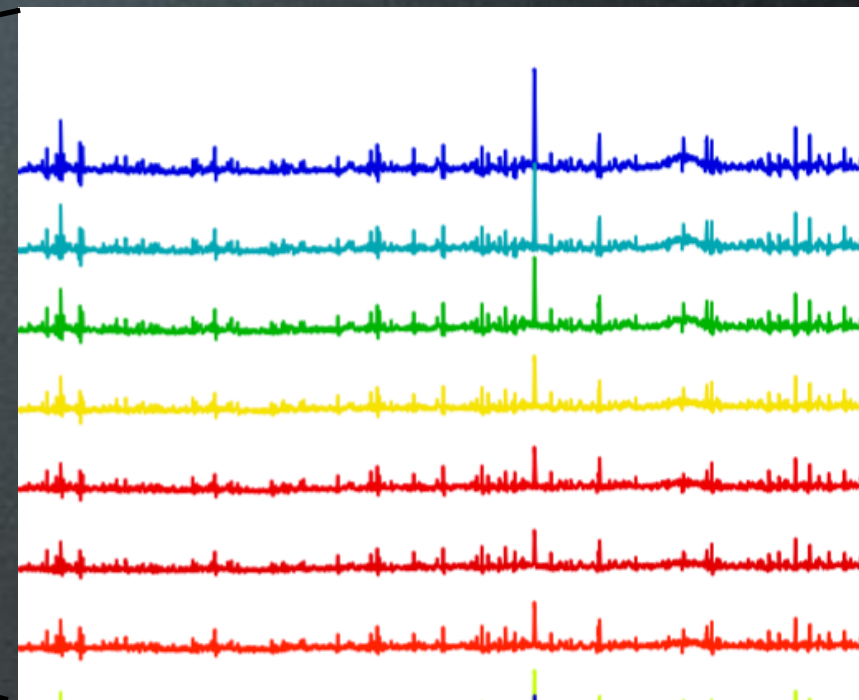
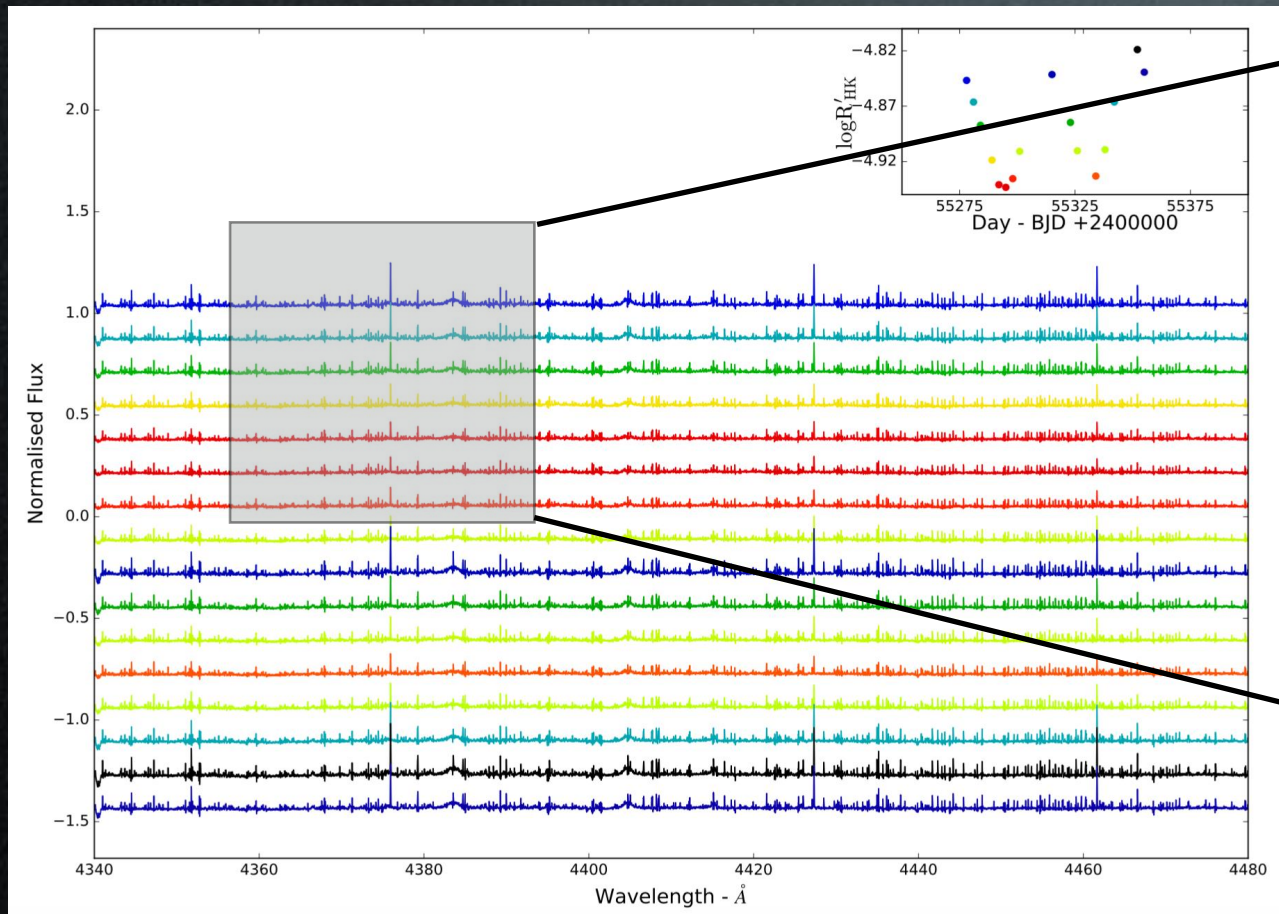
Active  
-----  
Inactive

A. Thompson et al. (2017)



# alpha Centauri B

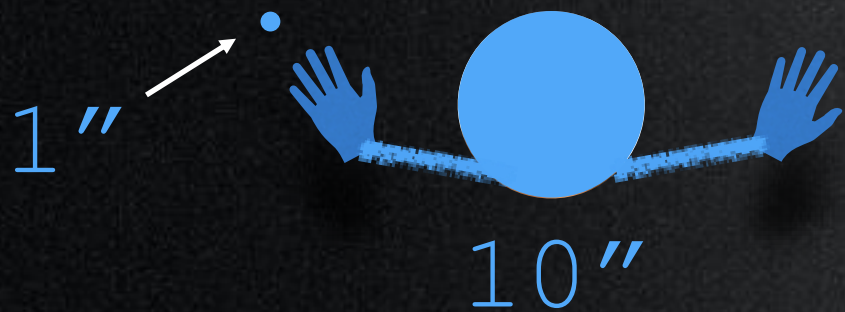
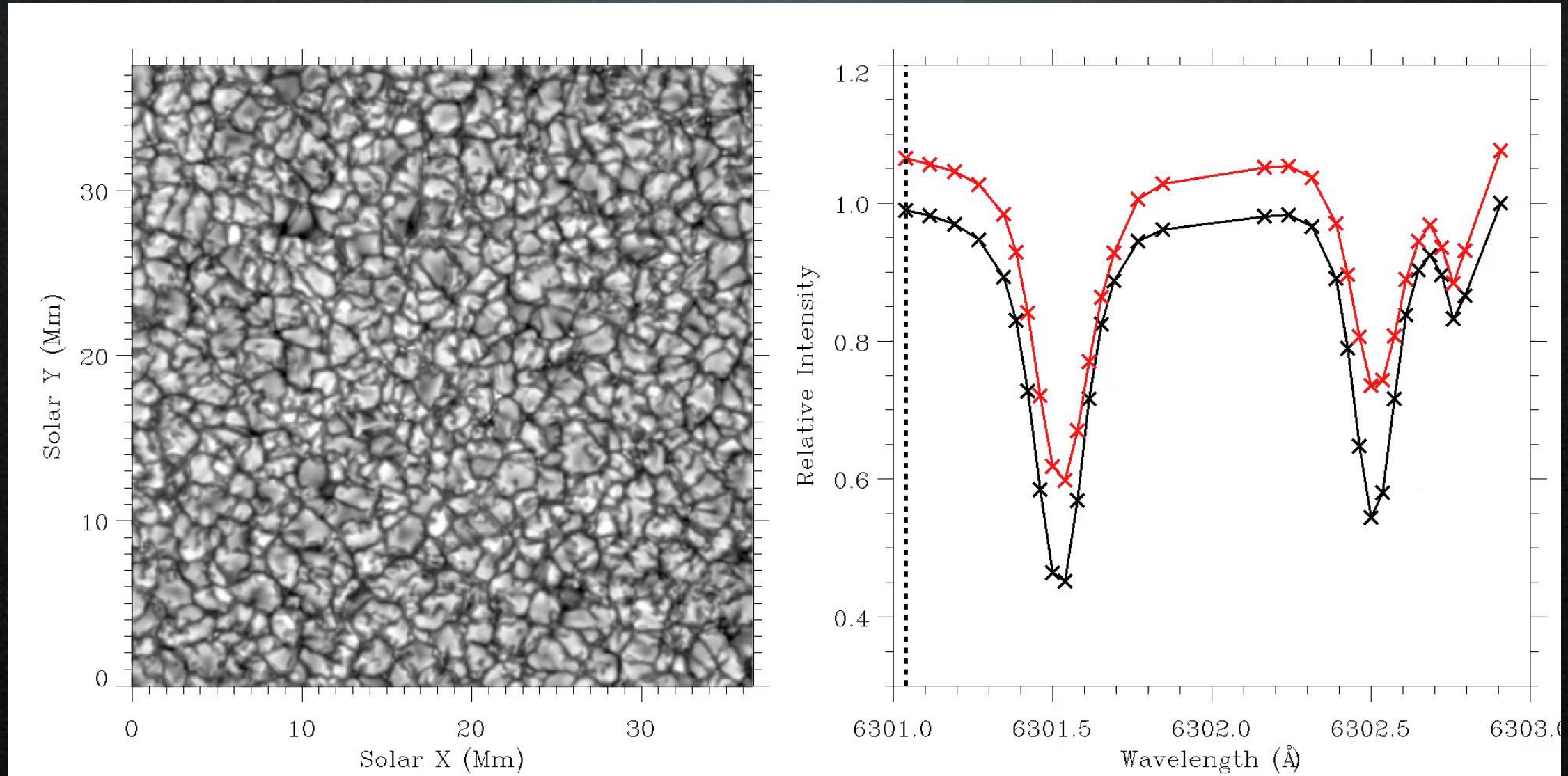
A. Thompson et al. (2017)



Leinhard et al. (under review)



# Clues from the Sun





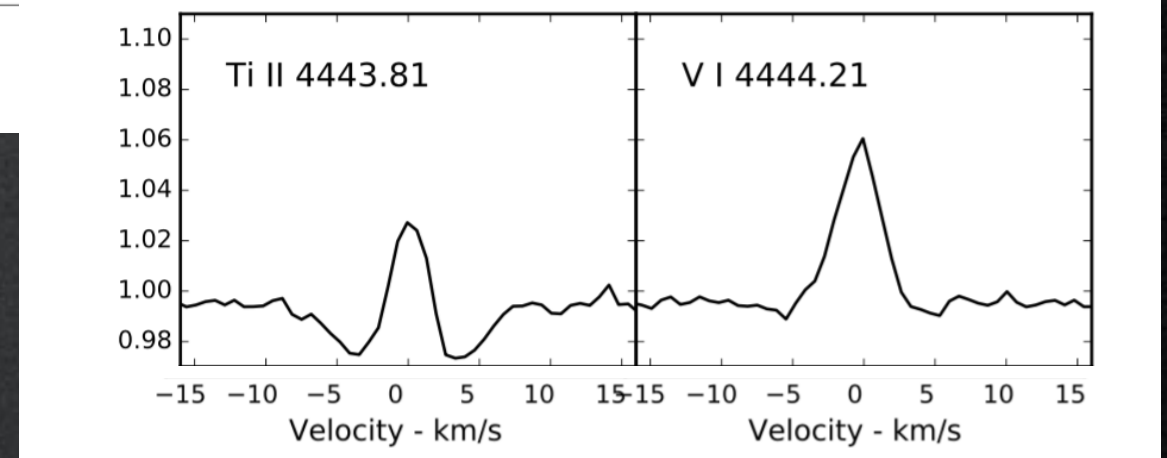
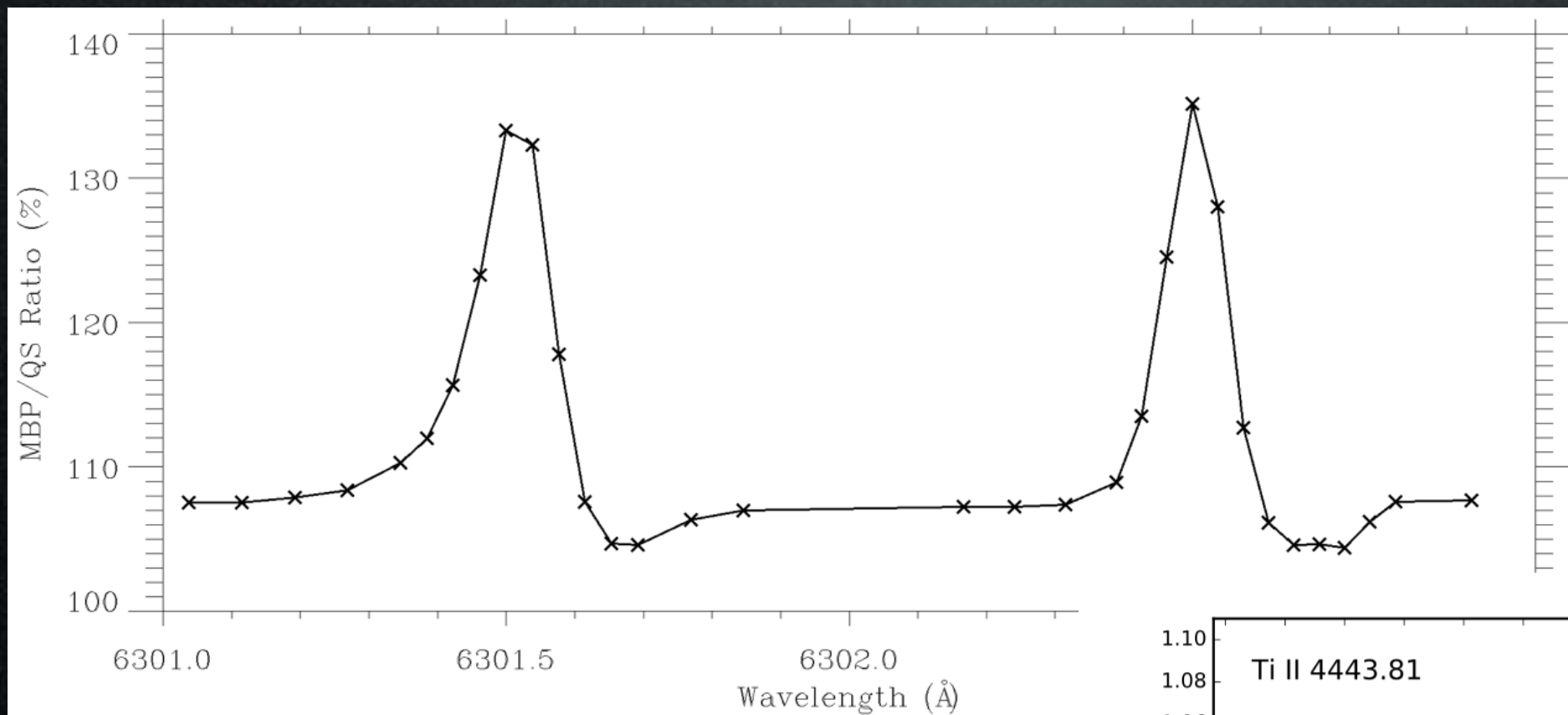
# Clues from the Sun

51,118 Magnetic Bright Point spectra (= 'active' region)

66,500,000 (+ another 330) quiet Sun spectra

Active

Inactive



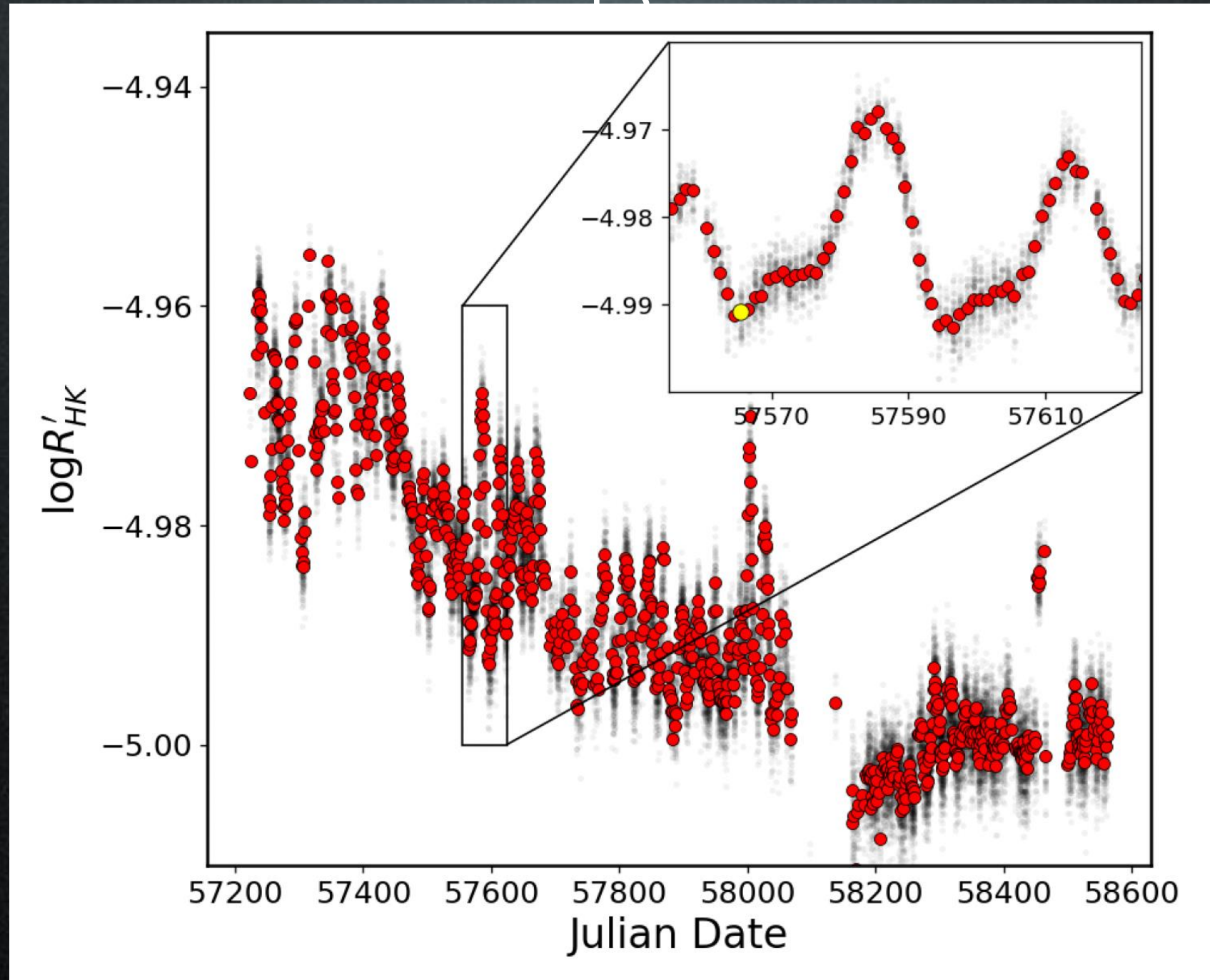
alpha Centauri B

D. Jackson et al. in prep



# The Sun as alpha Cen

B

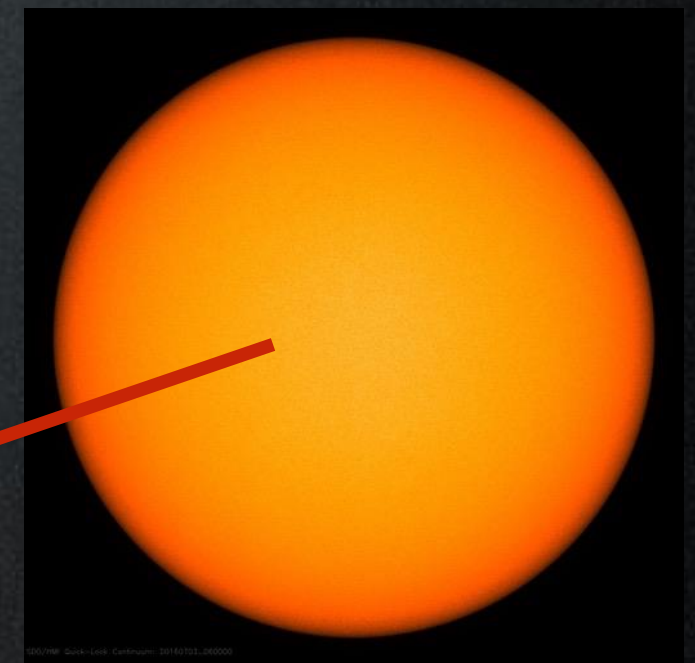
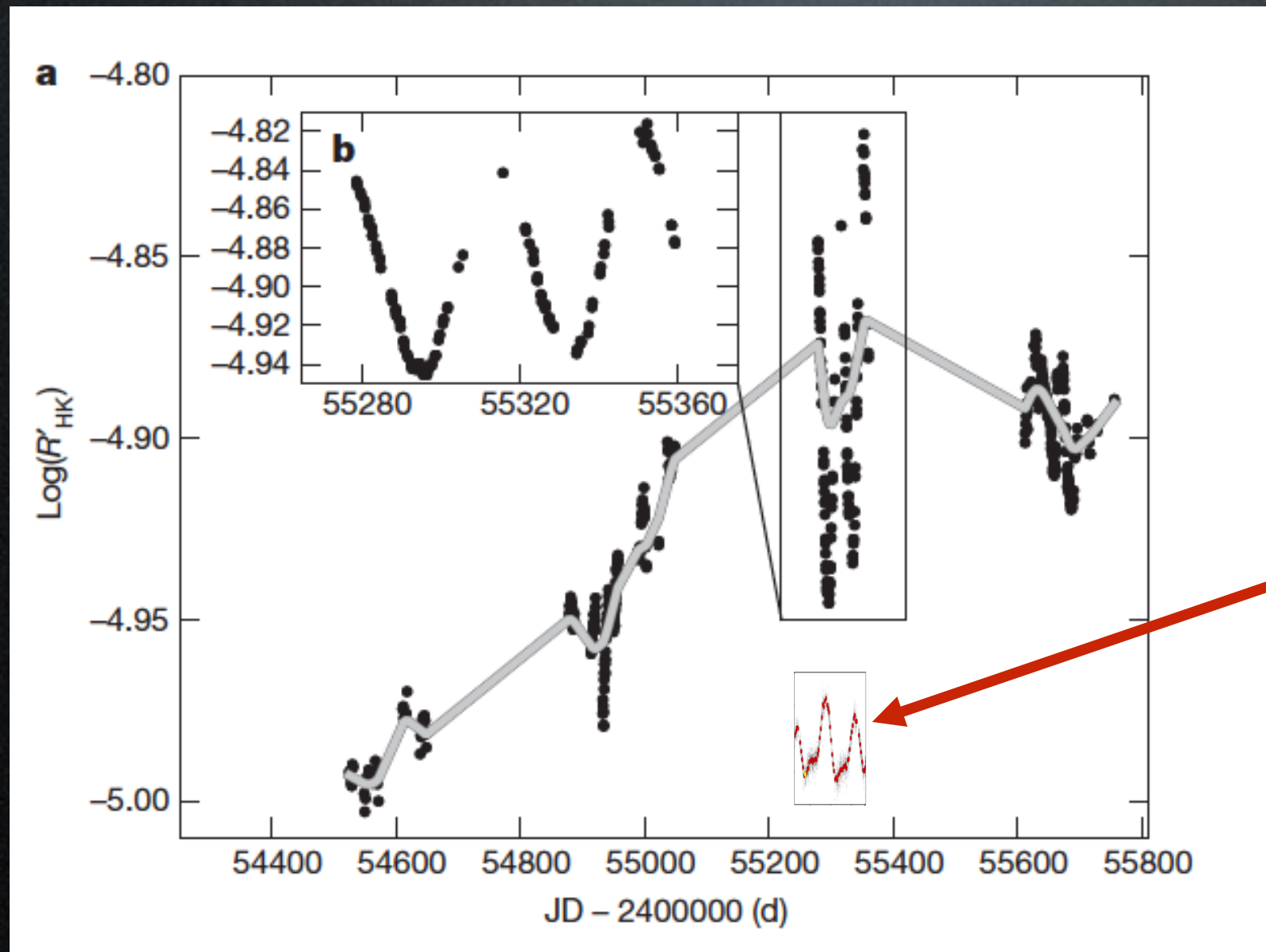


A. Thompson et al (2020)



# The Sun as alpha Cen

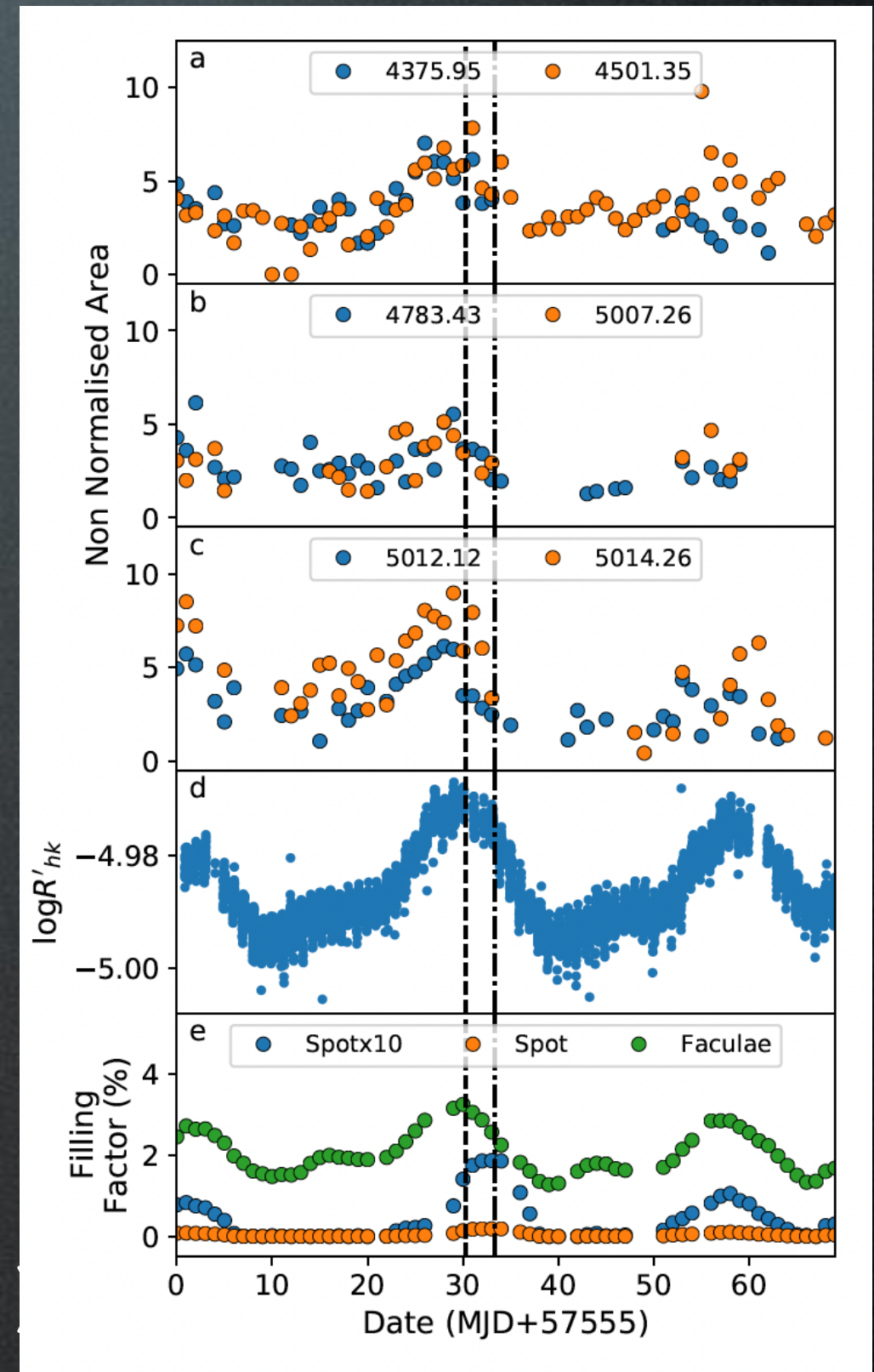
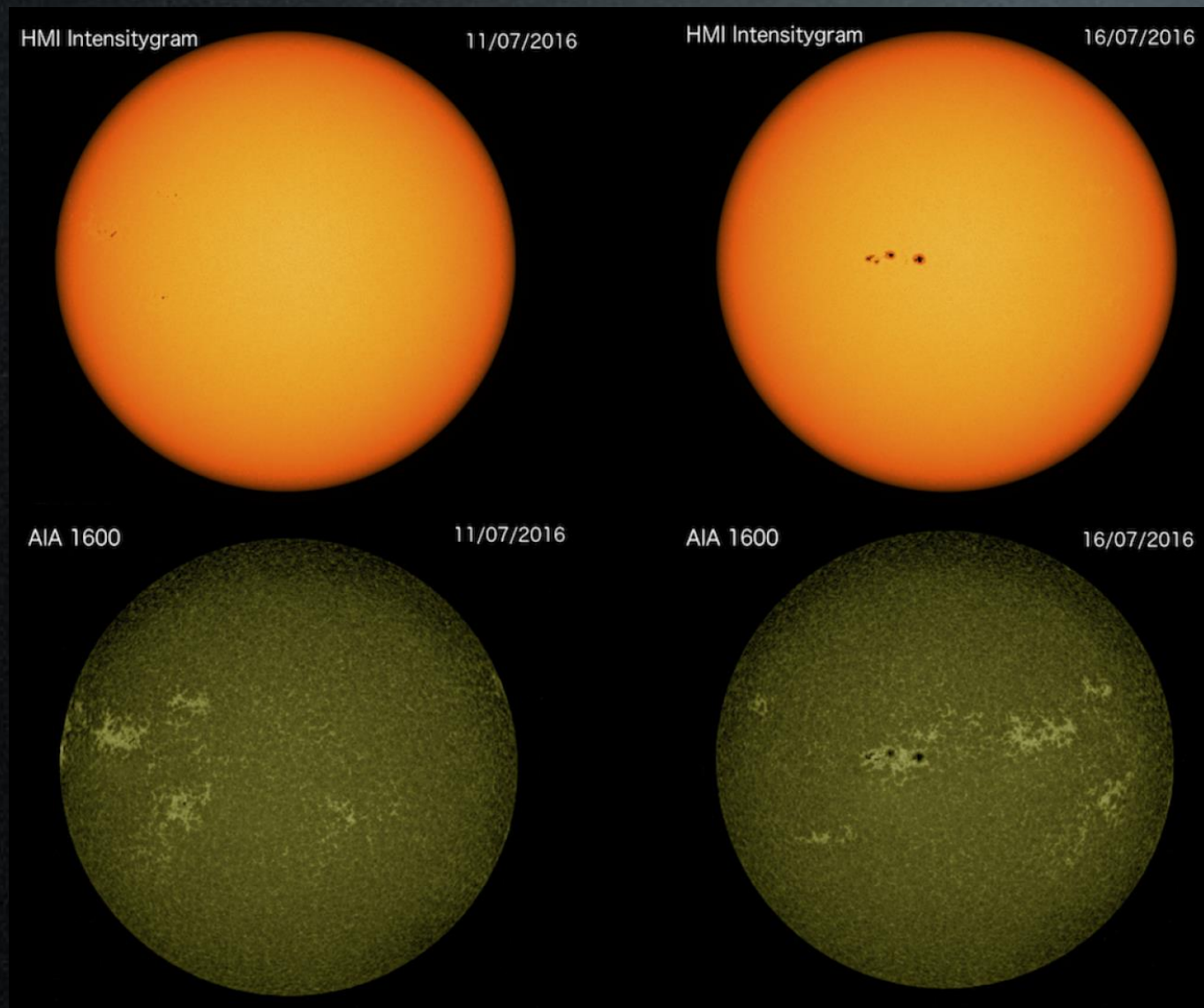
## B





# The Sun as alpha Cen

## B

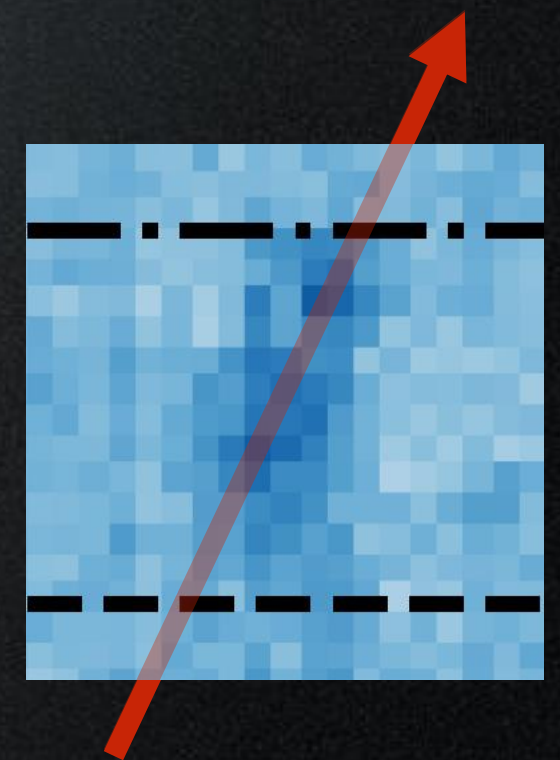
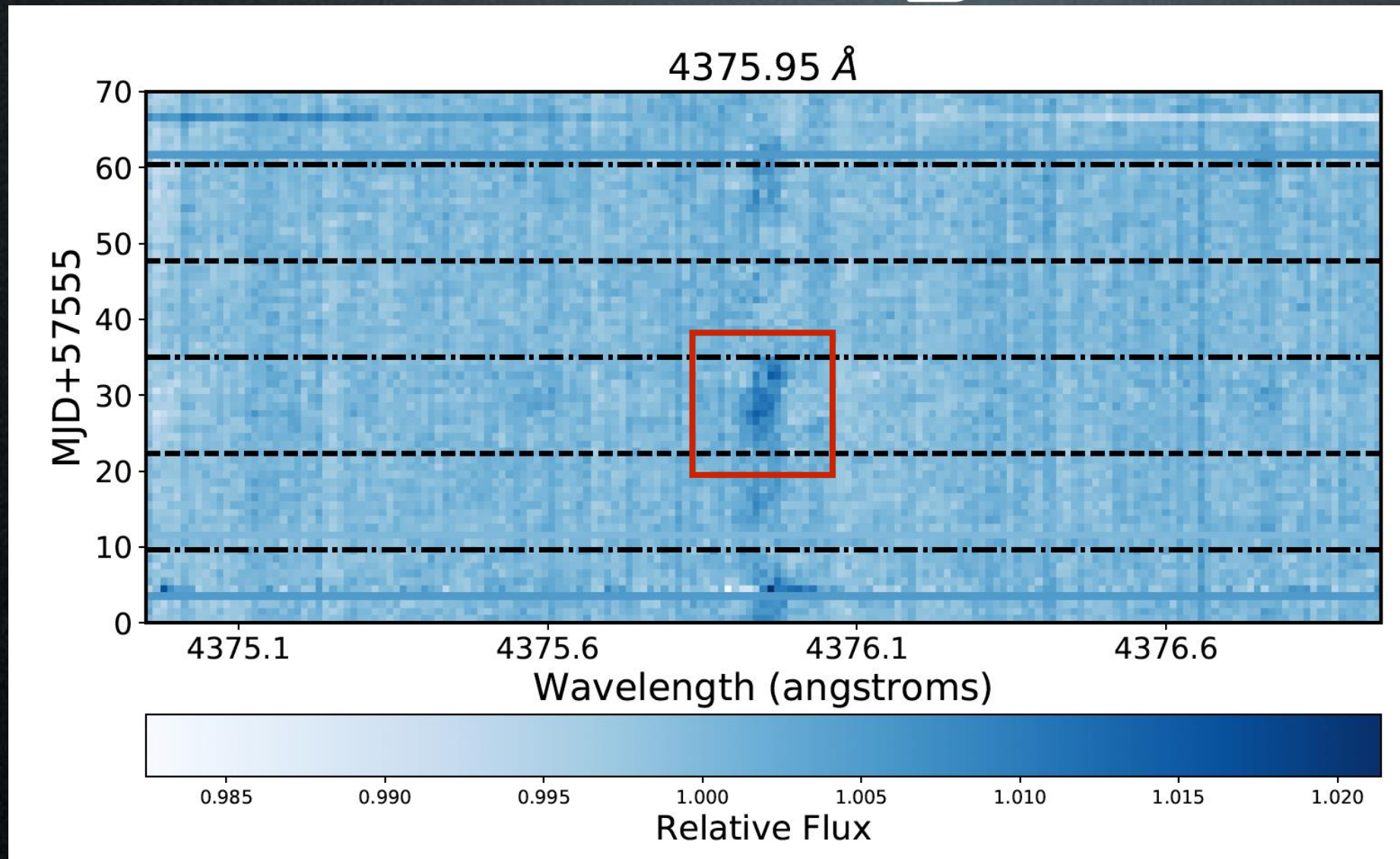


A. Thompson et al (2020)



# The Sun as alpha Cen

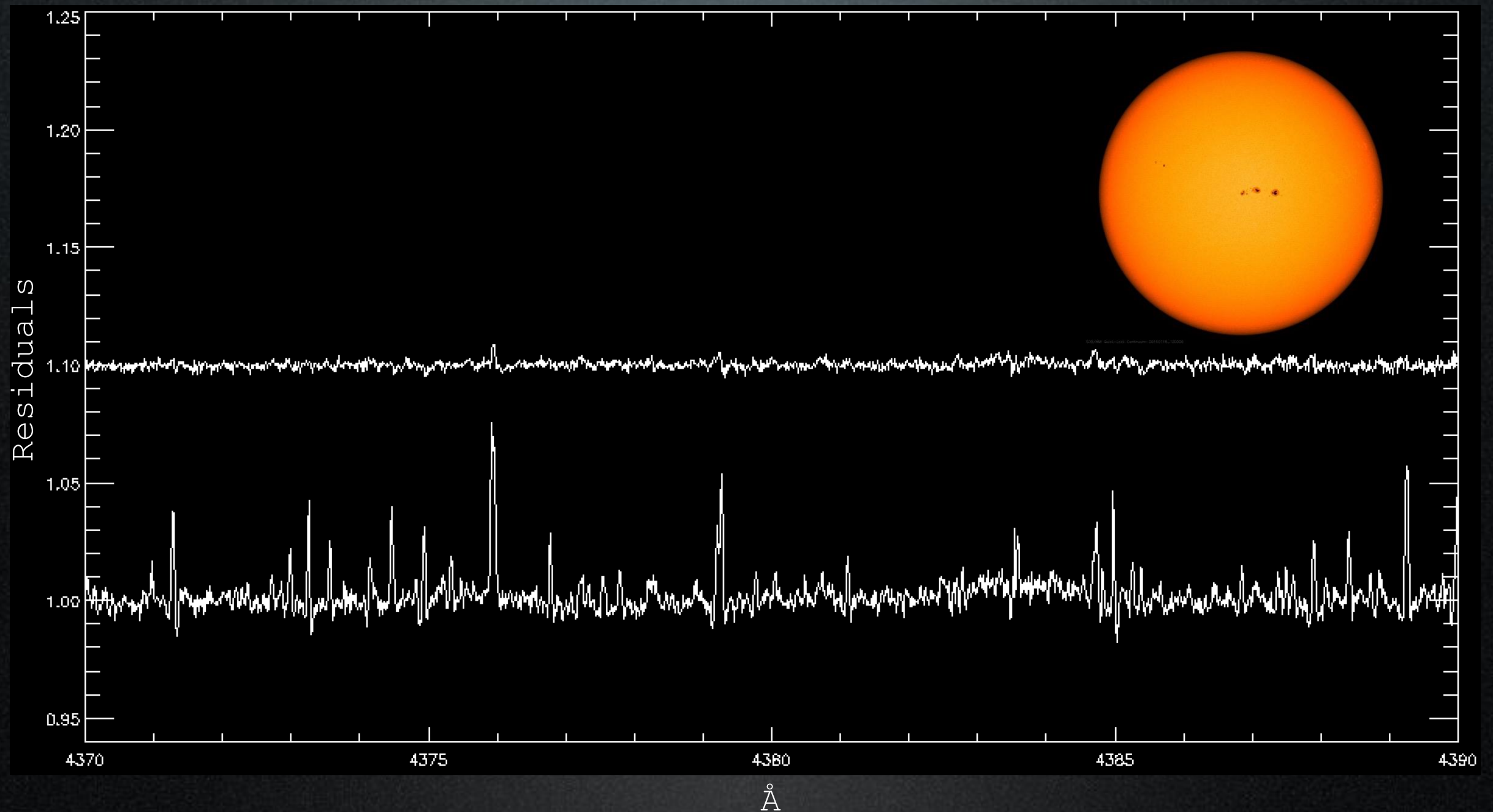
B



A. Thompson et al (2020)

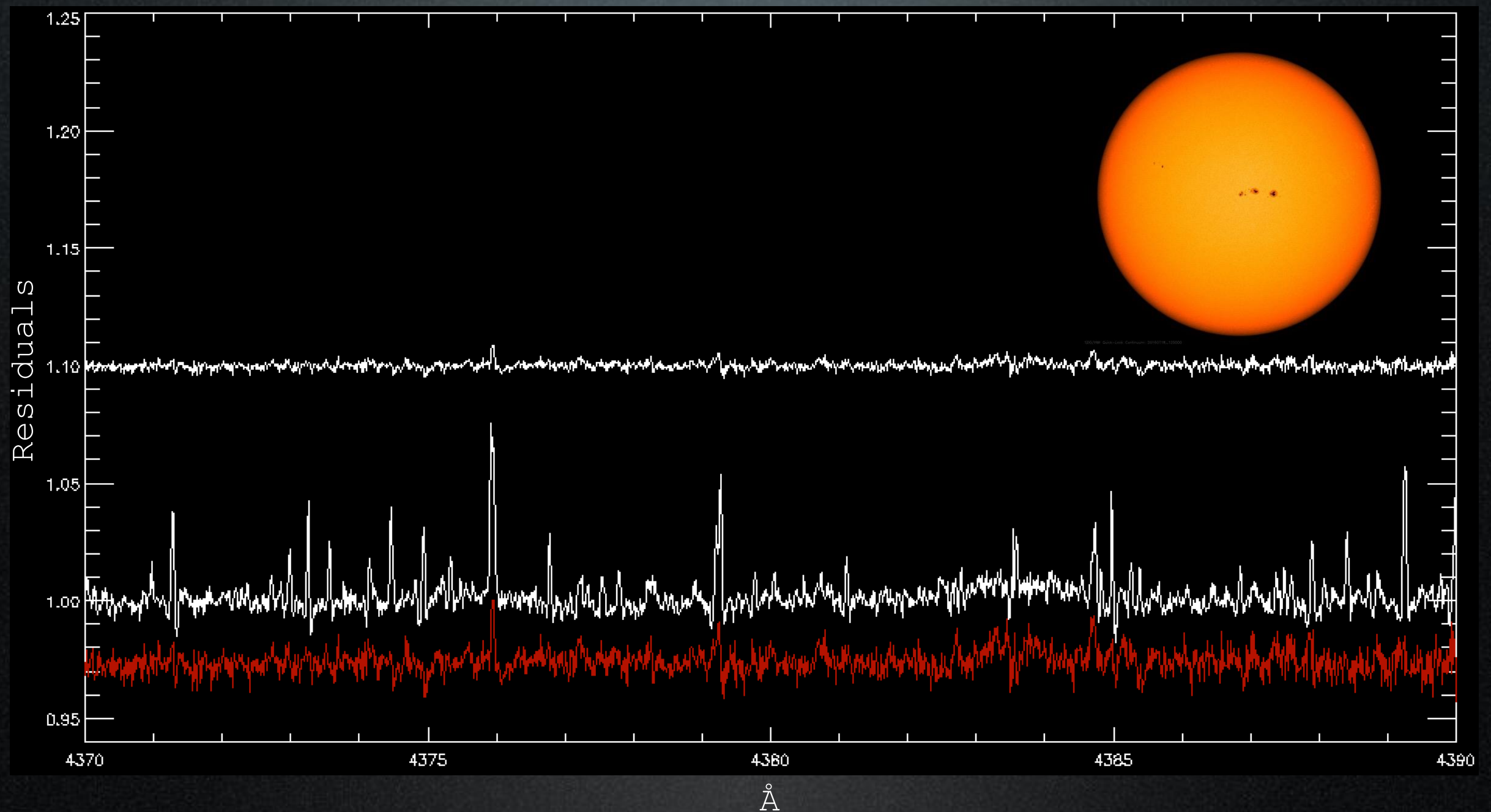


# alpha Centauri B b versus the Sun



A. Thompson et al (2020)

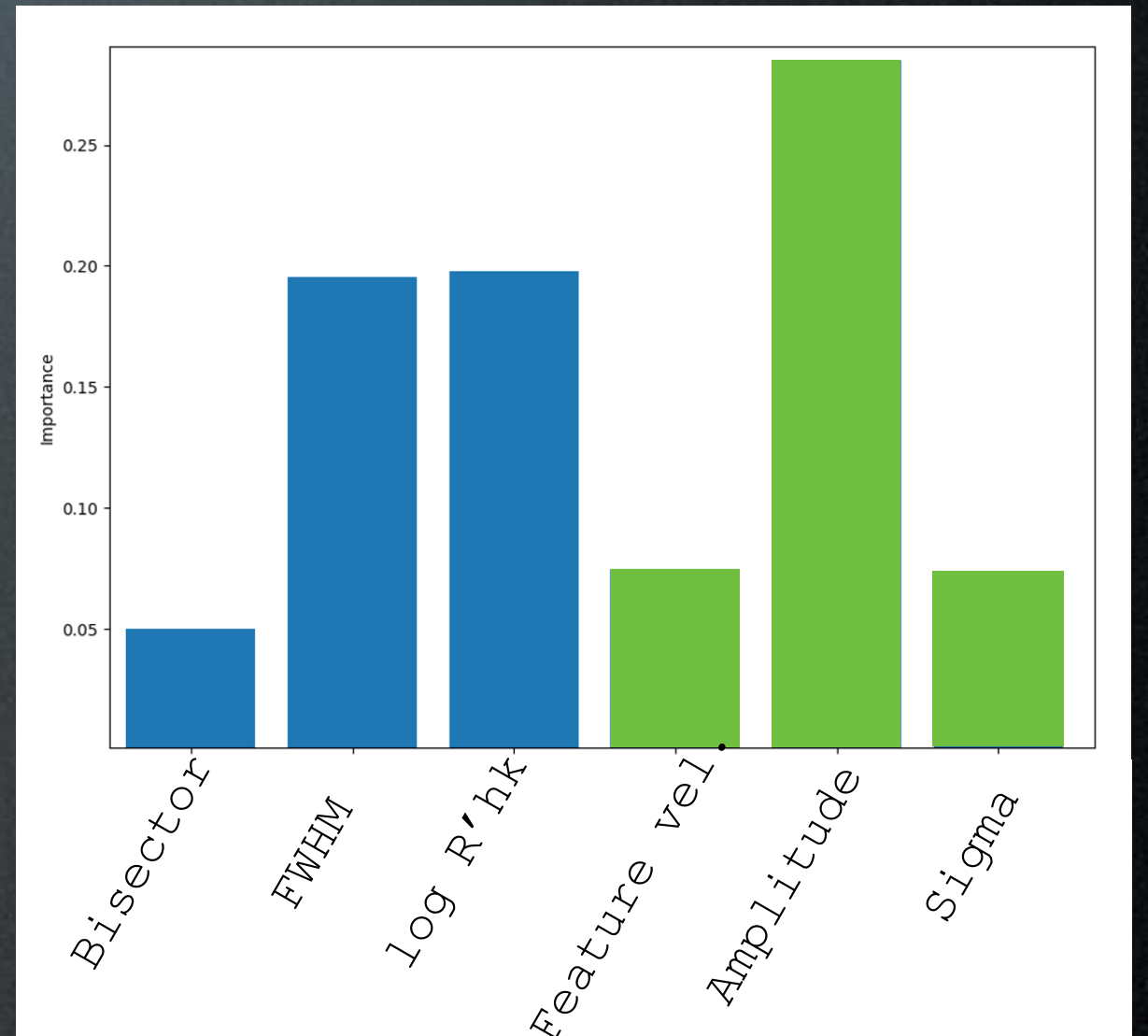
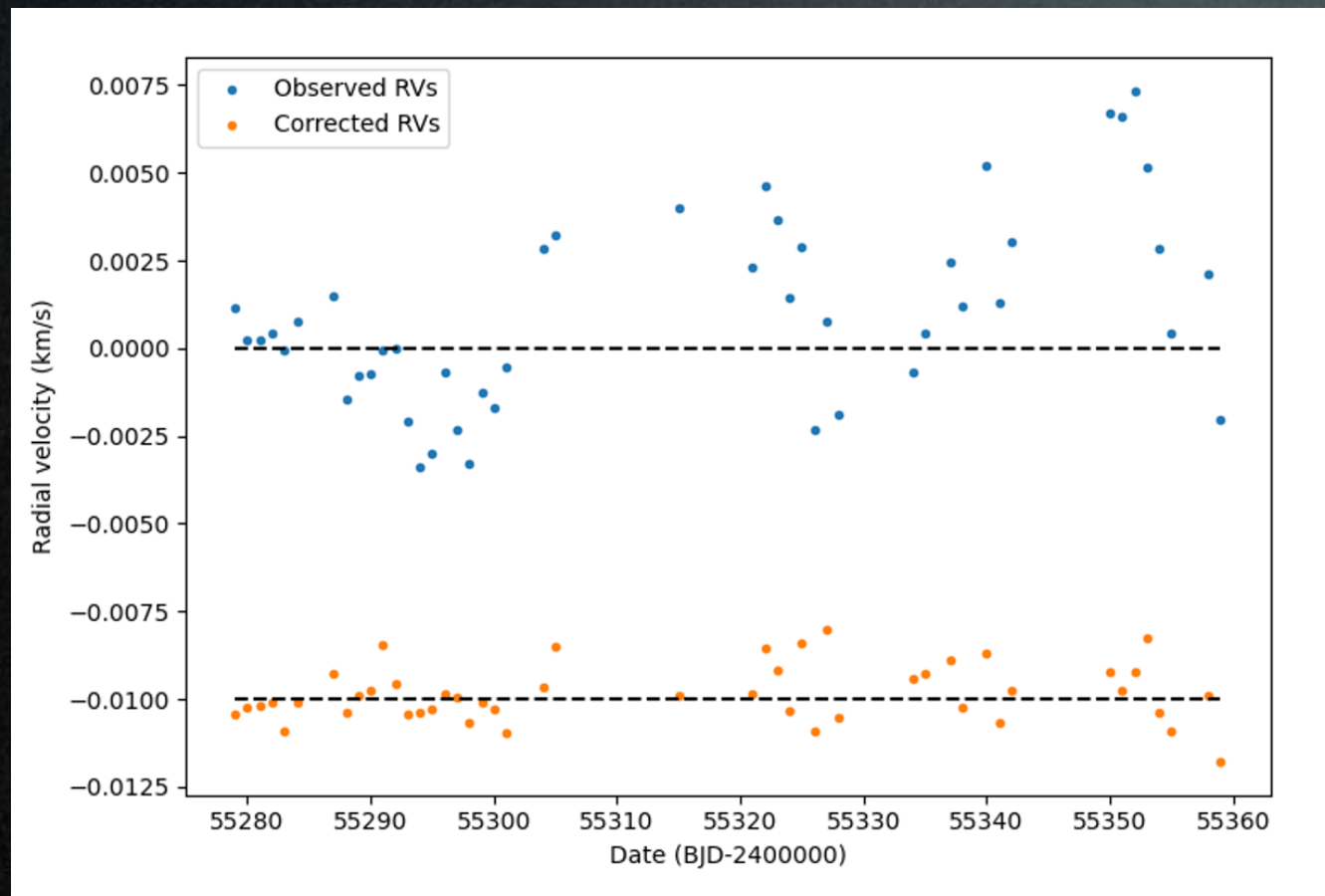
# alpha Centauri B versus the Sun



A. Thompson et al (2020)



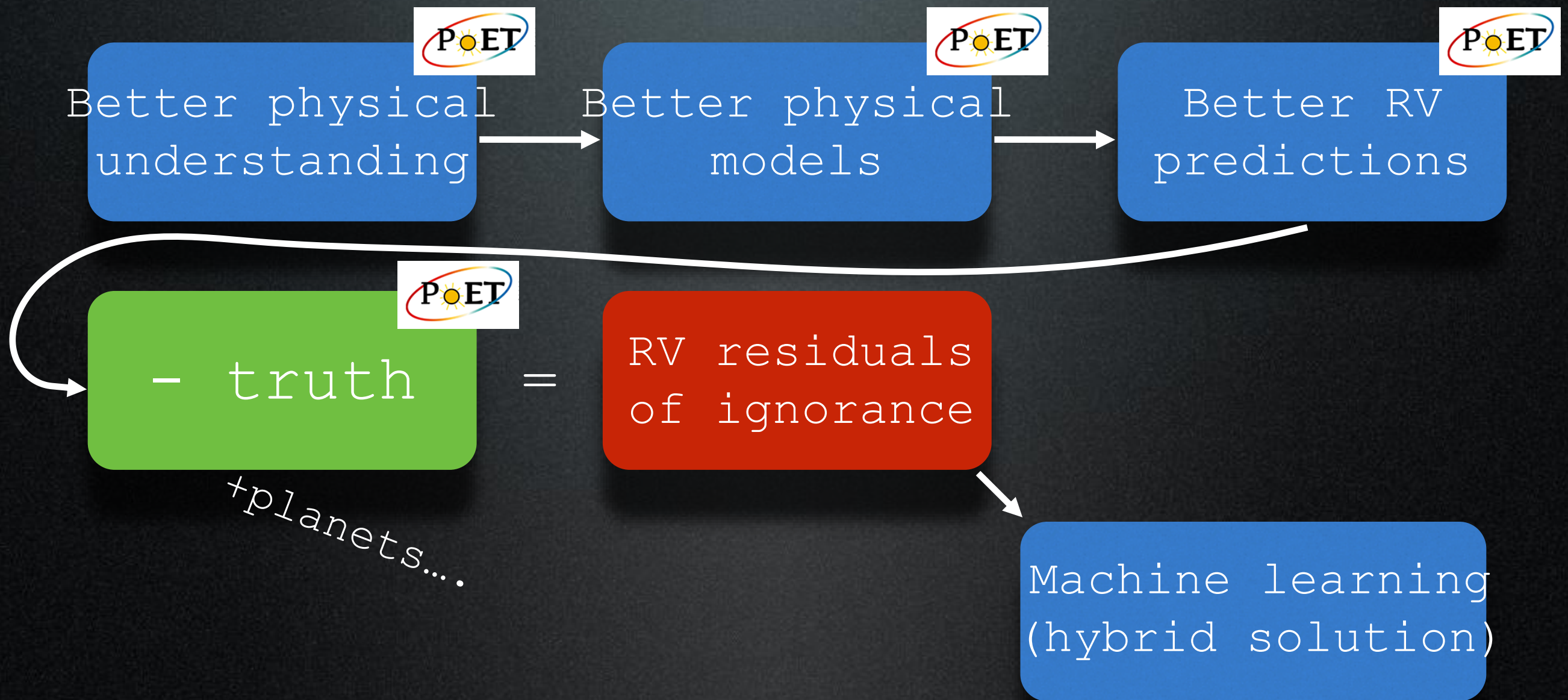
# Mitigating activity



D. Jackson et al. (beyond preliminary..)

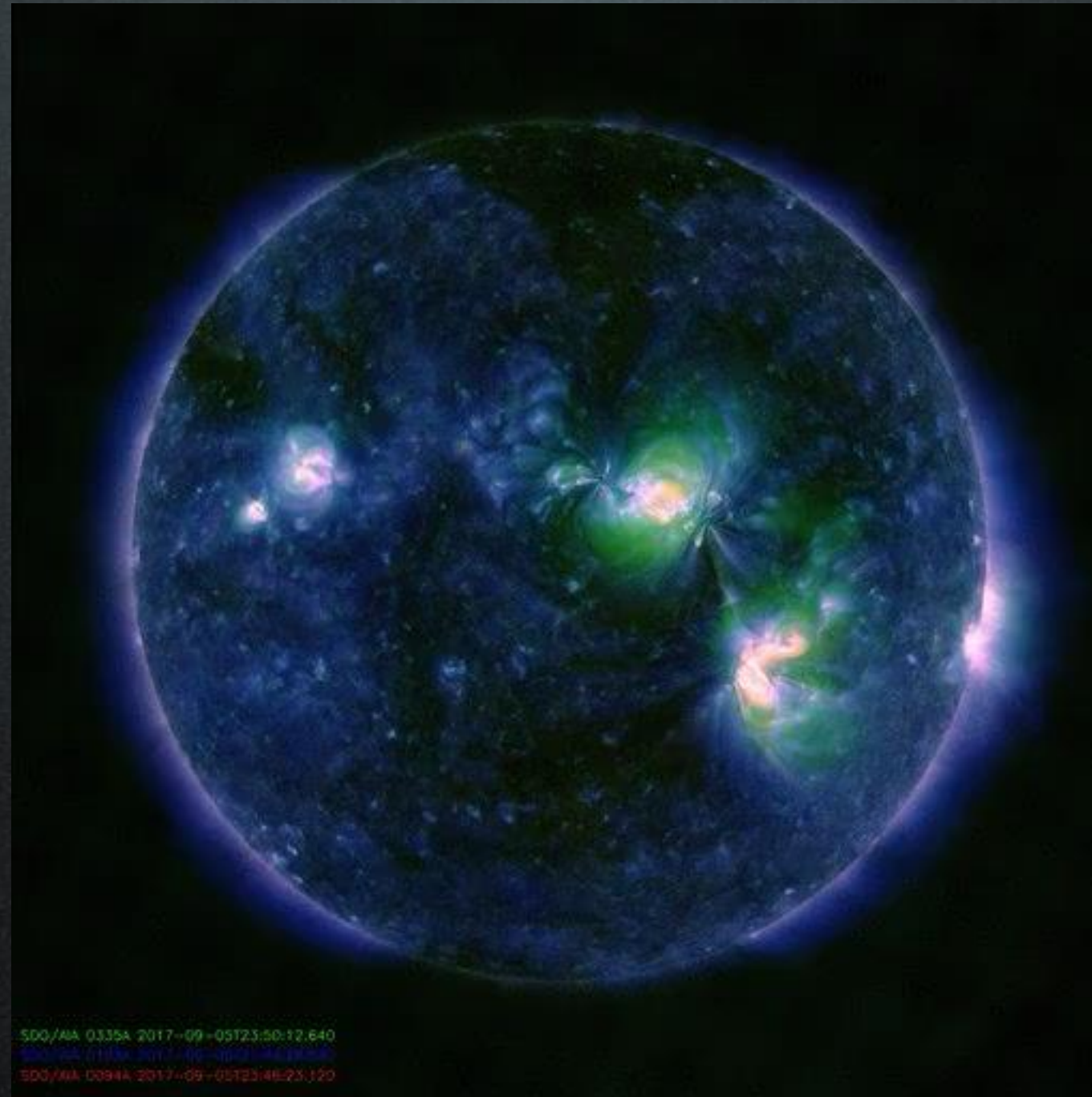
# non-Conclusions

there's probably no 'silver bullet'. Sad face





# Flares



M. Sci student: Niamh Malligan

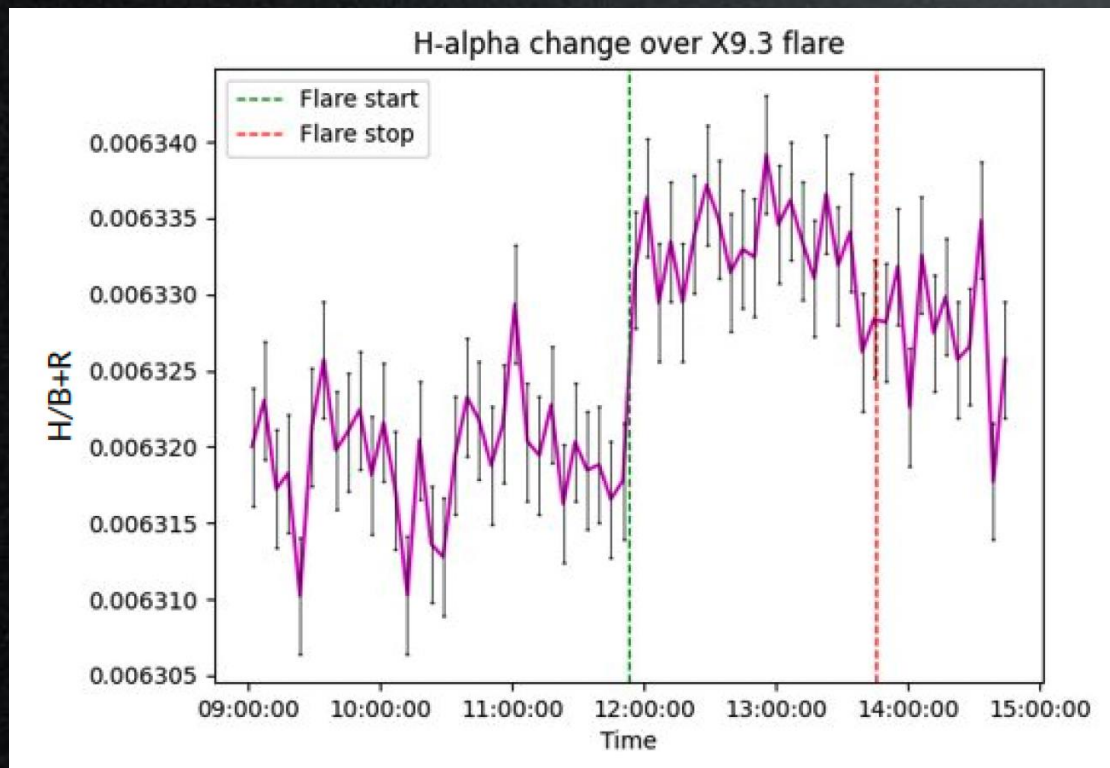
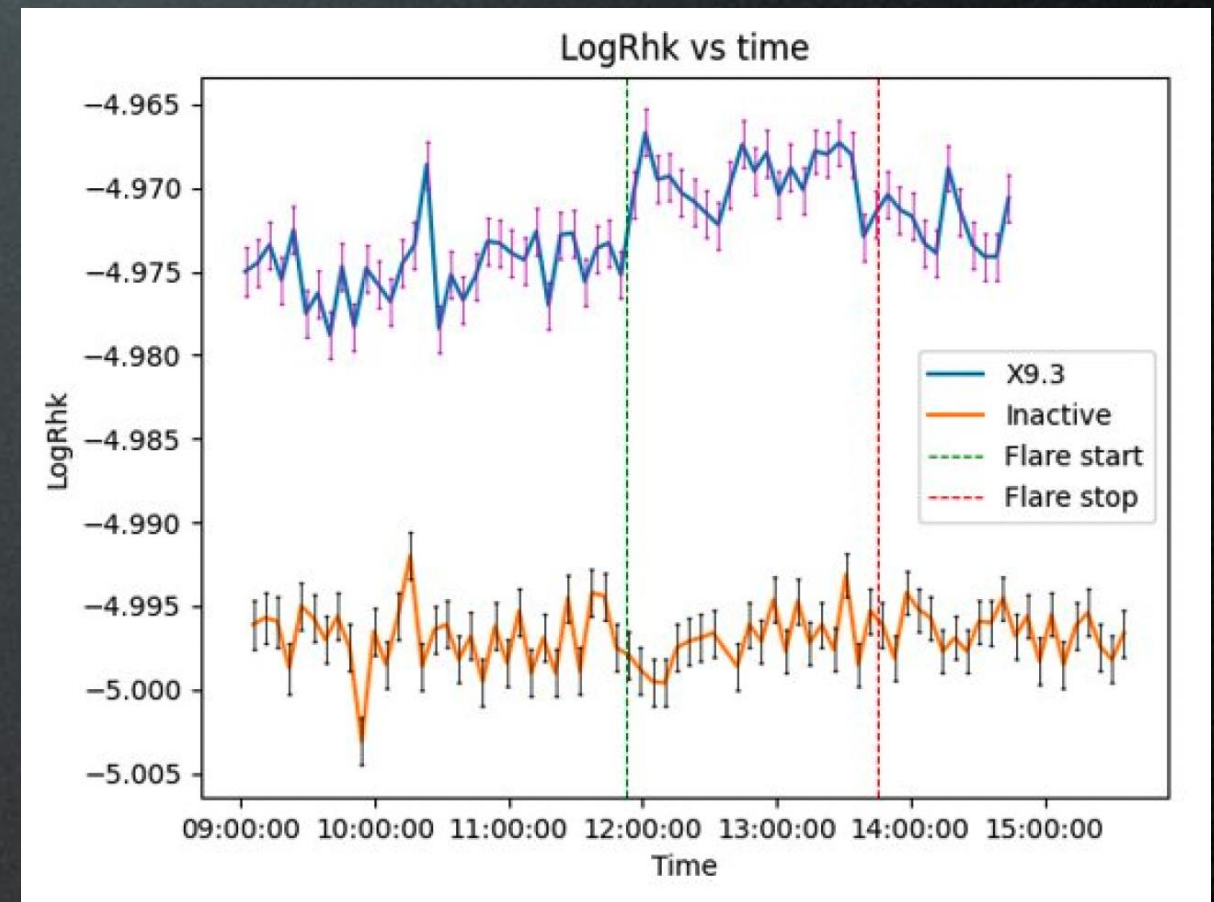
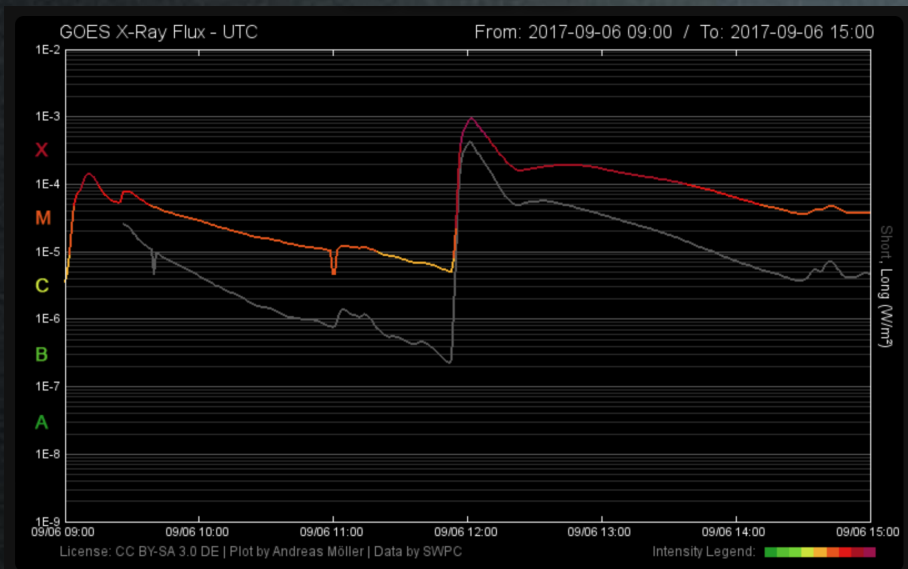


# Flares



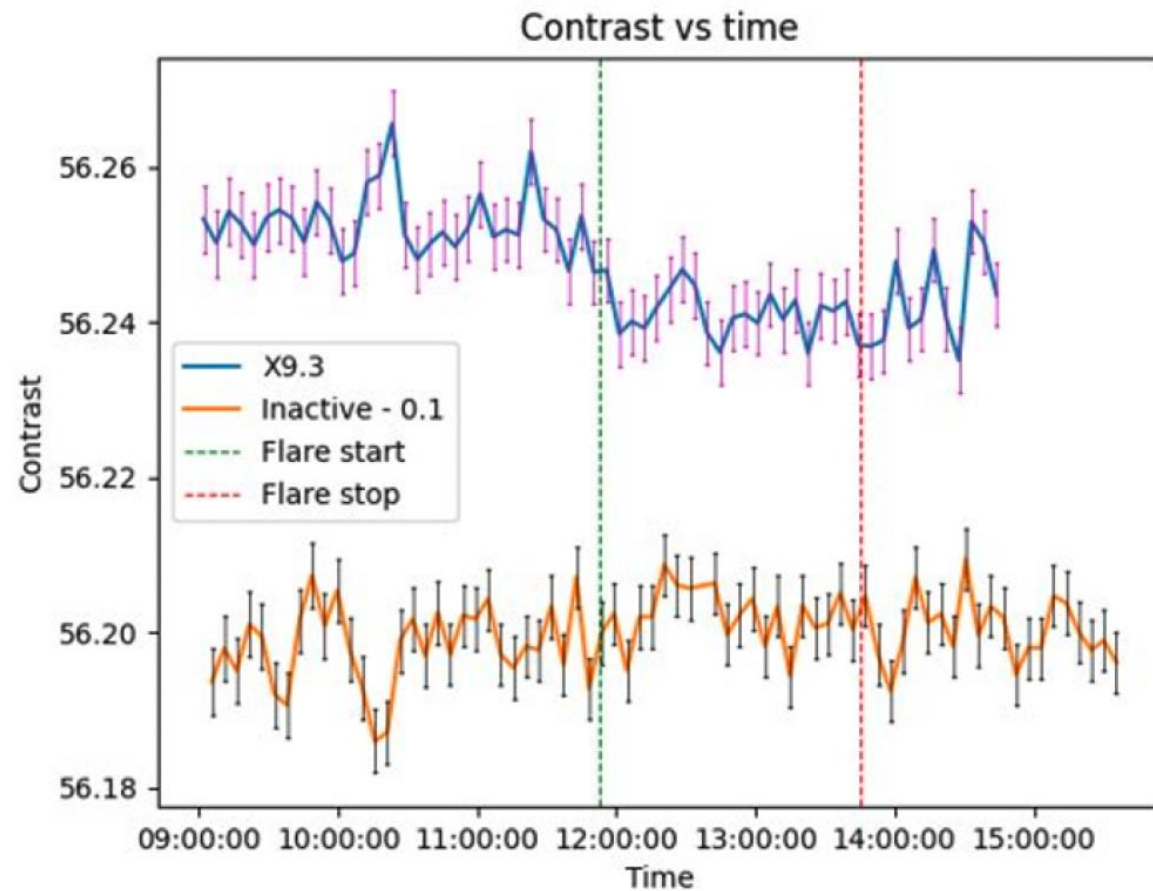
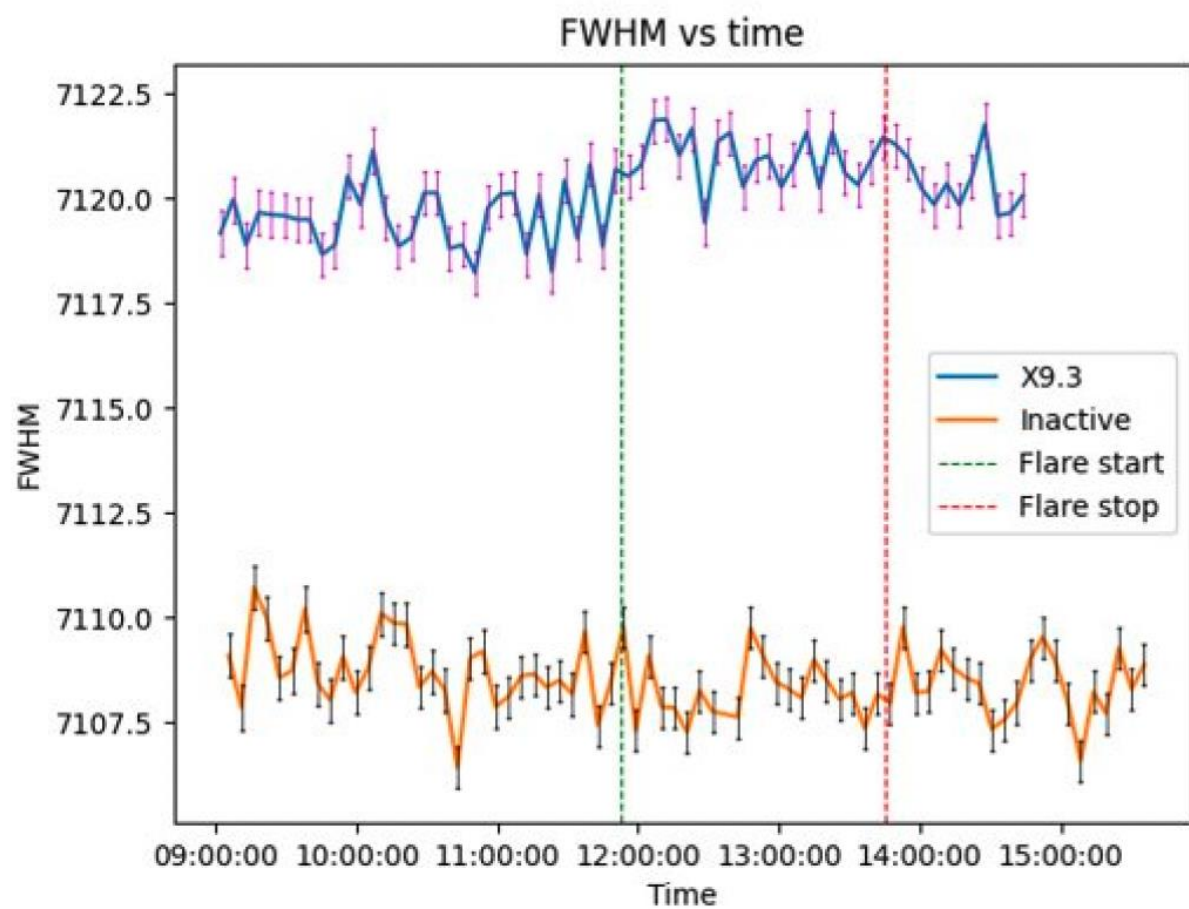


# Flares



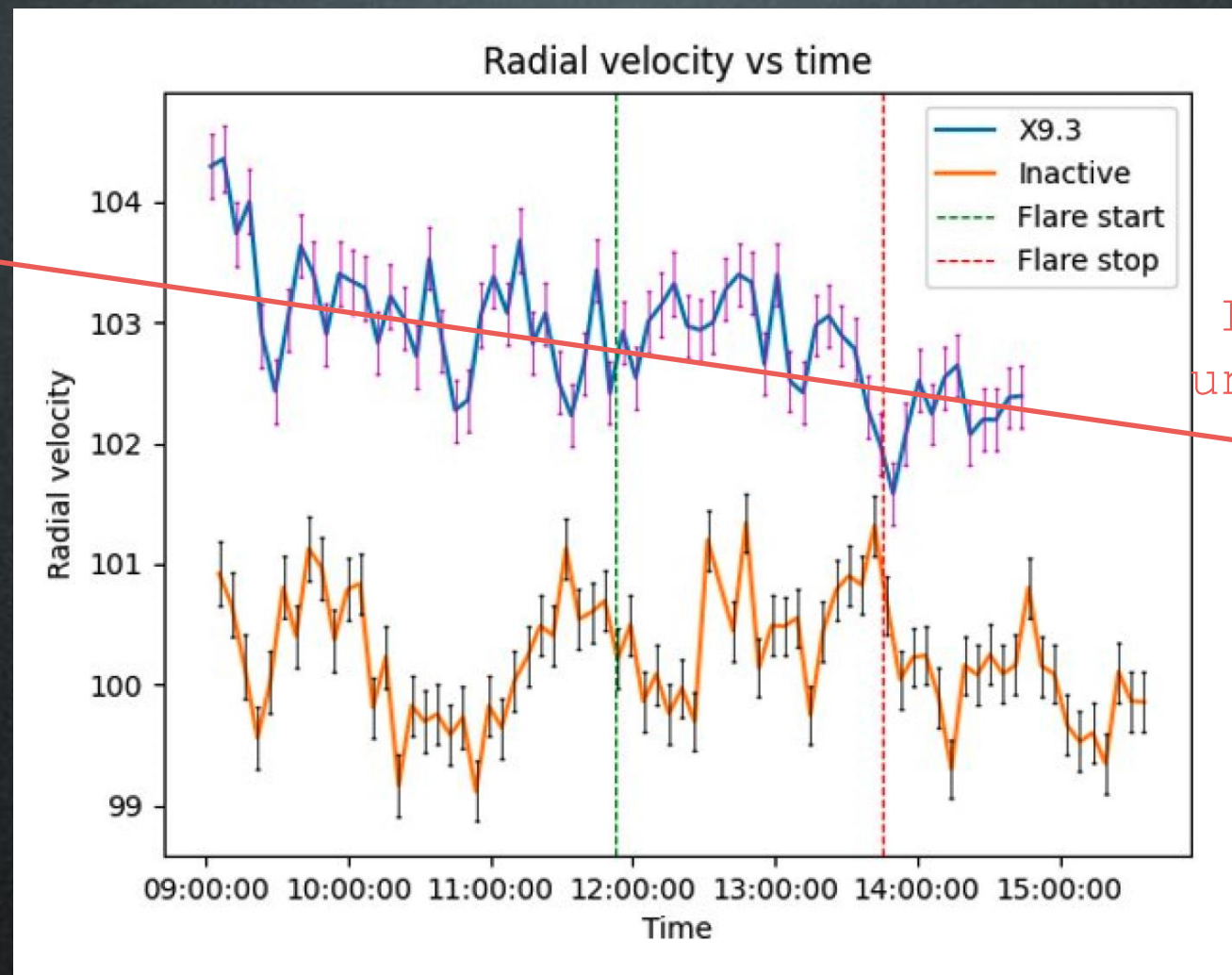


# Flares





# Flares

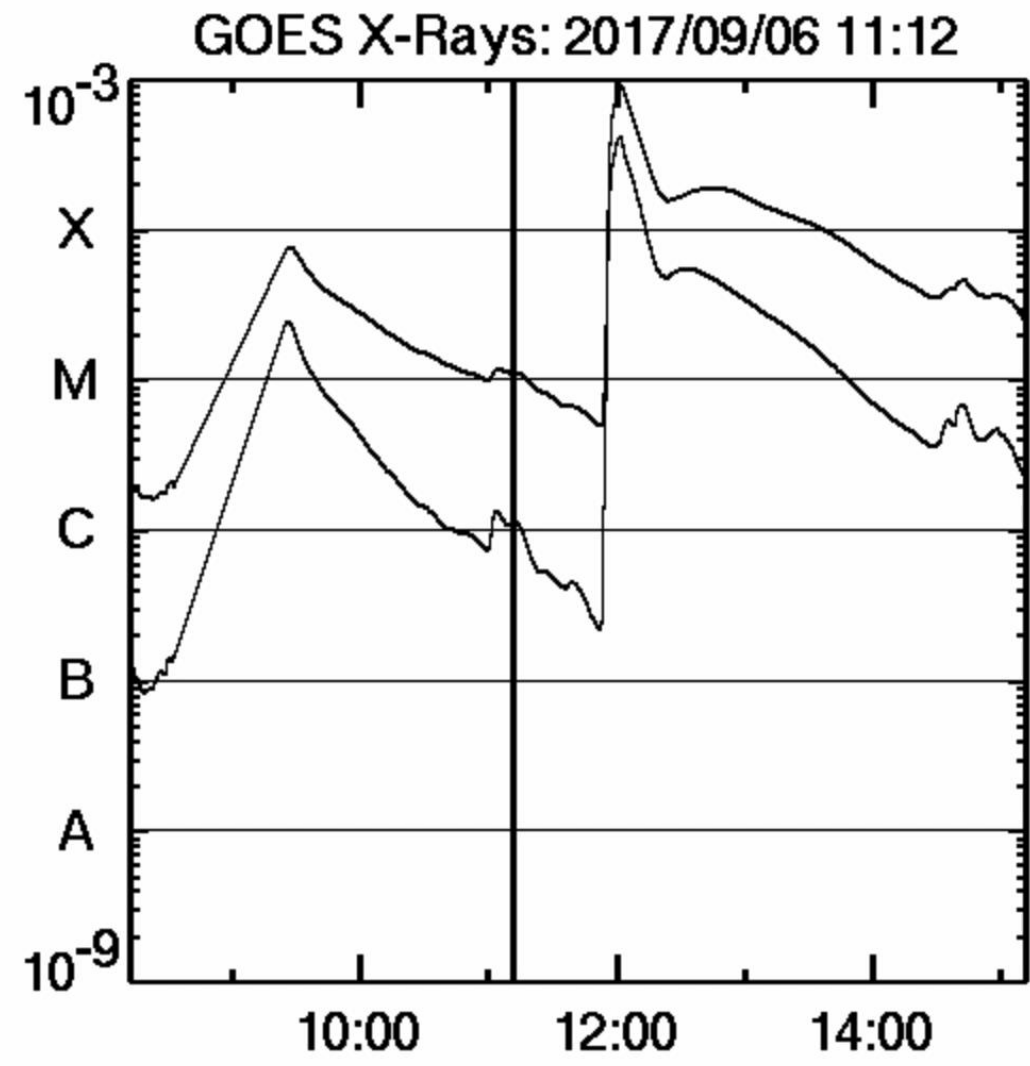


Long-term trend due to underlying active region

Do flares impact activity indicators  
BUT not the RVs.....?

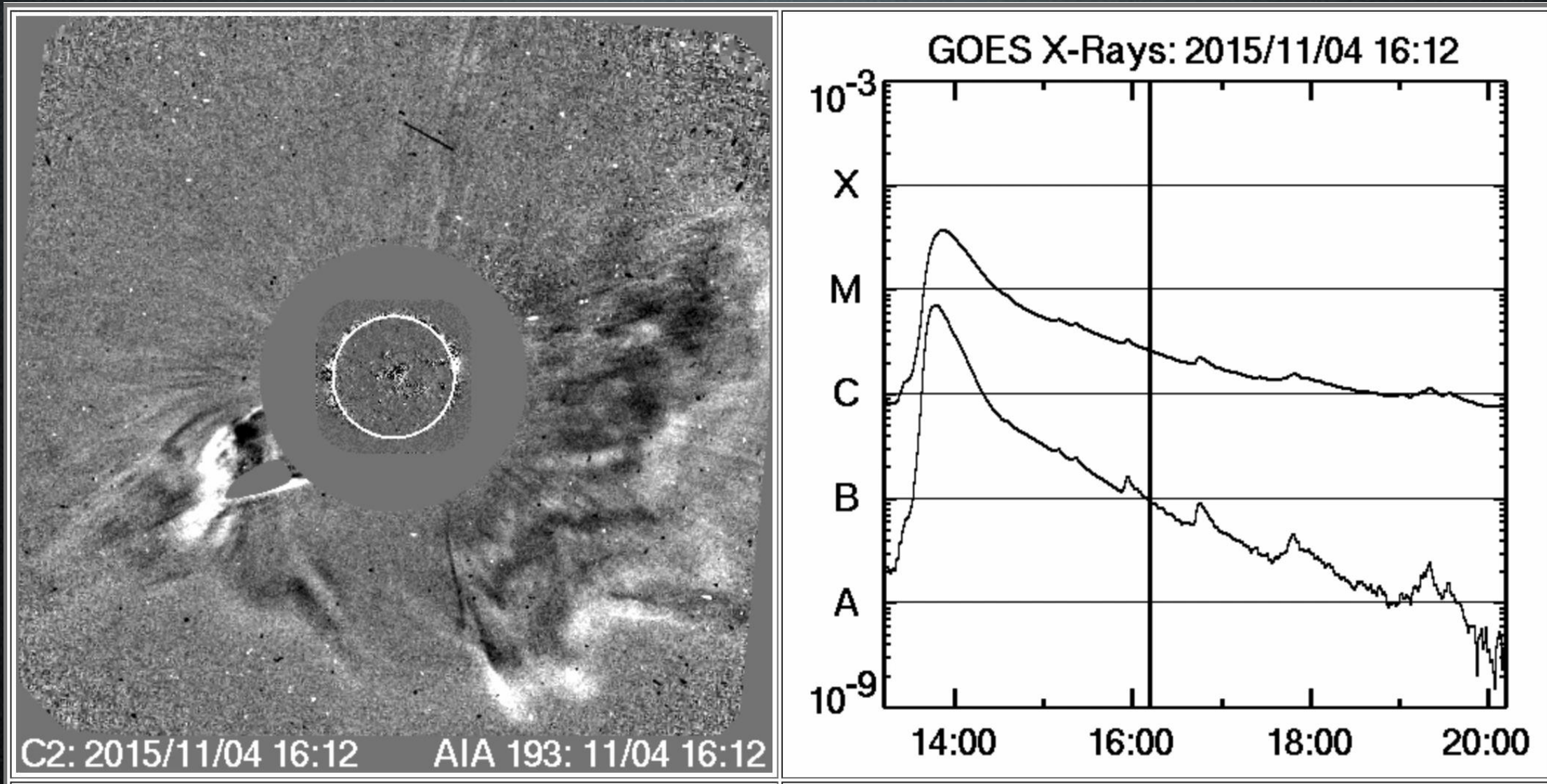


# CMEs



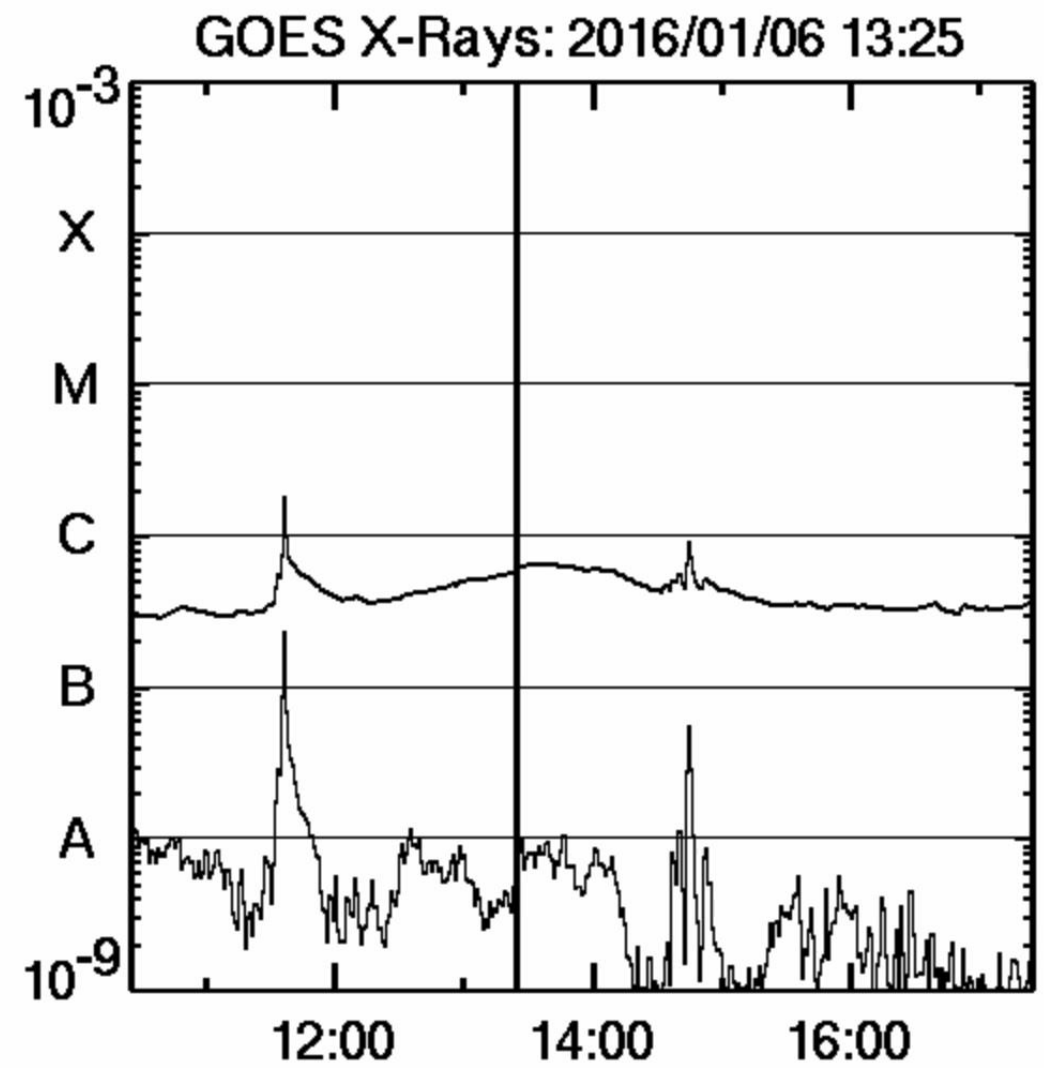
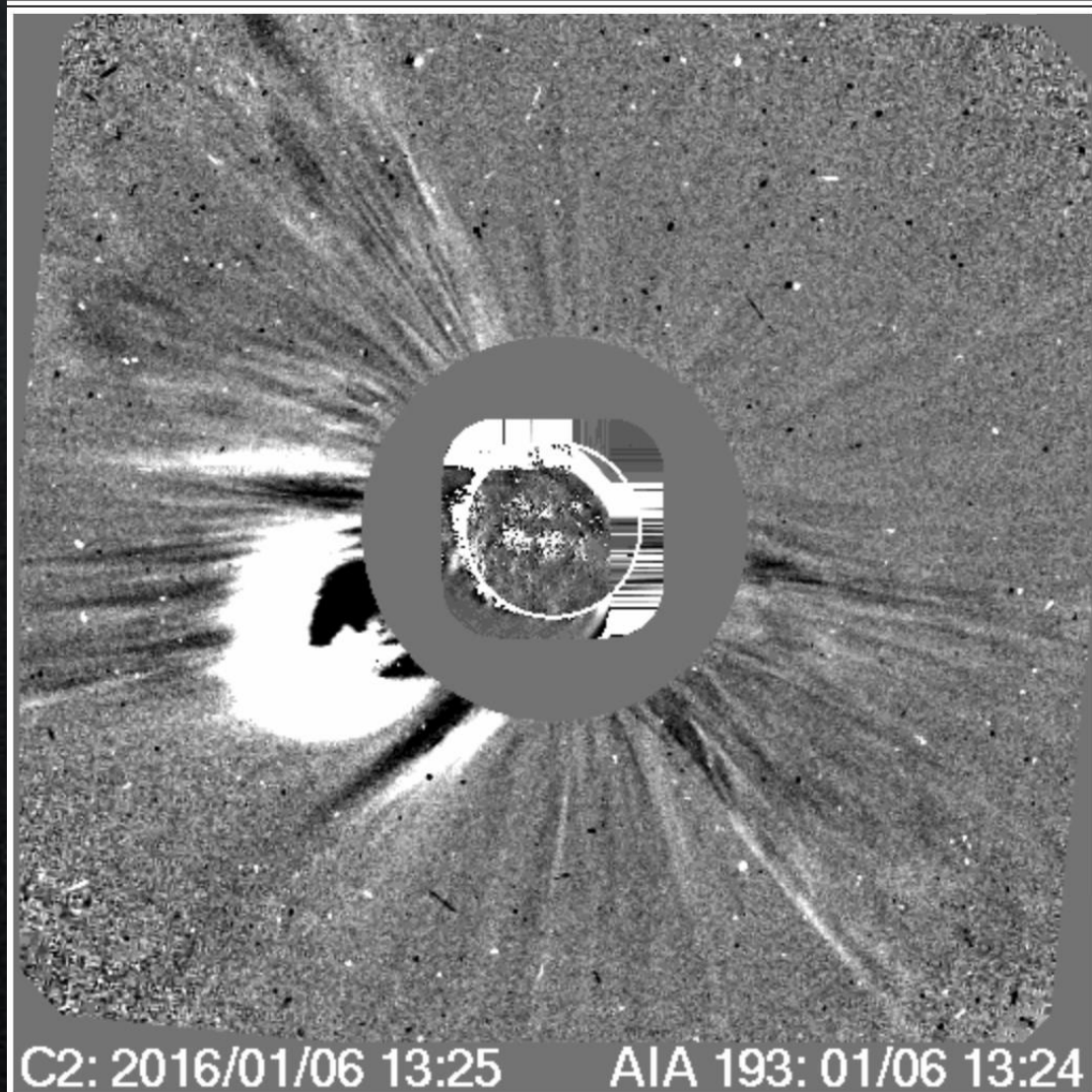


# CMEs



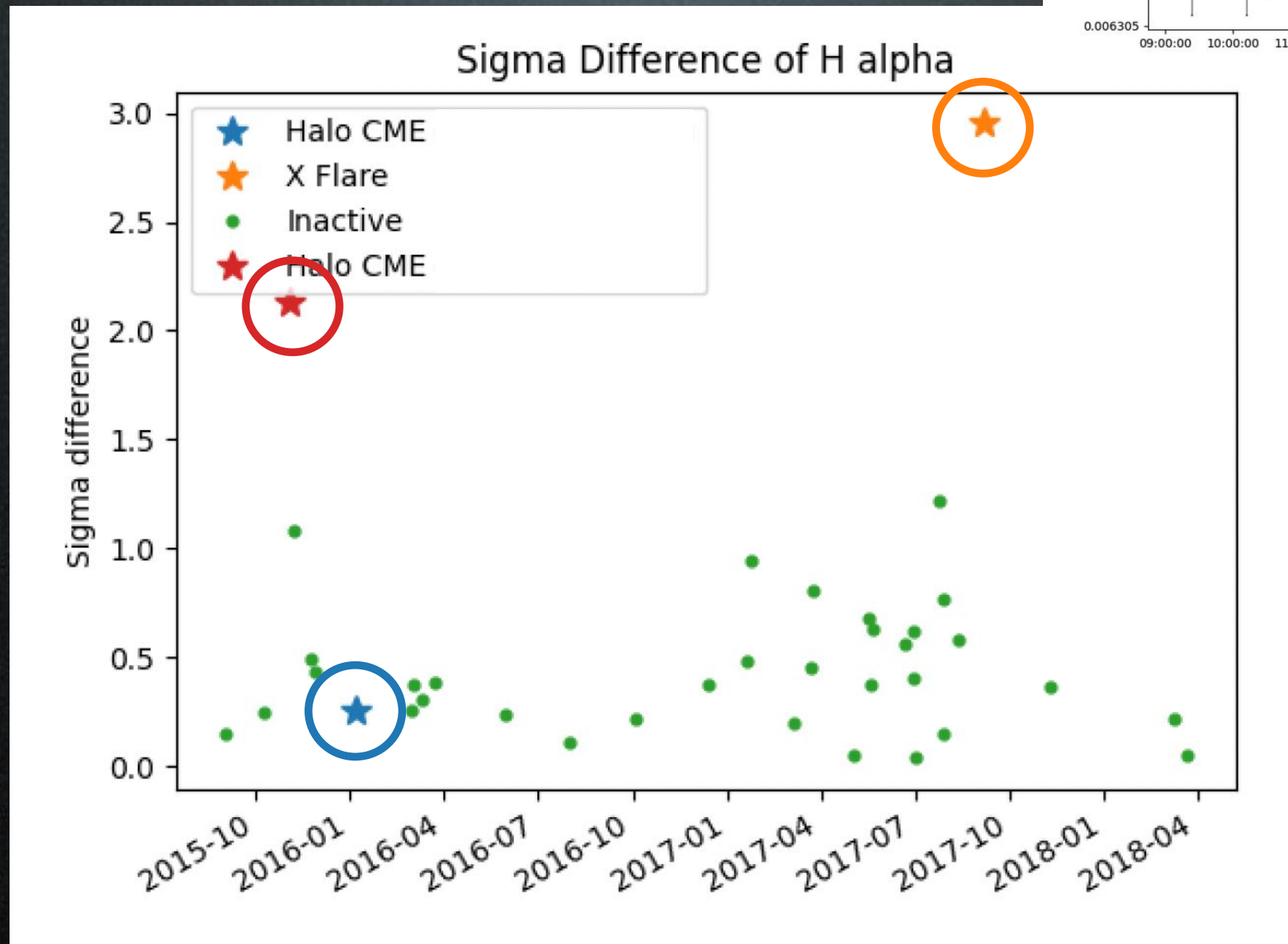
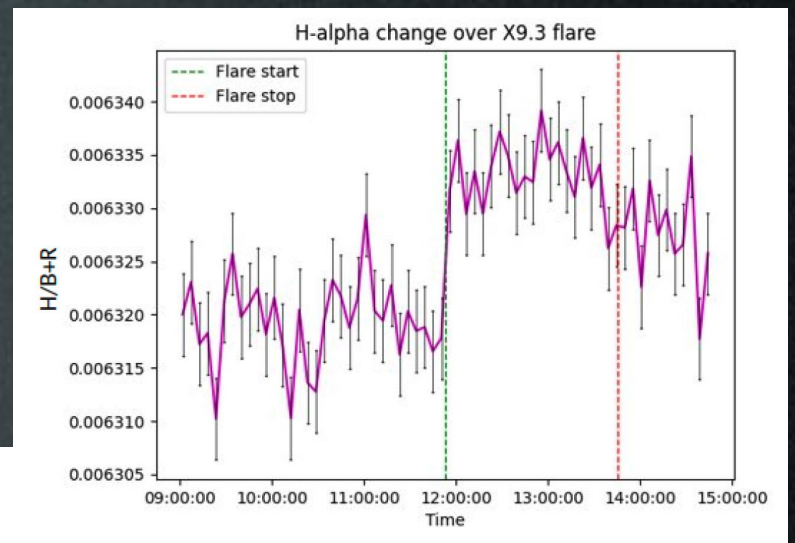


# CMEs



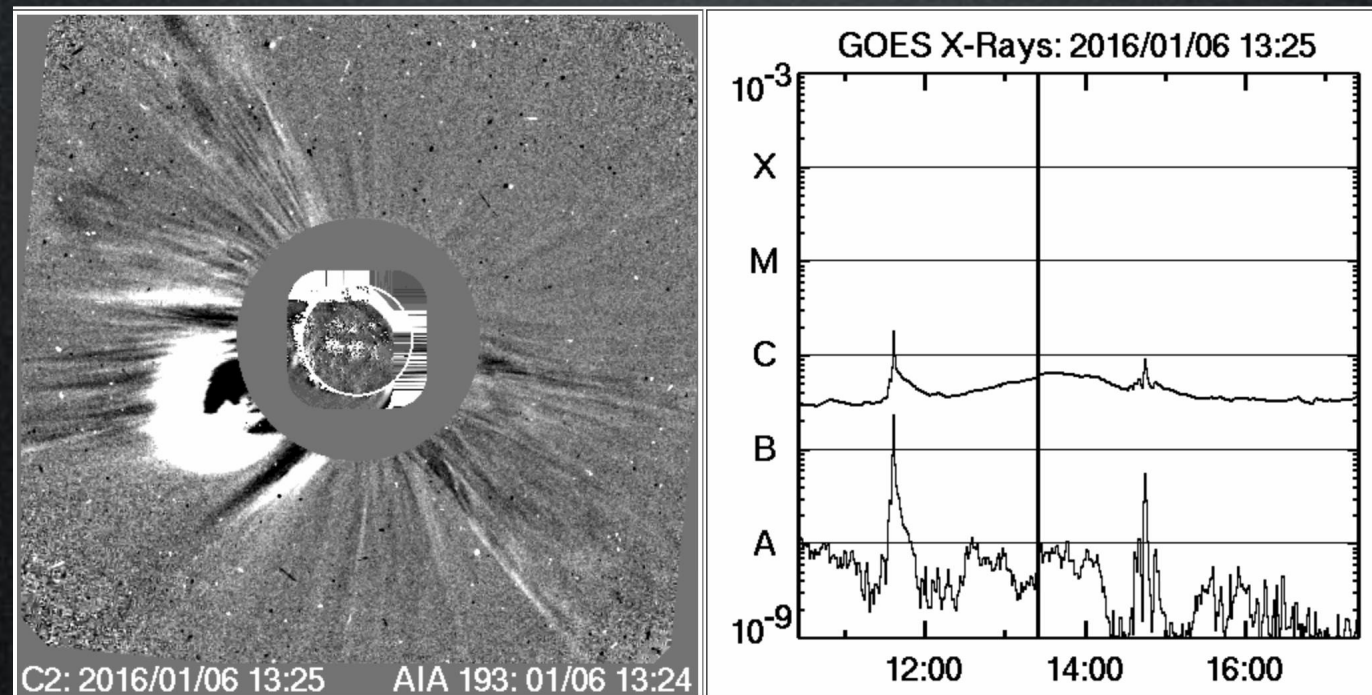
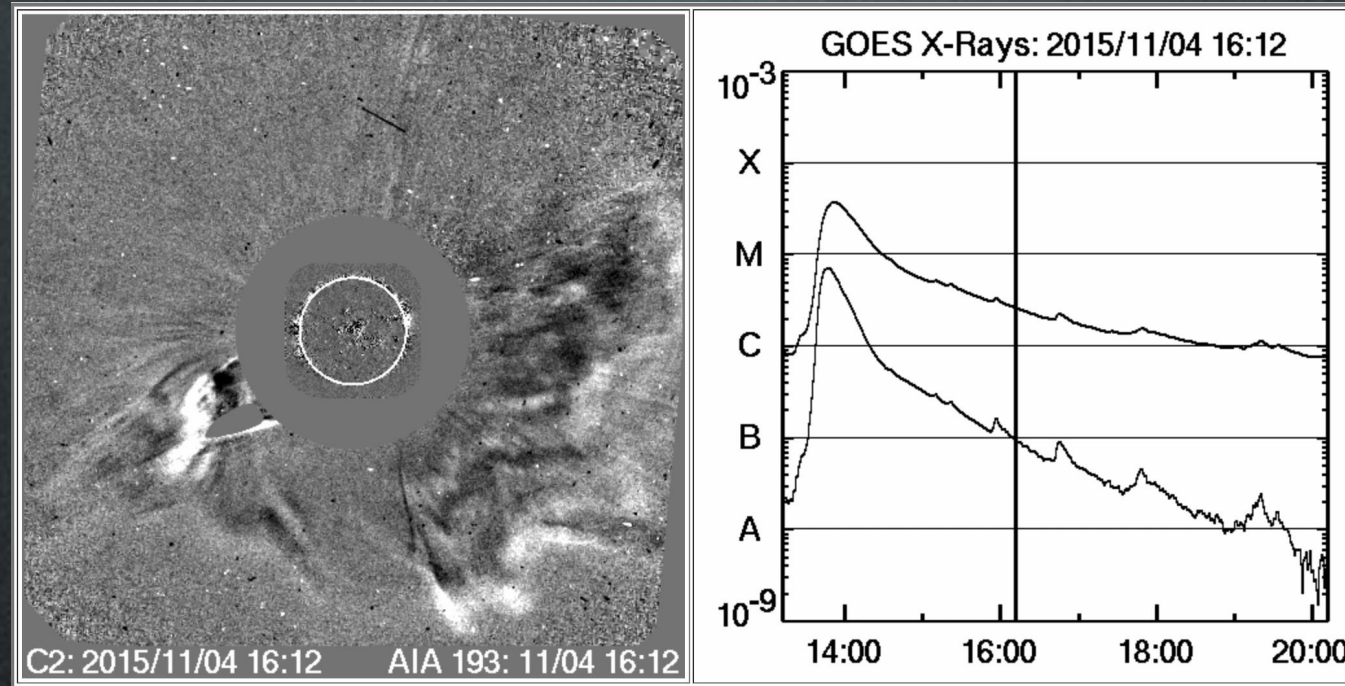


# CMEs



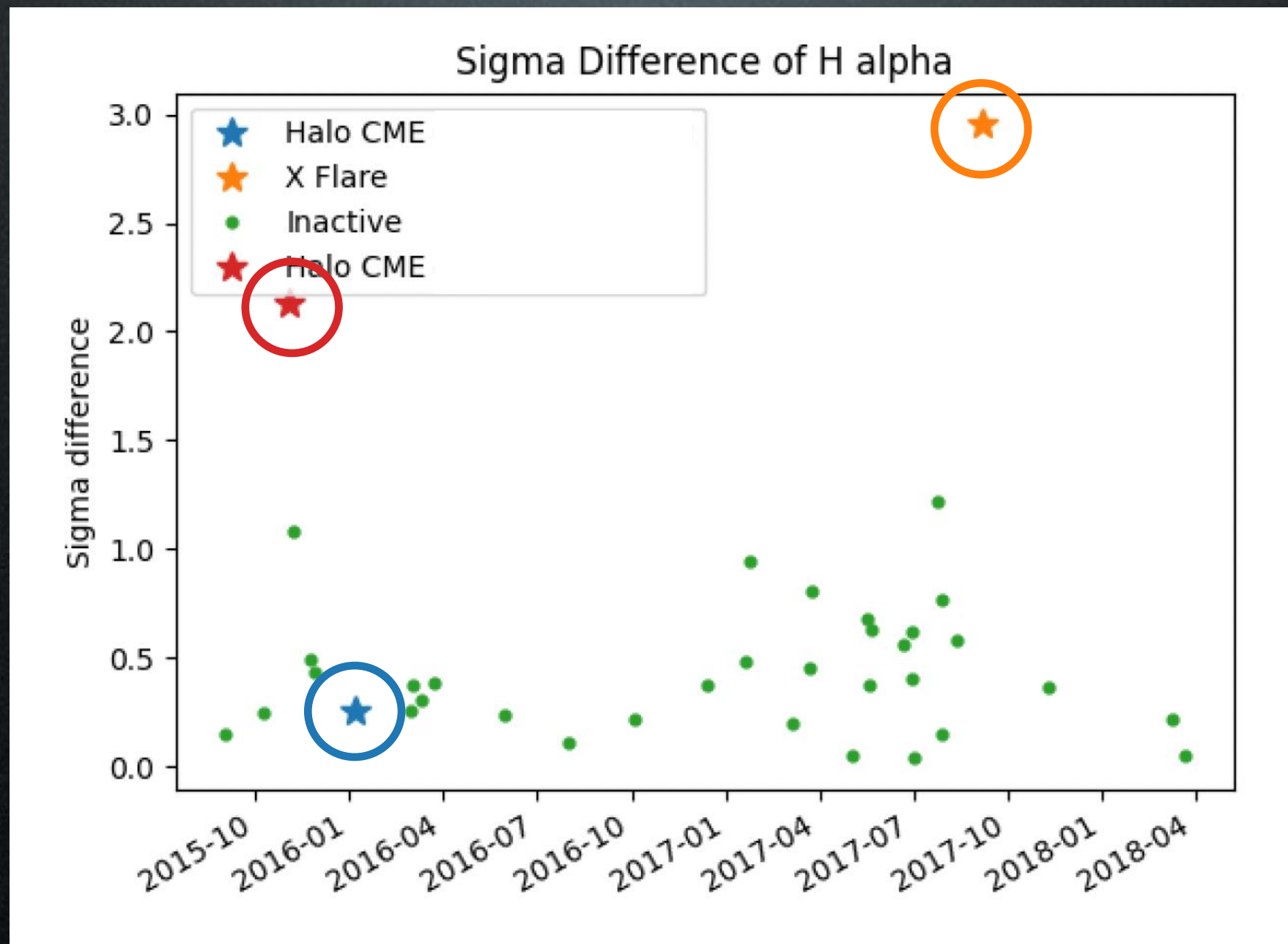


# CMEs



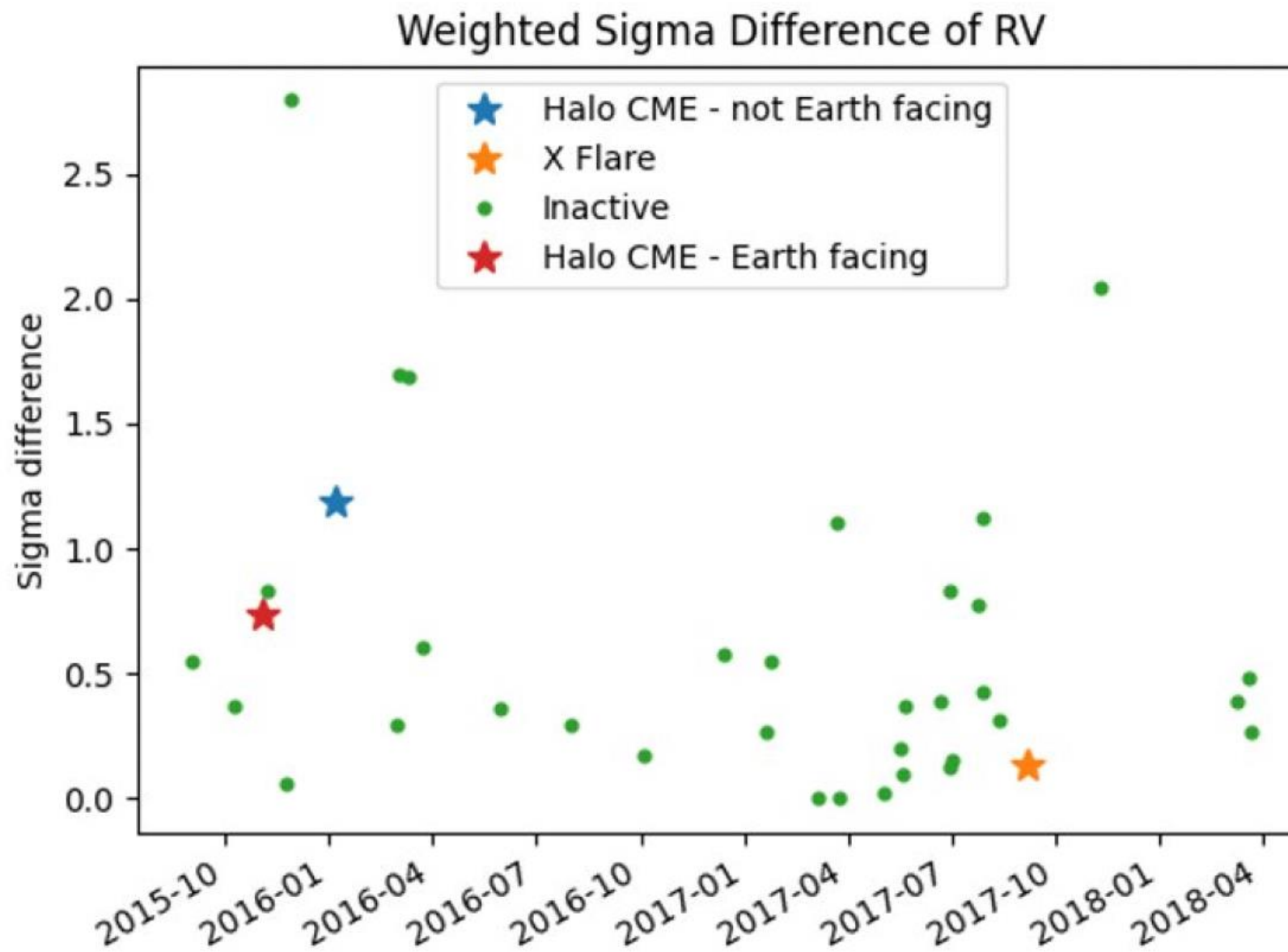


# CMEs



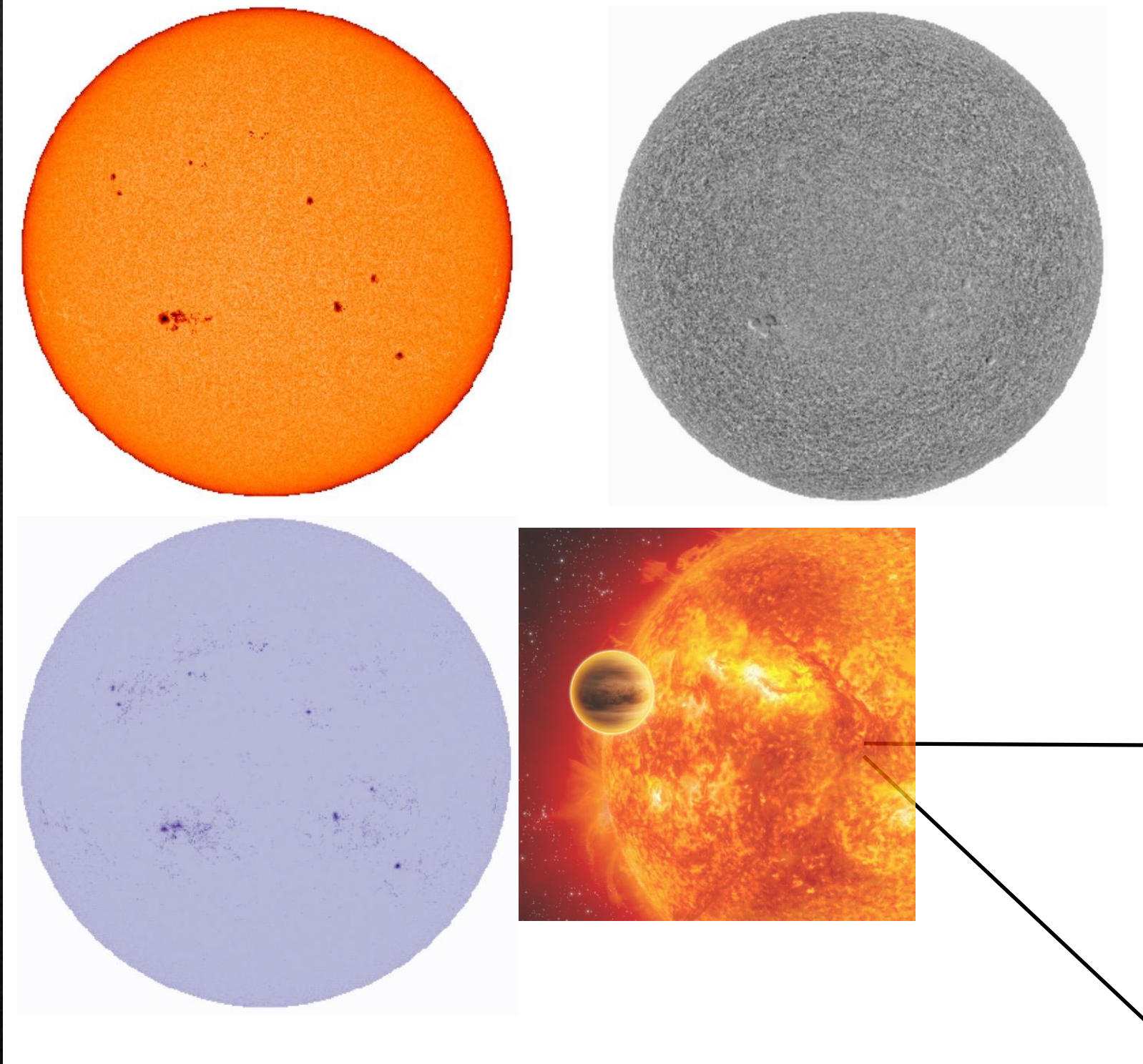


# CMEs





Stars are complex!





# Conclusions

Dominant RV variations: Suppression of convective blueshift

Impact on individual lines can be seen.

Probable route to identifying activity sensitive/insensitive

Flares/CMEs may affect activity proxies, but not RVs?

effects can be seen on the Sun near solar minimum!