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Service d'Astrophysique
Laboratoire AIM

# STARS WITH SMALL DIPOLE VISIBILITIES AND THE TASMANIAN DEVILS

R.A. García, WG#1 and WG#8 KASC Teams

Fruitful collaborations during KITP with:

J. C-D, G. Houdek, F. Ligniers, S. Mathur, B. Pablo, M. Pinsoneault, V. Silva-Aguirre, M. Takata…

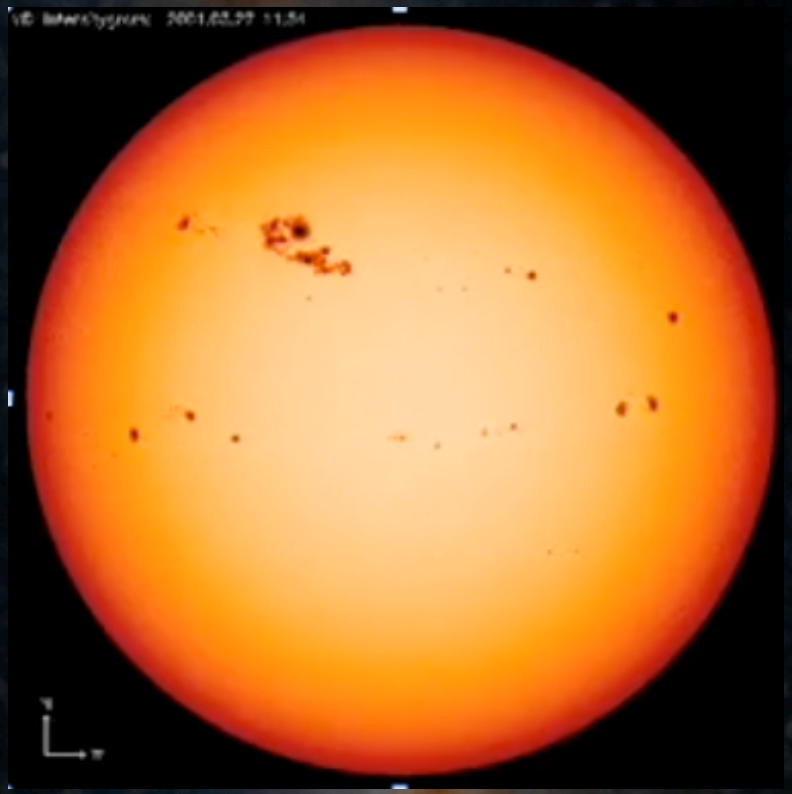
# PROBLEMS TO ADDRESS

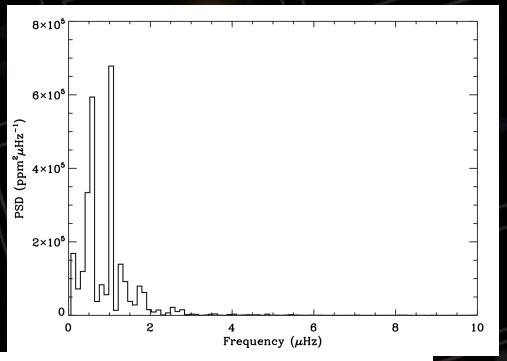
- Stars with rapid rotation:
  - 20-30% of break up velocity in the RGB and after!
- Stars with a smaller visibility in the l=1 ridge
  - Related problem or completely different physical origin ?

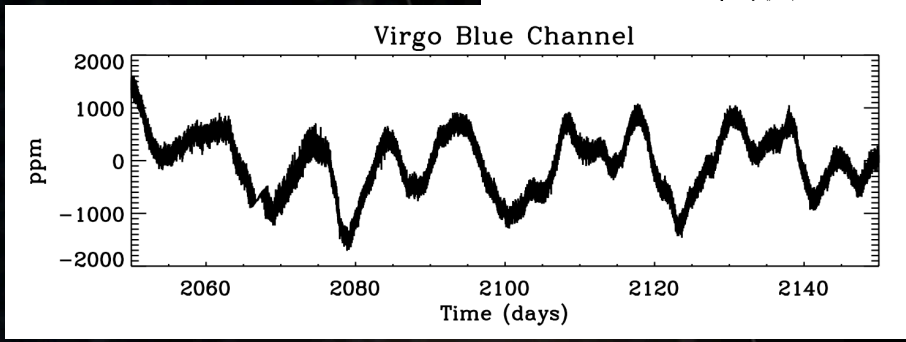
# METHODOLOGY

- We study the signature in the light-curve of stellar spots crossing the visible disk of stars
  - Gives the surface rotation corresponding to the active longitudes
    - Allows to also determine the surface differential rotation

[e.g. CoRoT targets: Mosser et al. 2009, Mathur et al. 2010…]






Solar Activity Maximum

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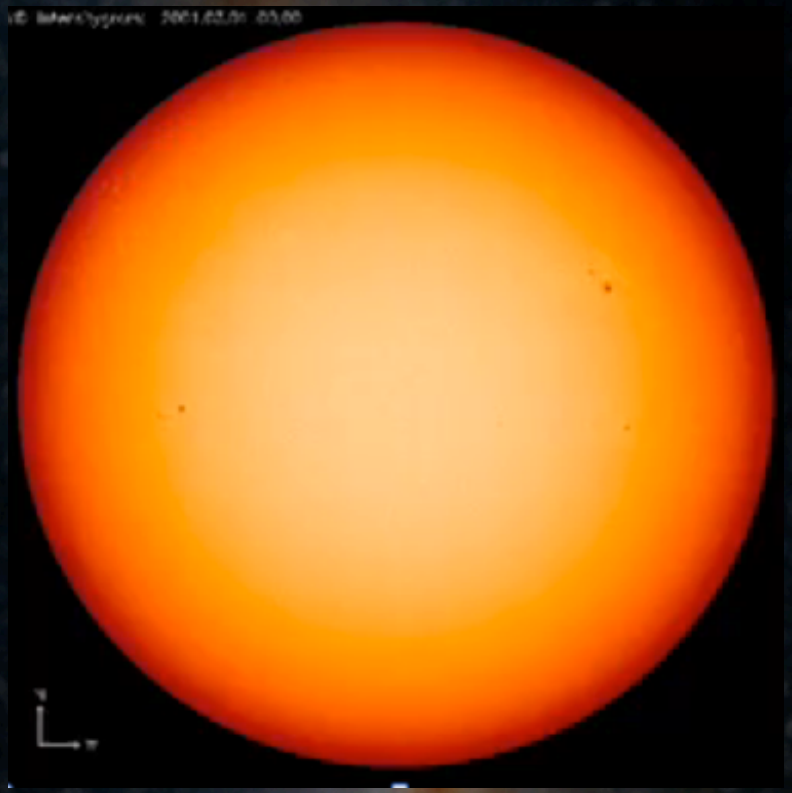
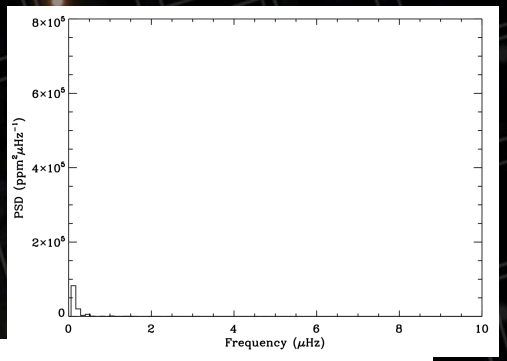
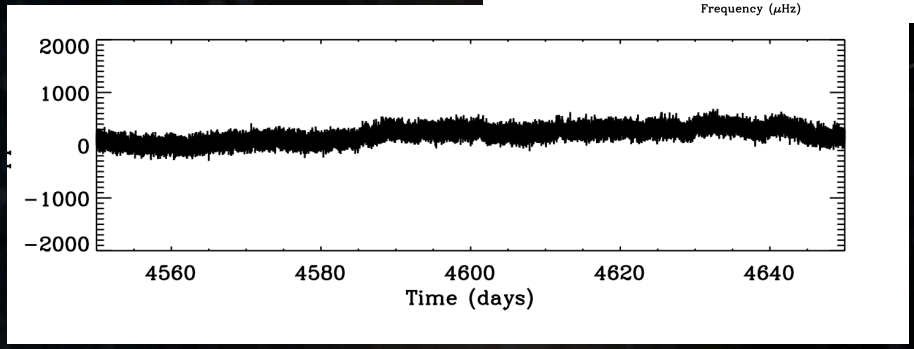
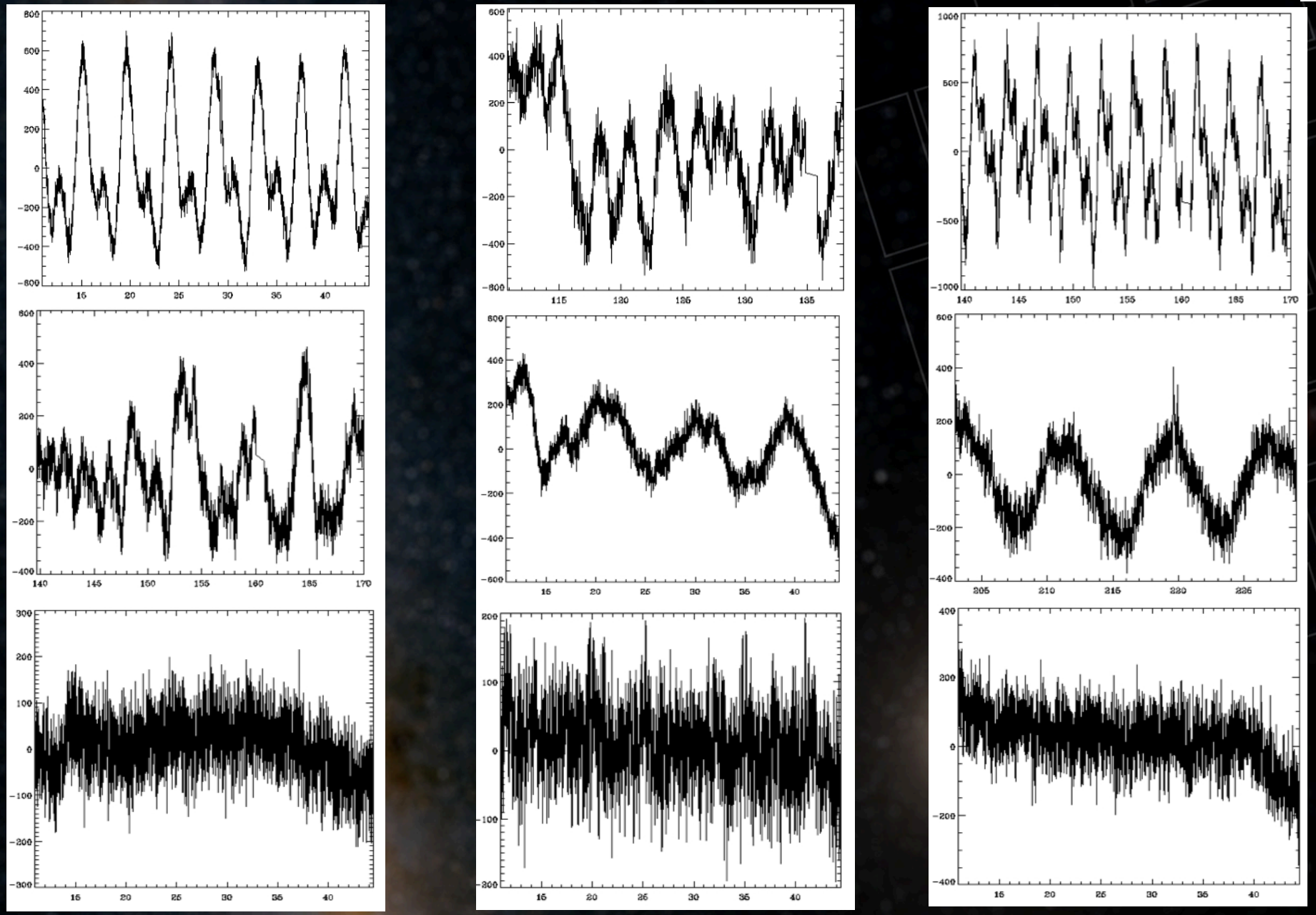


Solar Activity Minimum



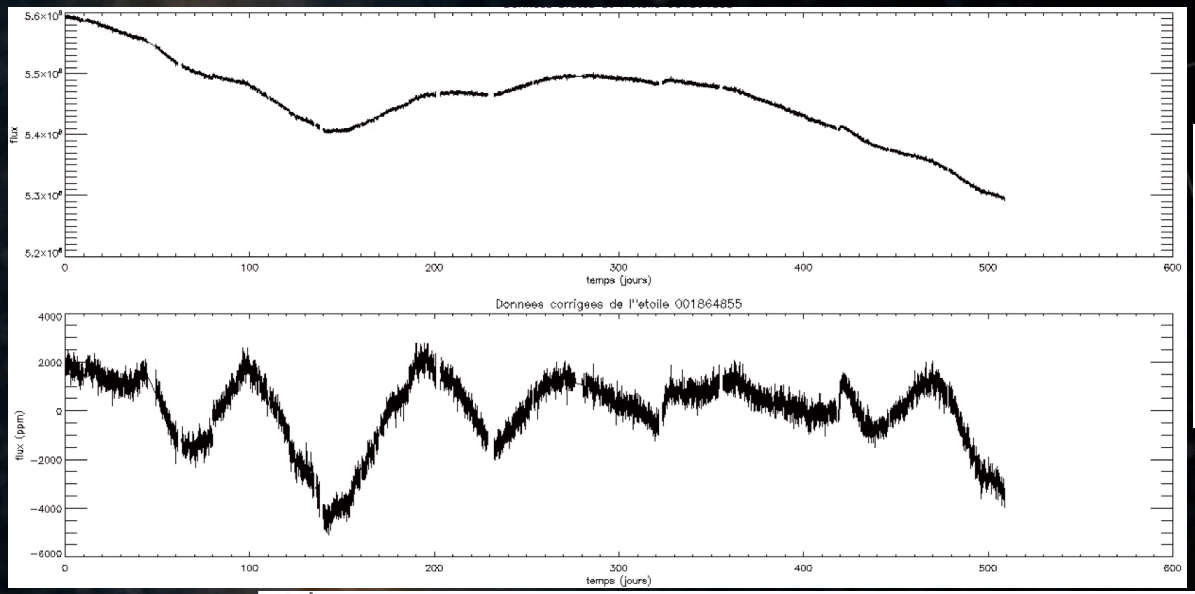



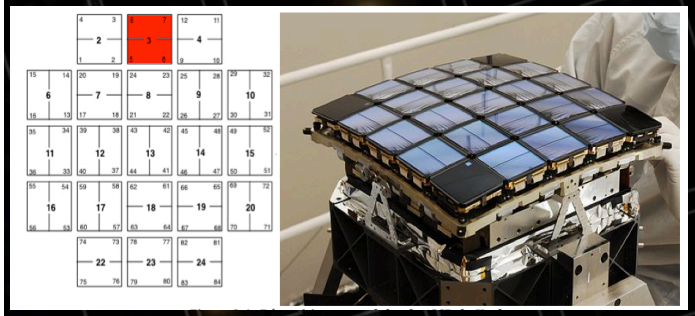
# EXAMPLE OF *KEPLER* LIGHT CURVES (S-L S)

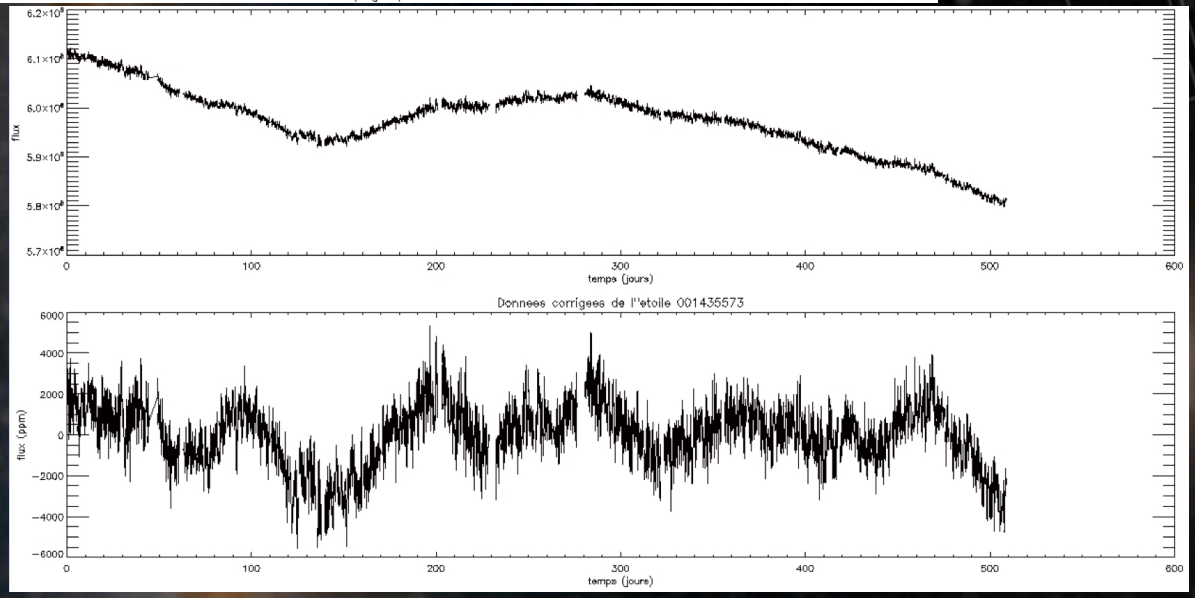


# STABILITY OF *KEPLER* LIGHT CURVES

- Long frequency trends are similar for different stars in the same module (RG LC)

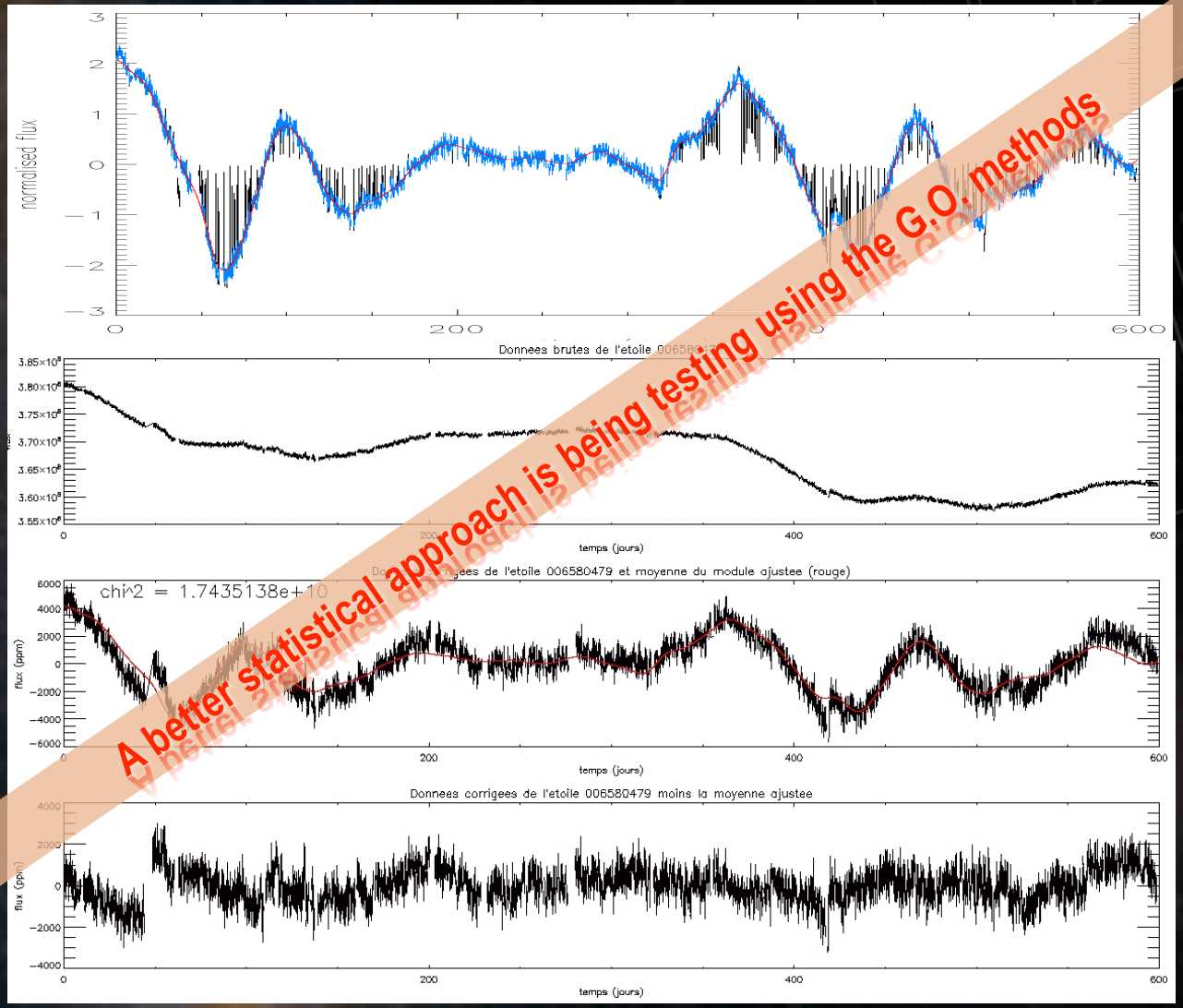


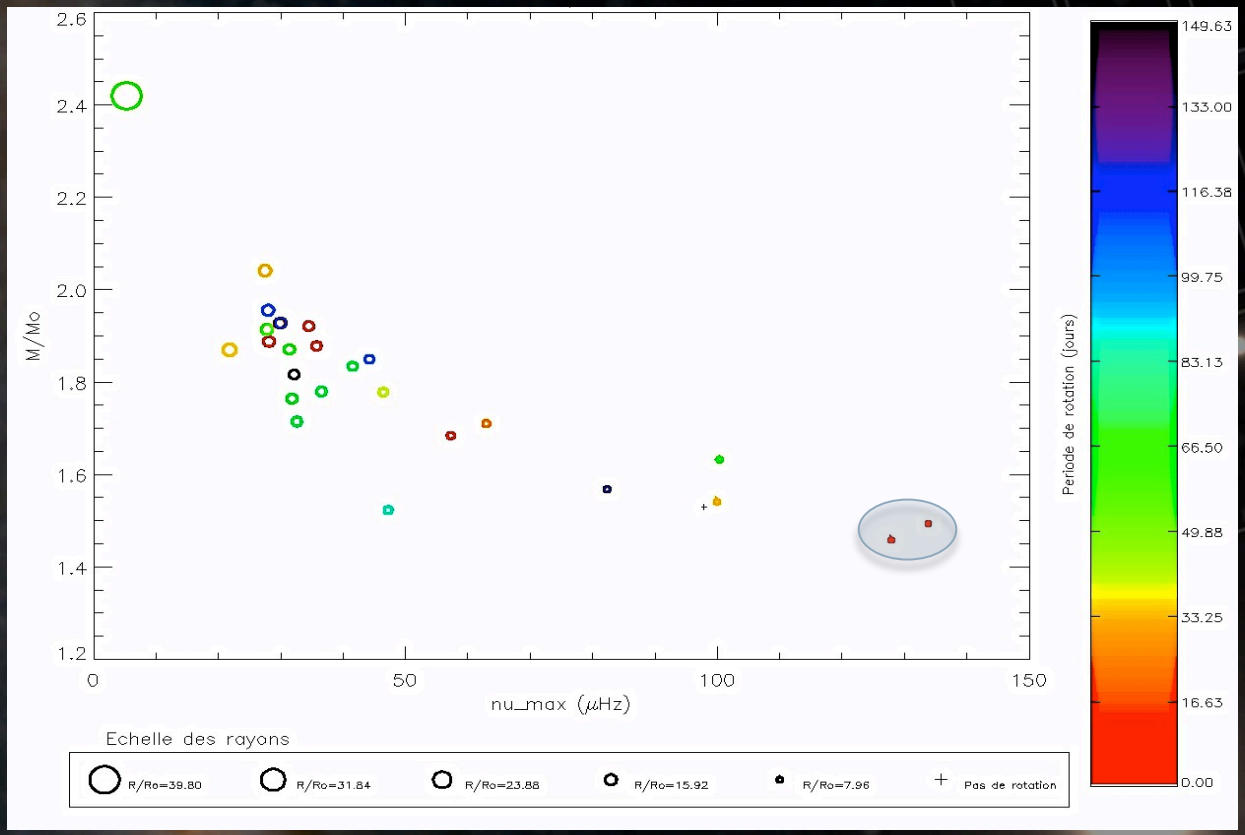


# STABILITY OF *KEPLER* LIGHT CURVES

- We use the RG LC data to determine the common, long period, signal in each module
  - ~60 stars per sequence of modules.



# SURFACE ROTATION IN RED-GIANT



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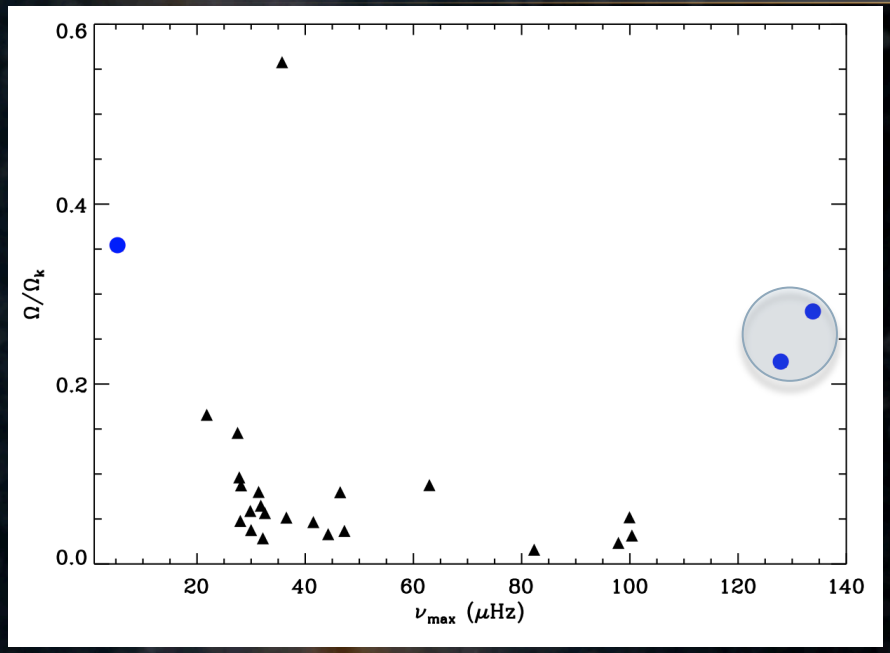
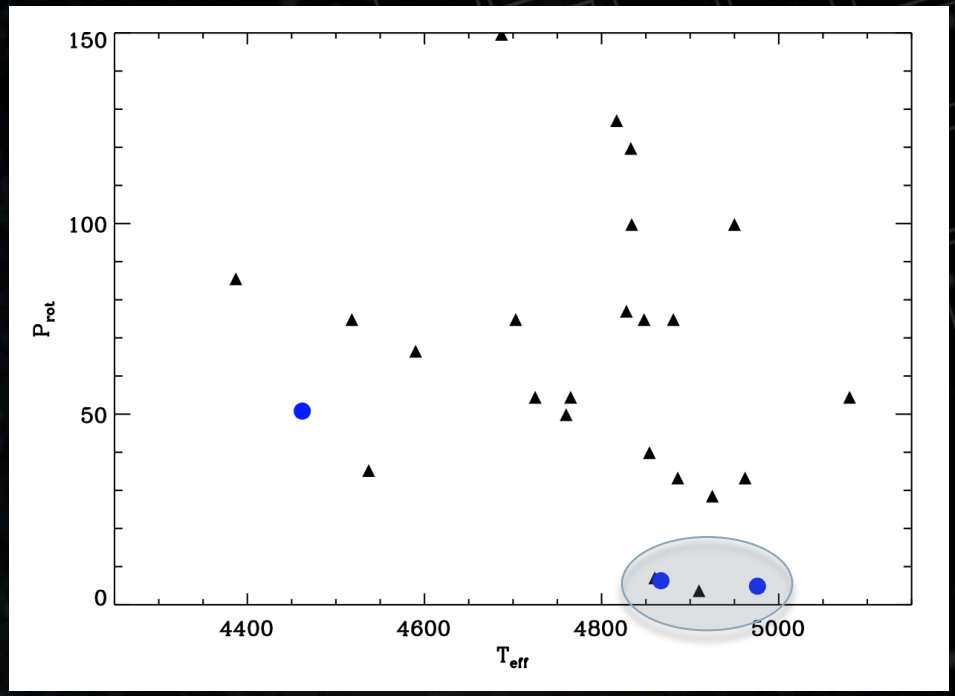
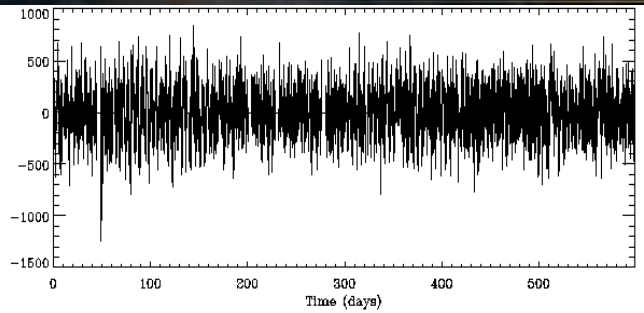
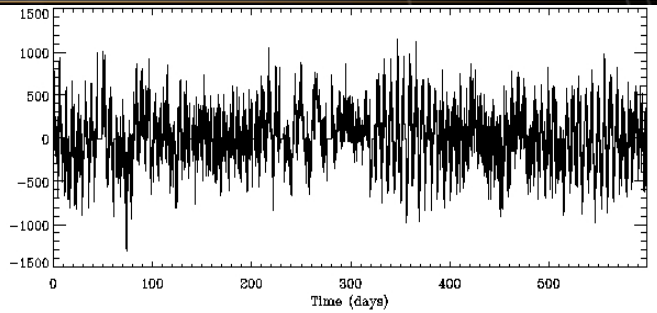
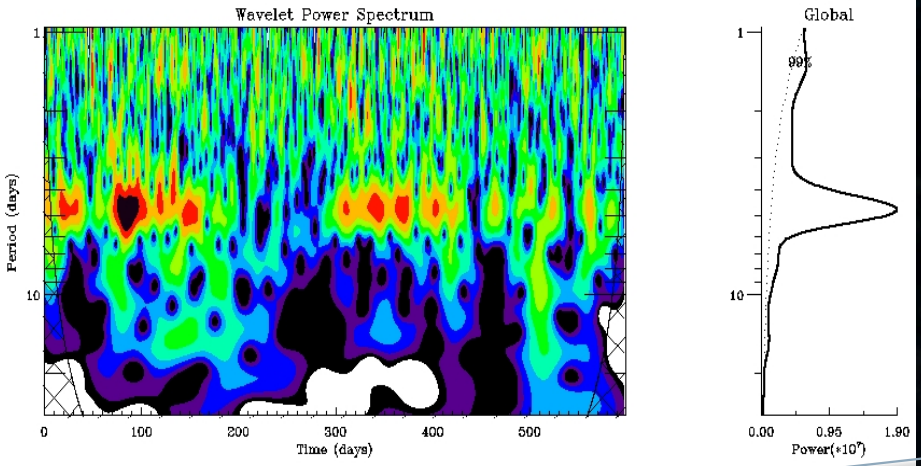


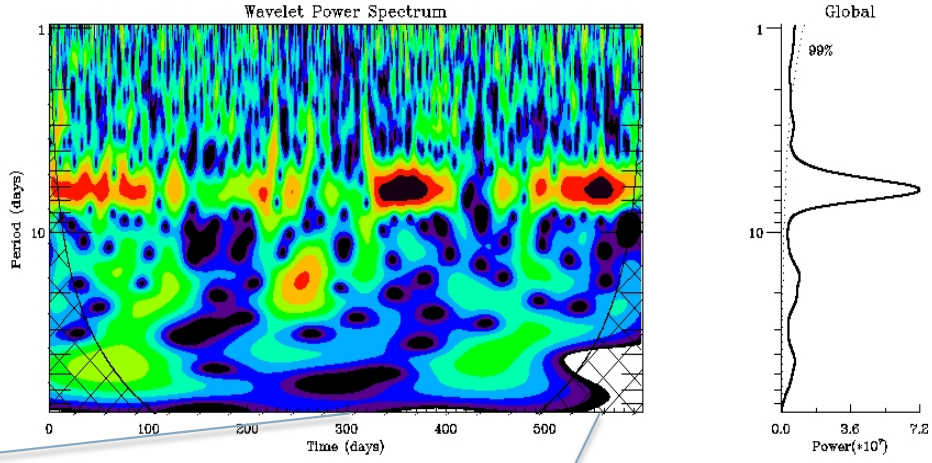



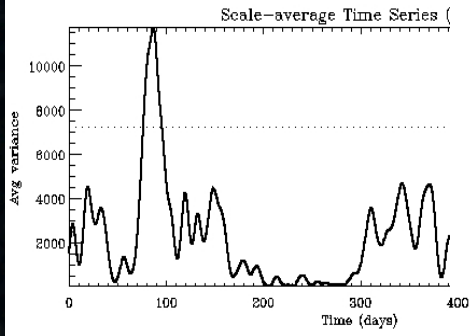
# FAST SURFACE ROTATORS (<7 DAYS)

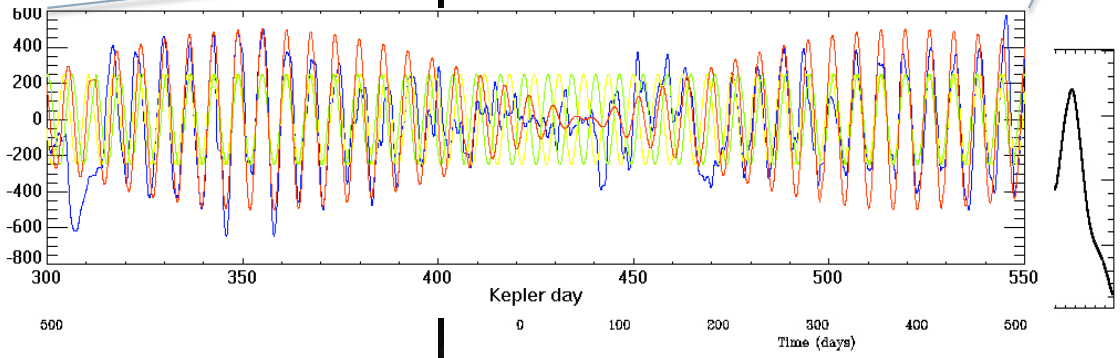


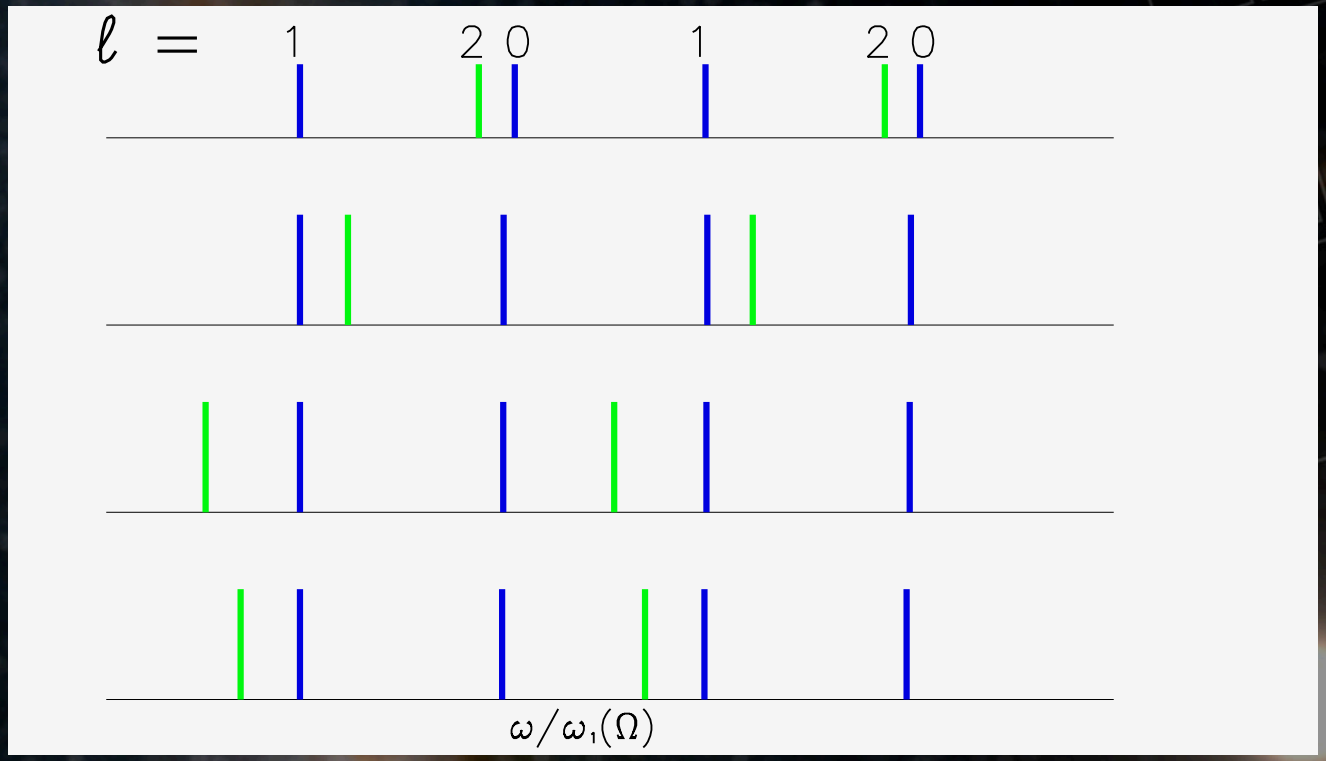




Period =6.2days

$\nu$ =1.85$\mu$Hz

# SURFACE ROTATION IN RED-GIANT

- The surface is rotating at 20-30% break up velocity
- If the interior spins at these velocities
  - There should be structural changes in the position of the frequencies ($d_{02}$ >>)




[F. Lignieres, based on Reese 2008]

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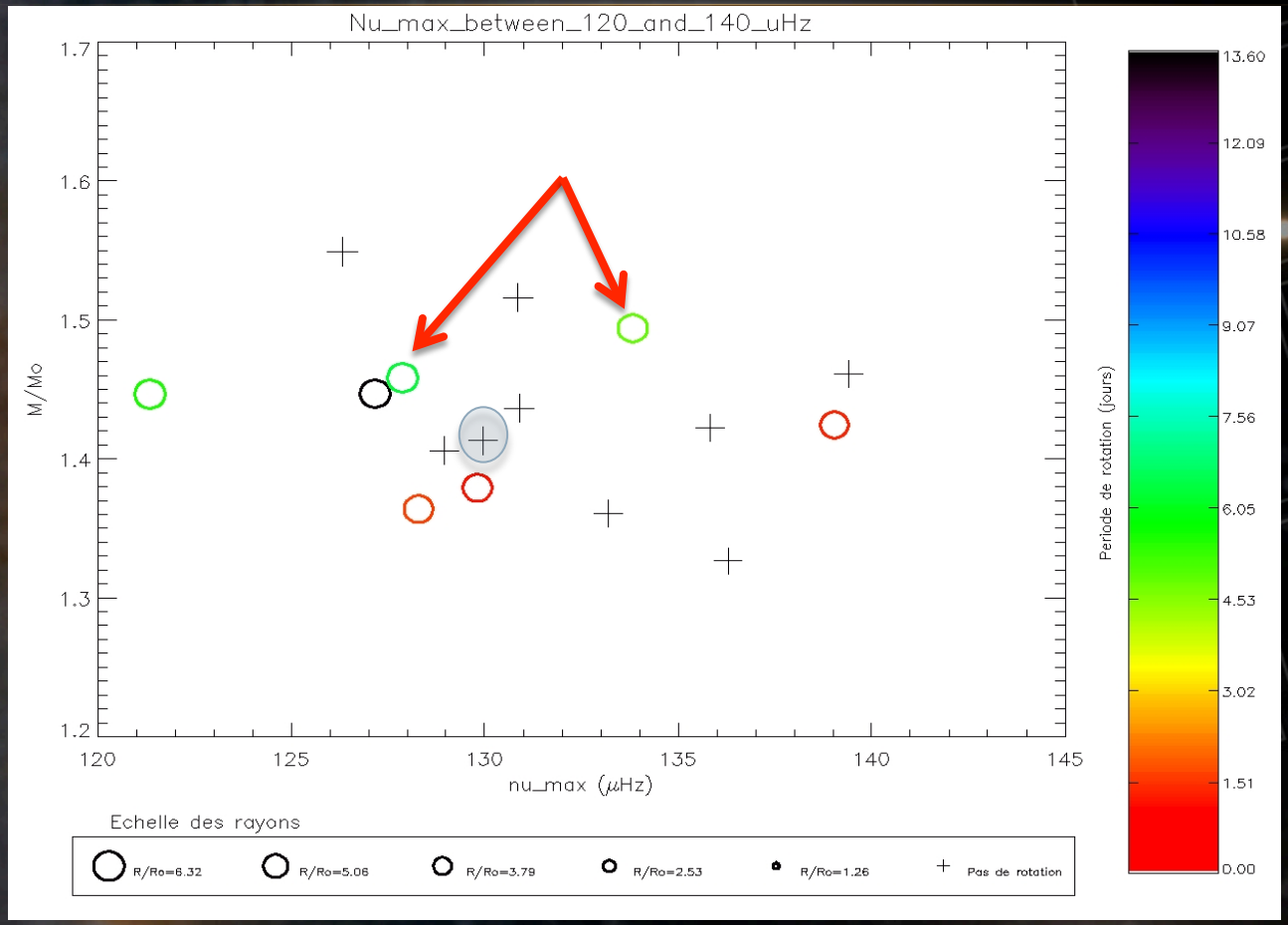
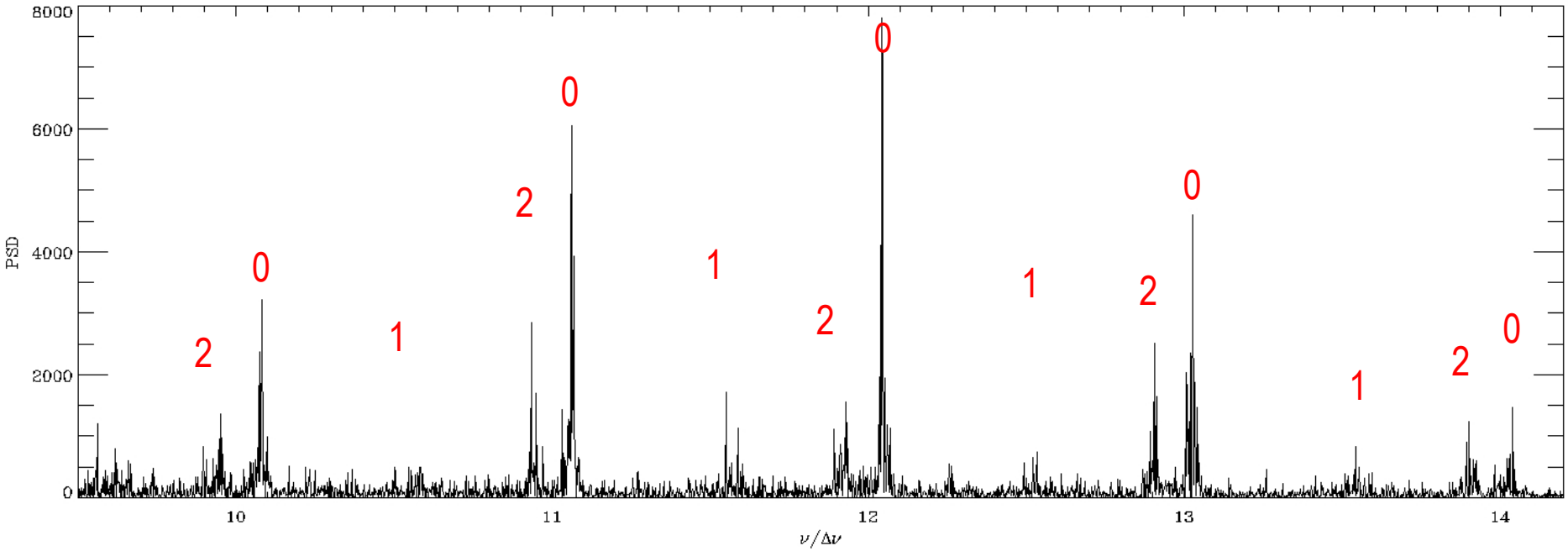



- Stars showing fast surface rotation
- Comparison star with no clear surface rotation (RGB)
- Stars with
  - $M/M_{\odot}$~1.4-1.5
  - $R/R_{\odot}$ ~6.1

# FAST SURFACE ROTATORS (<7 DAYS)




- Stars with slow surface rotation show a complicate l=1 structure
  - Many mixed modes
- Fast surface rotators
  - L=0, 2 in the same positions
  - L=1 ridge with very small visibility

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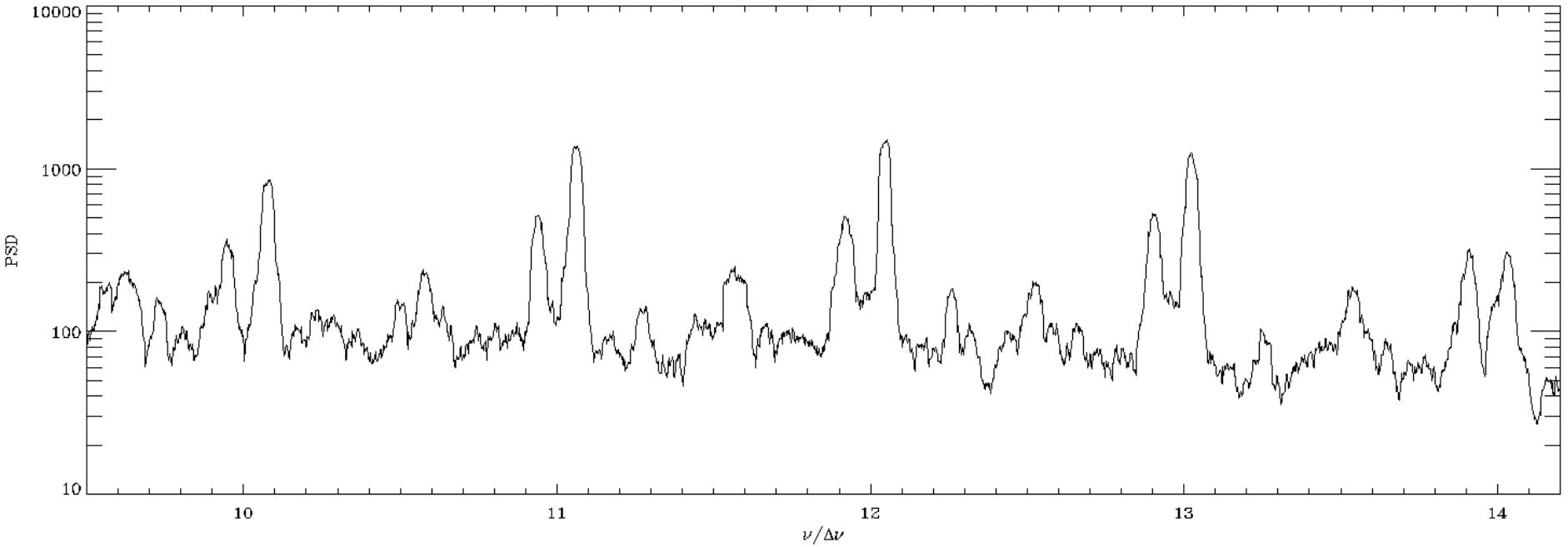


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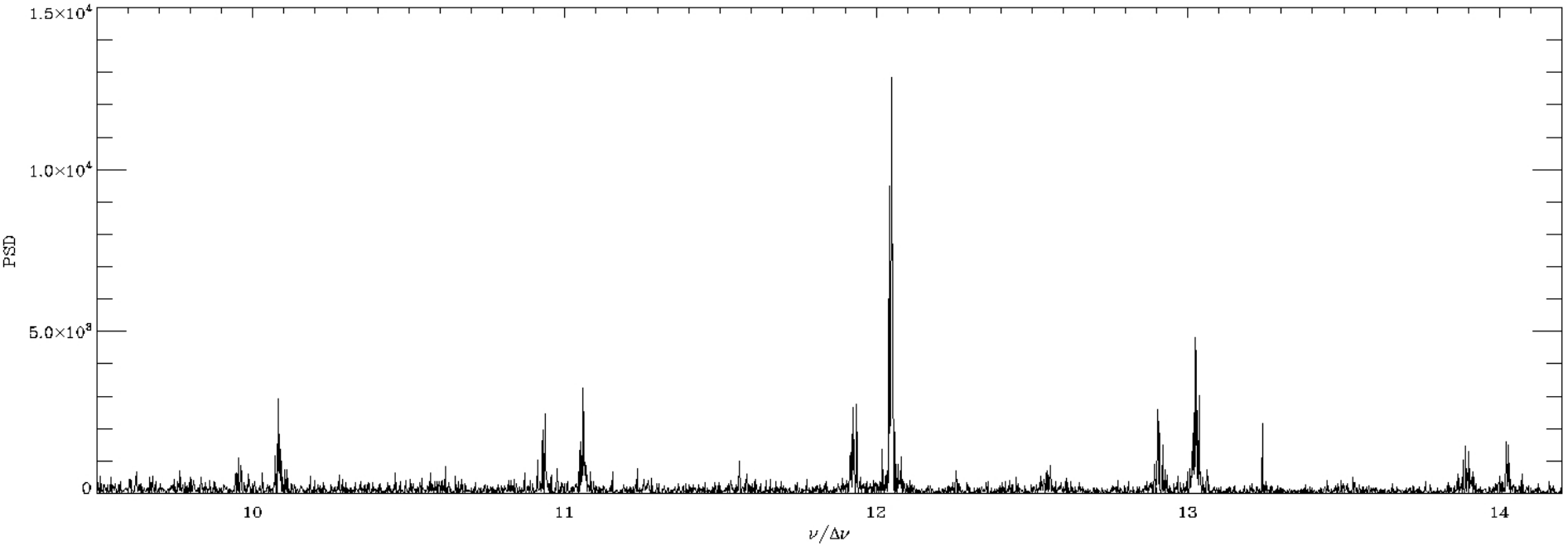
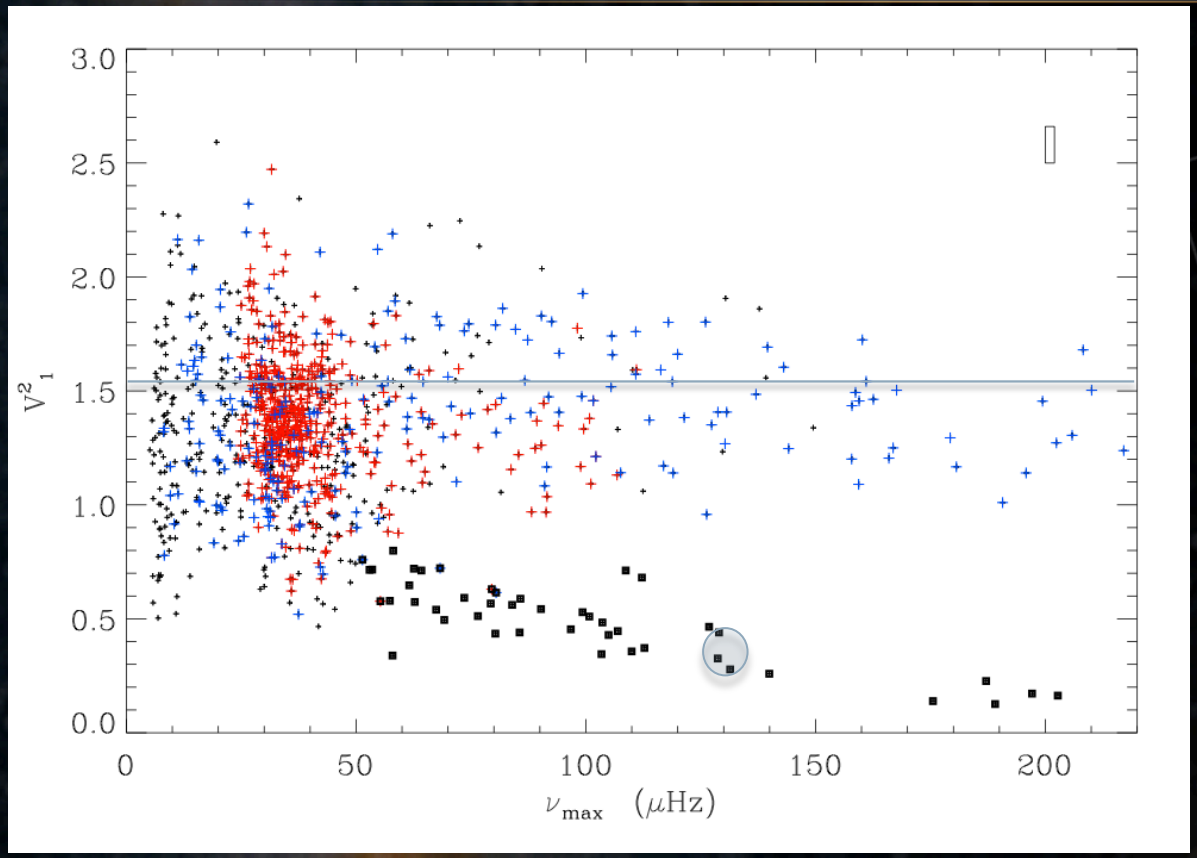
# KIC 3443483




- Apart from the reduced visibility of the l=1 modes
  - Frequencies of modes as expected => Slow internal rotation
  - Vsini~9 ± 0.5 km/s => i~ 9°
  - Fast surface rotation and slow internal rotation => Merger with small object that dissolves in the atmosphere

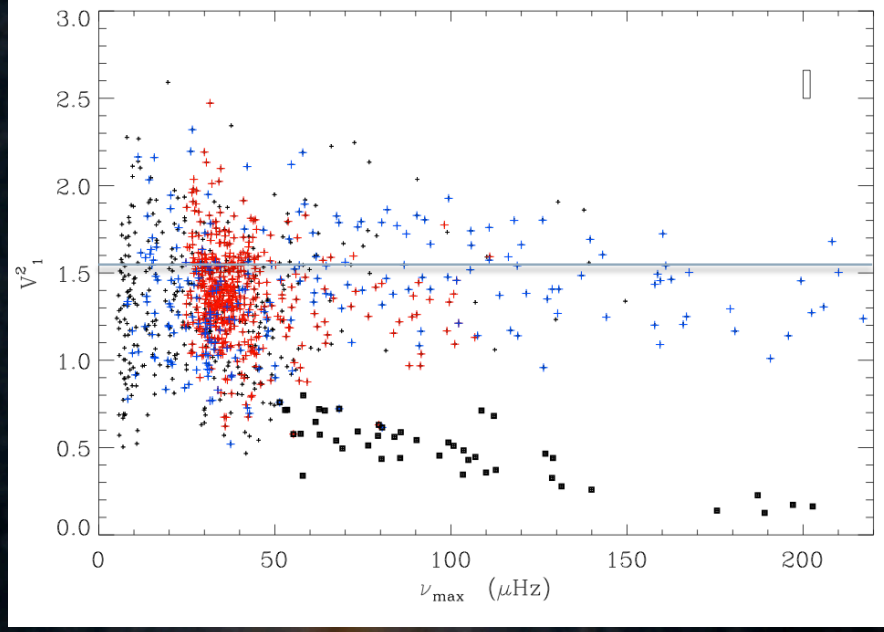
# PROBLEM WITH L=1 MODES

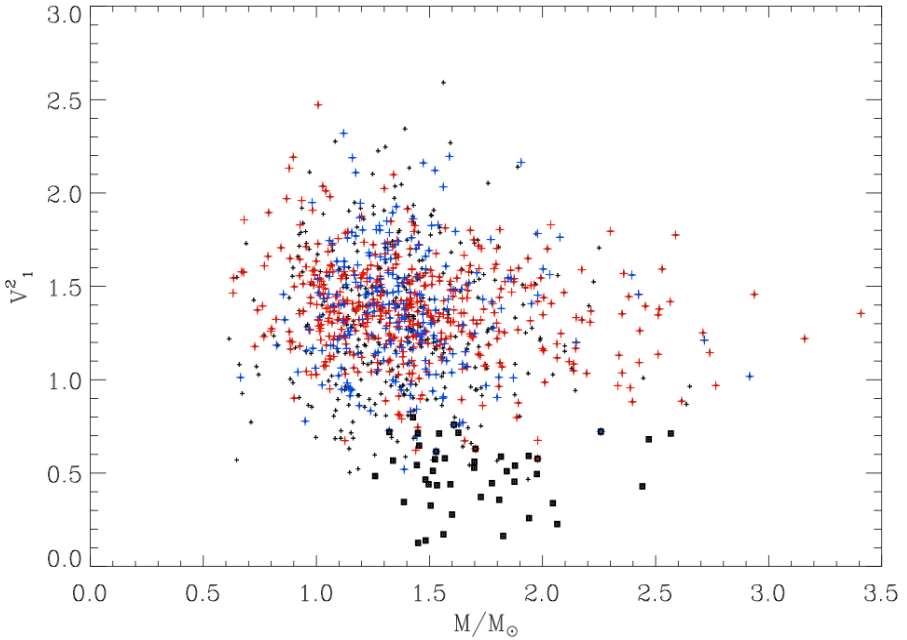


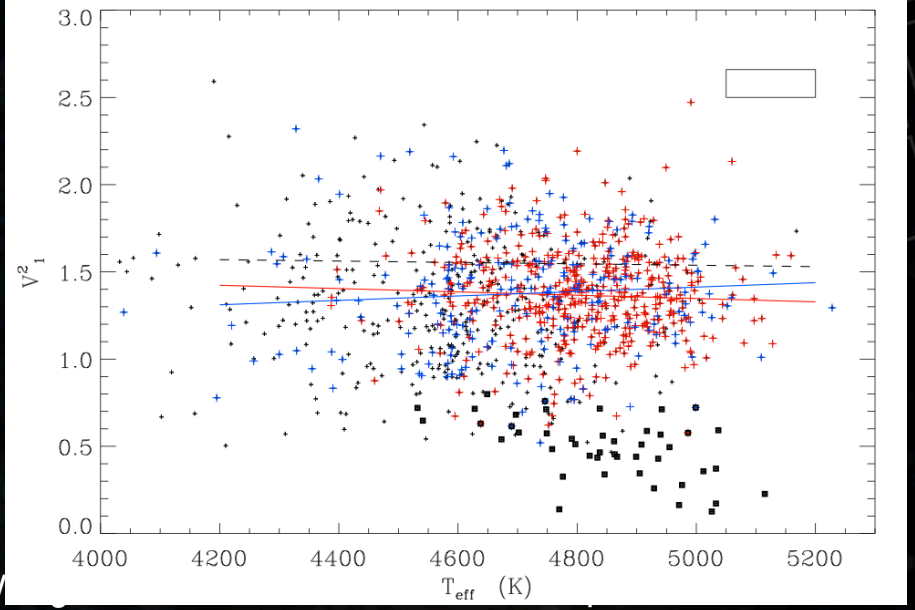

[Mosser et al. 2011 in press]

- Lower limit at about ~50 μHz
- 3 S-L observed up to $v_{max}$ ~ 488 μHz
- Possible explanation:
  - very efficient coupling p-g mode => very high mode mass, low surface amplitudes

# PROBLEM WITH L=1 MODES

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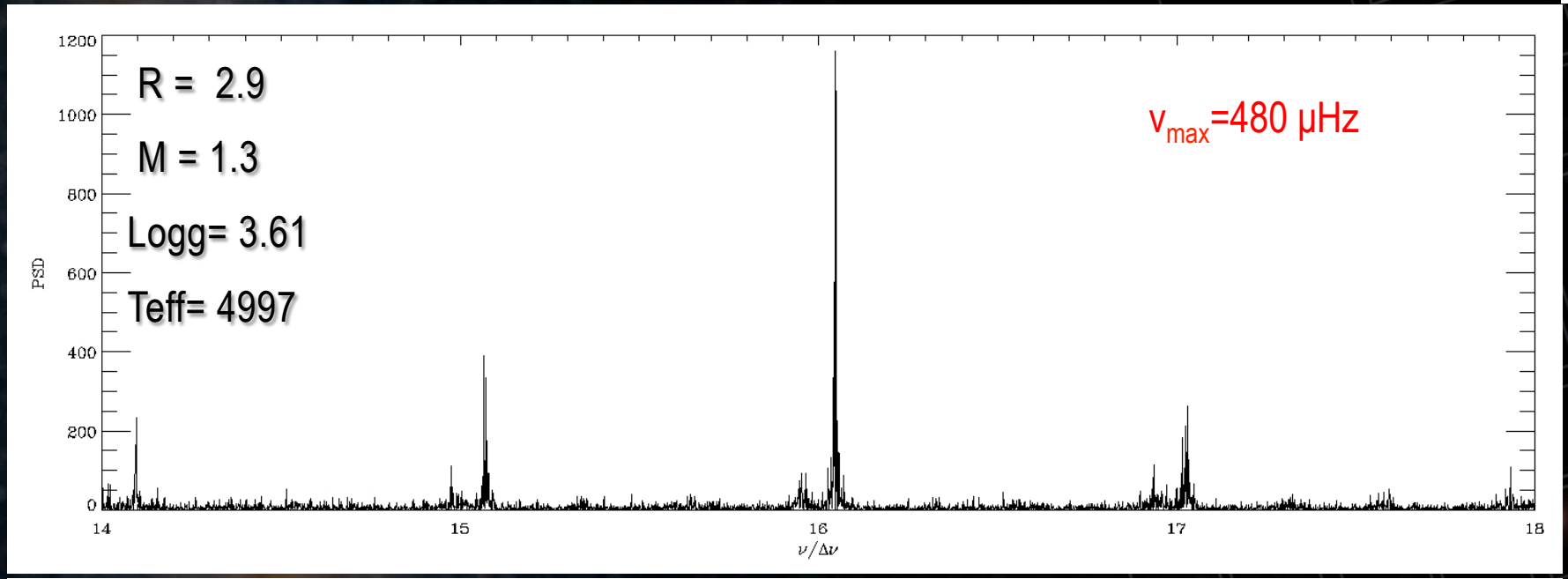
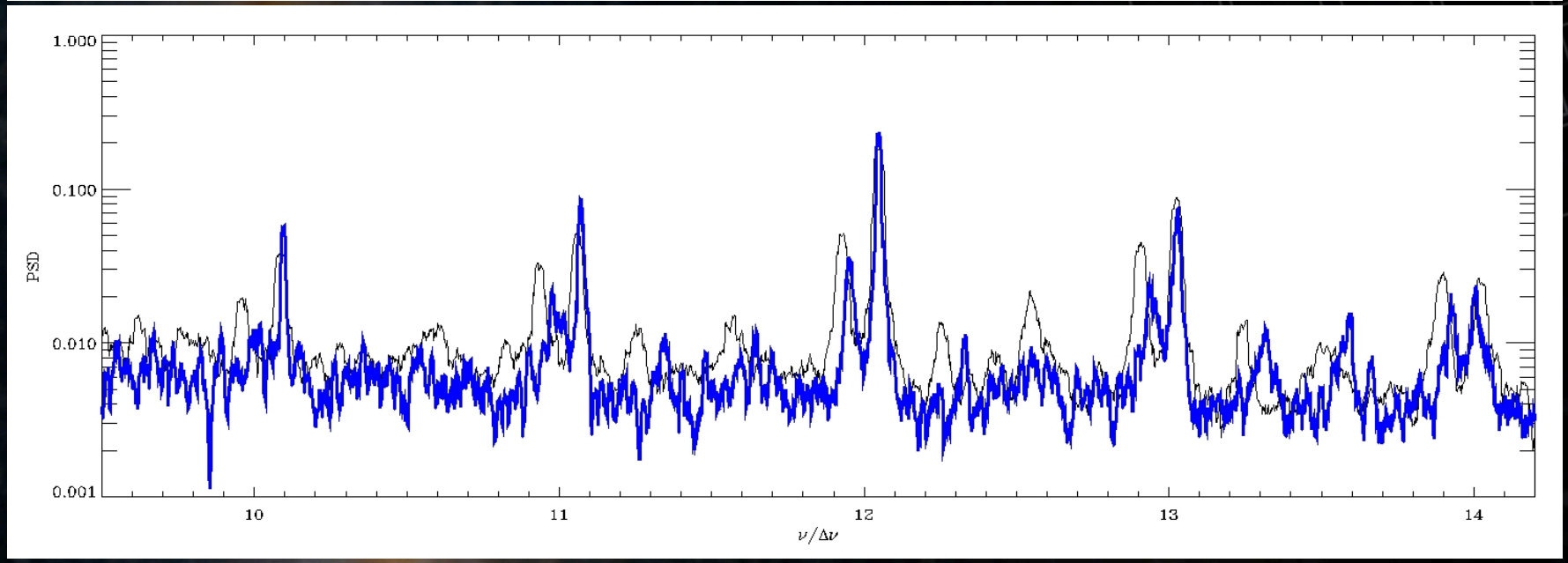
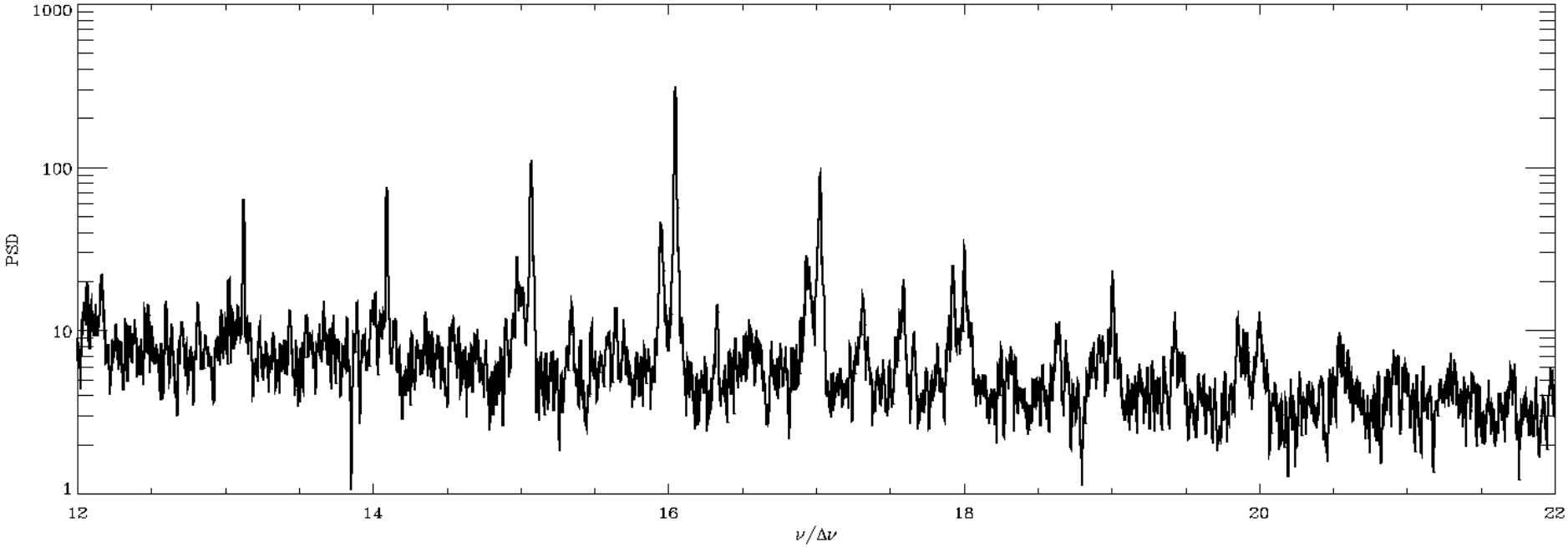
# HIGHEST NU_MAX STAR (WG#1)






- At high frequency (n>17)
  - L=1 modes appear with a high (Normal?) visibility at higher frequencies?

# CONCLUSIONS

- Two effects seems to be unconnected
- Missing l=1
  - Related to better coupling, bigger mode inertia?
  - Relation $V^2_1$ α ($\nu_{max}$)
  - Star with $\nu_{max}$ = 480 μHz shows some normal $V^2_1$ at higher frequency
- High surface rotation
  - Merger of a smaller objects. Can it be constraint?
  - What do we need:
    - Spectroscopic measurements (on-going)
    - NARVALobservations scheduled (1 star)
    - What test can we do?


THANKS