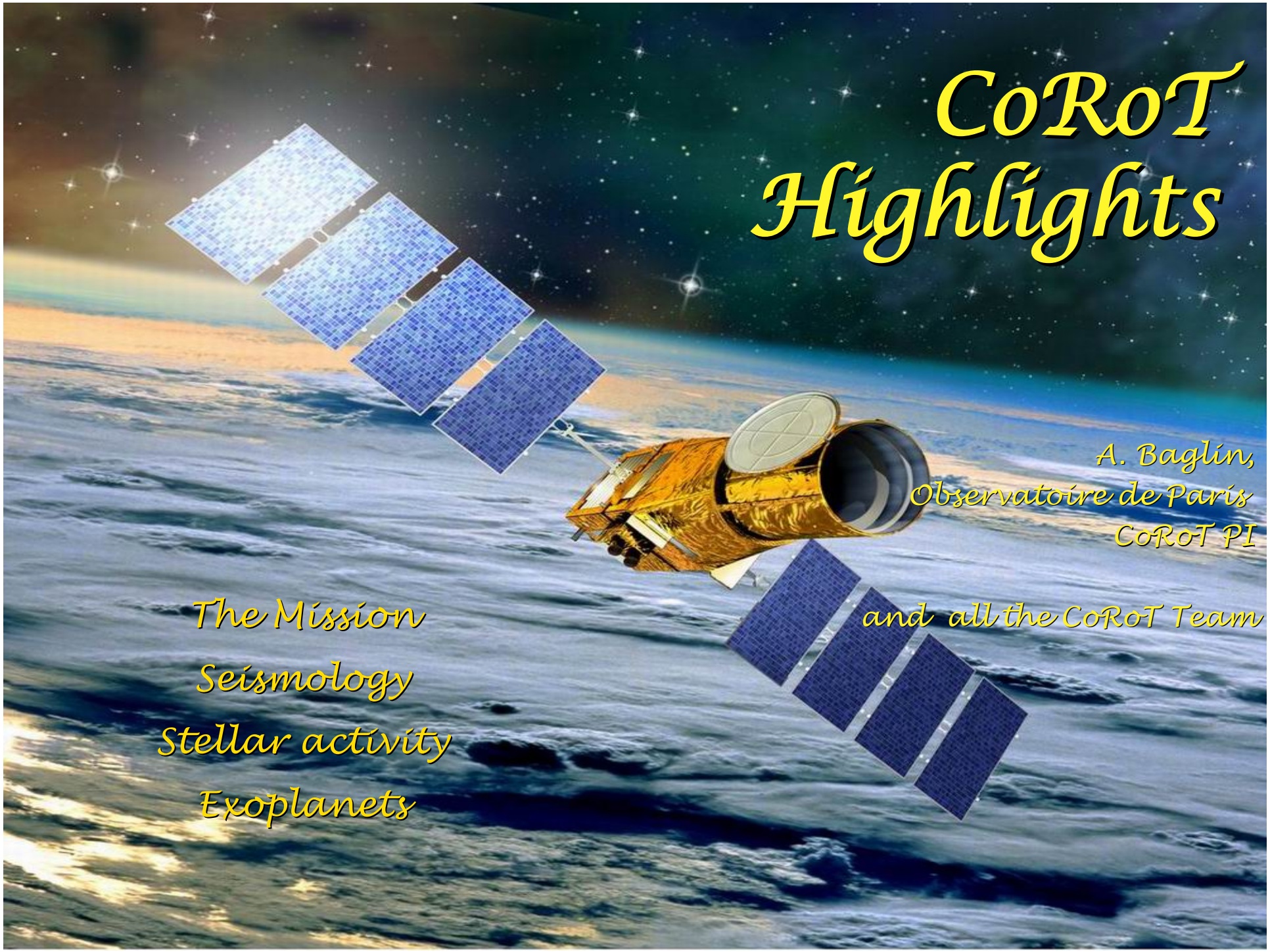

CoRoT
Highlights
A. Baglin,
Observatoire de Paris
CoRoT PI
and all the CoRoT Team
The Mission
Seismology
Stellar activity
Exoplanets

What is CoRoT ?

A space mission built and operated by CNES (France)
with ESA, Austria, Belgium, Brazil, Germany and Spain

Stellar ultra high precision relative photometry

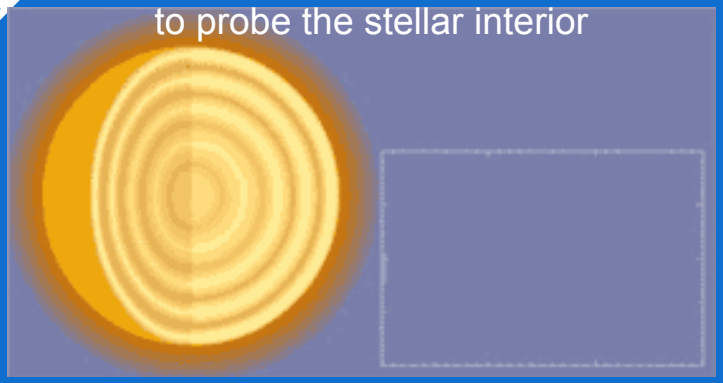
2 major Scientific

Programmes

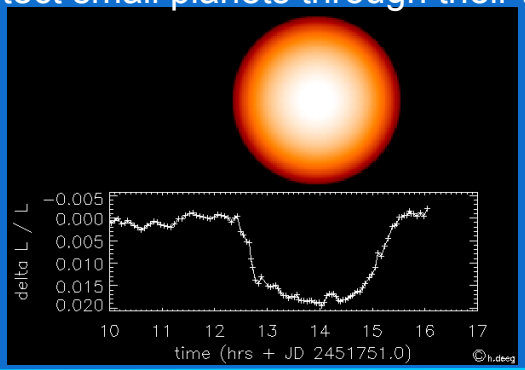
Same technical specifications

* Very high accuracy
  (1000 times better)
* Very long duration of observation
  of the same star ~150 days
* Very high duty cycle (> 90 %)

Detect stellar oscillations like in the Sun
to probe the stellar interior

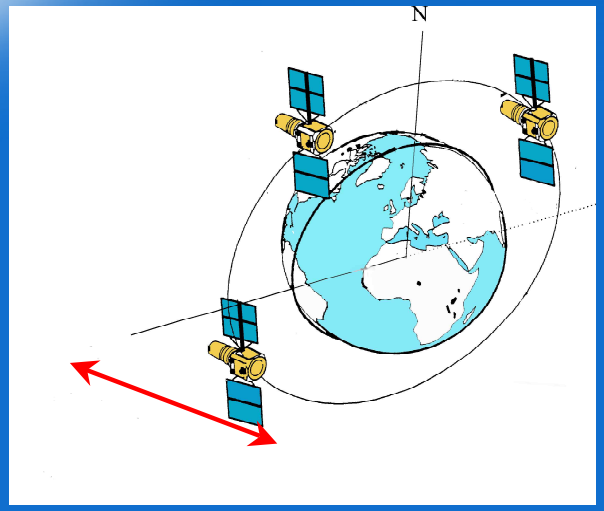


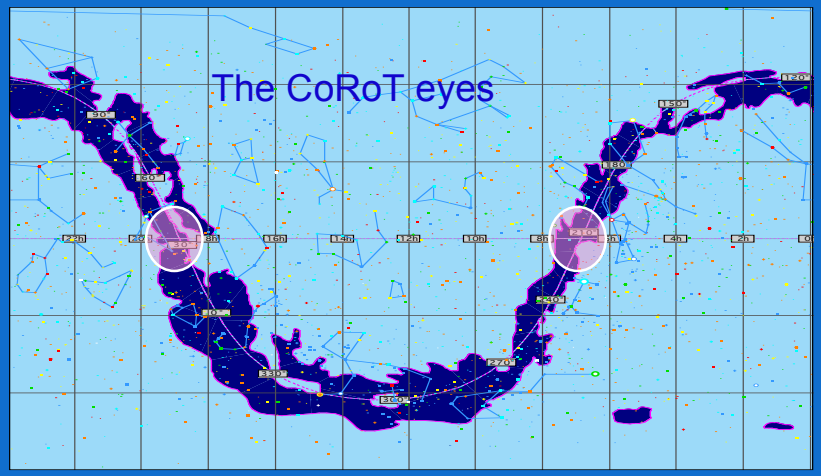
Detect small planets through their transit



The mission profile

Polar
orbit
at 896 km





Intermediate
size
mission

160 M$

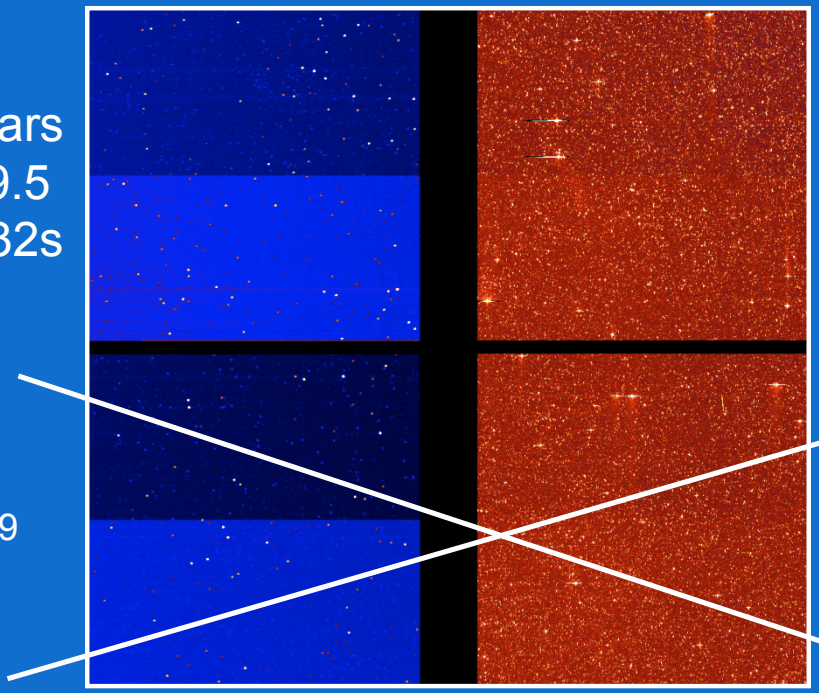
600 kg

The CoRoT focal plane

Camera with 4 detectors

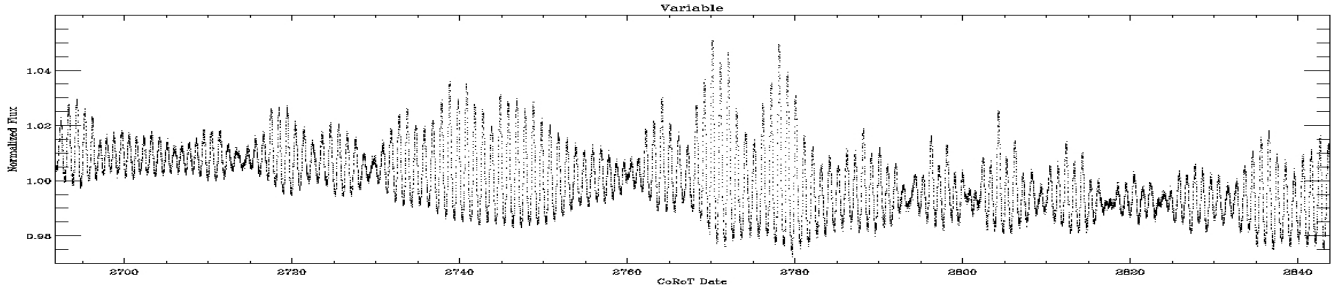
114 bright stars (+40)
110 000 faint ones (+40 000)

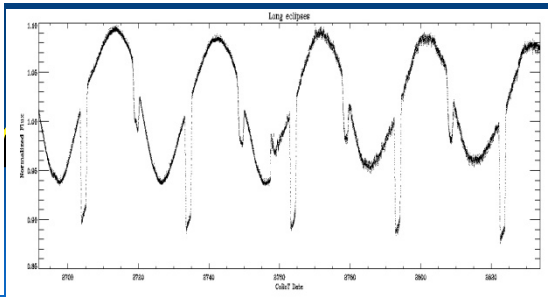
10 bright stars
V : 5.5 to 9.5
at 32s

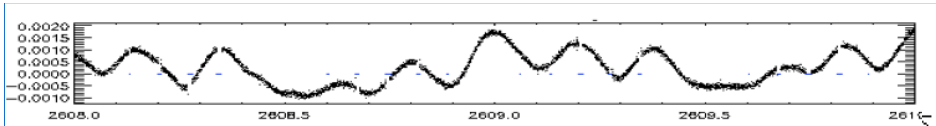


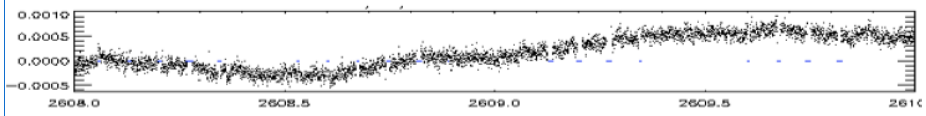
12 000
Faint stars
R : 10 to 16
At 32 or 512 s

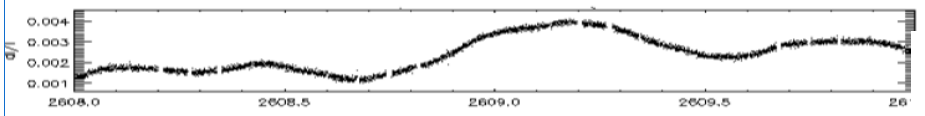
March 8 2009

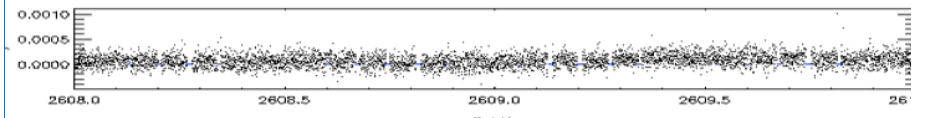

Variable
Normalized Flux
CoRoT Date

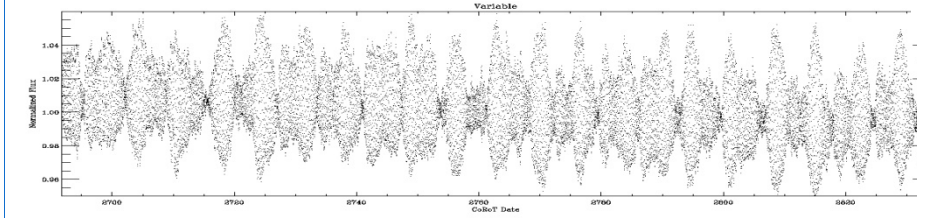

Long eclipses

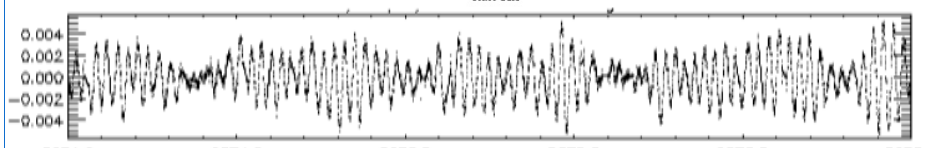


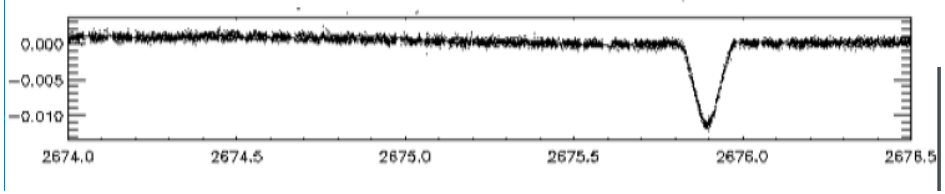


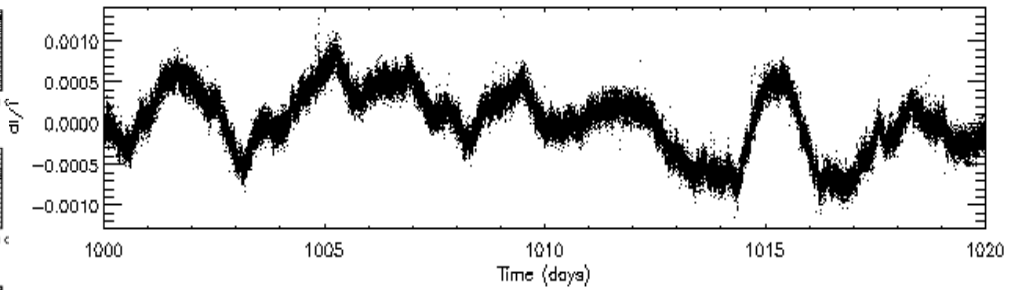


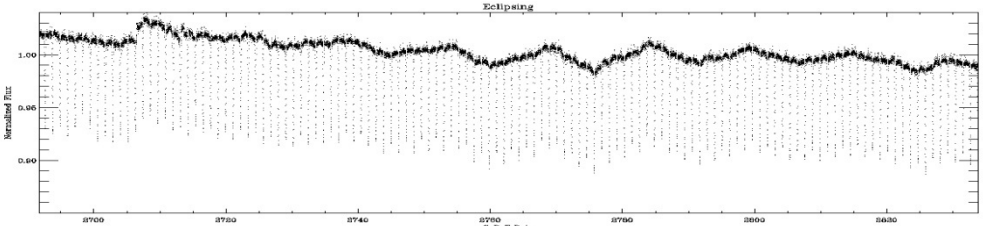


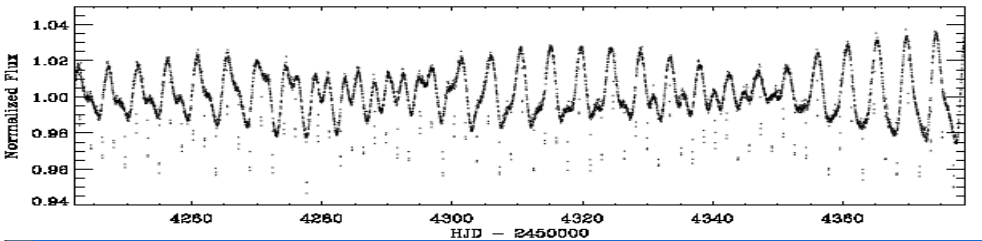

Variable
Normalized Flux
CoRoT Date

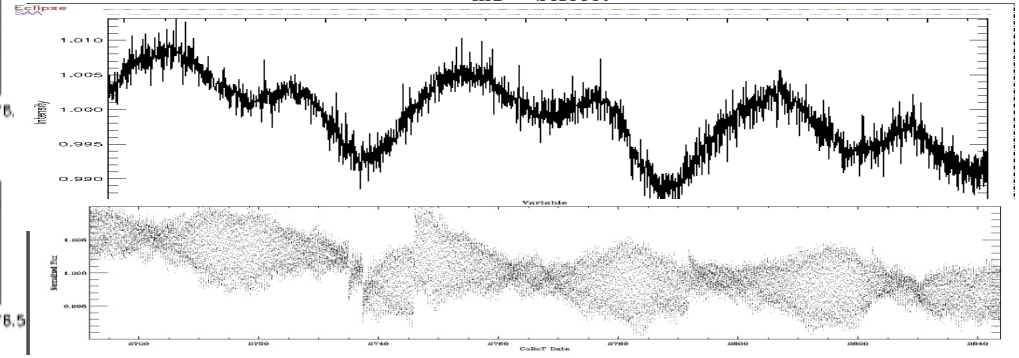





dI/I
Time (days)

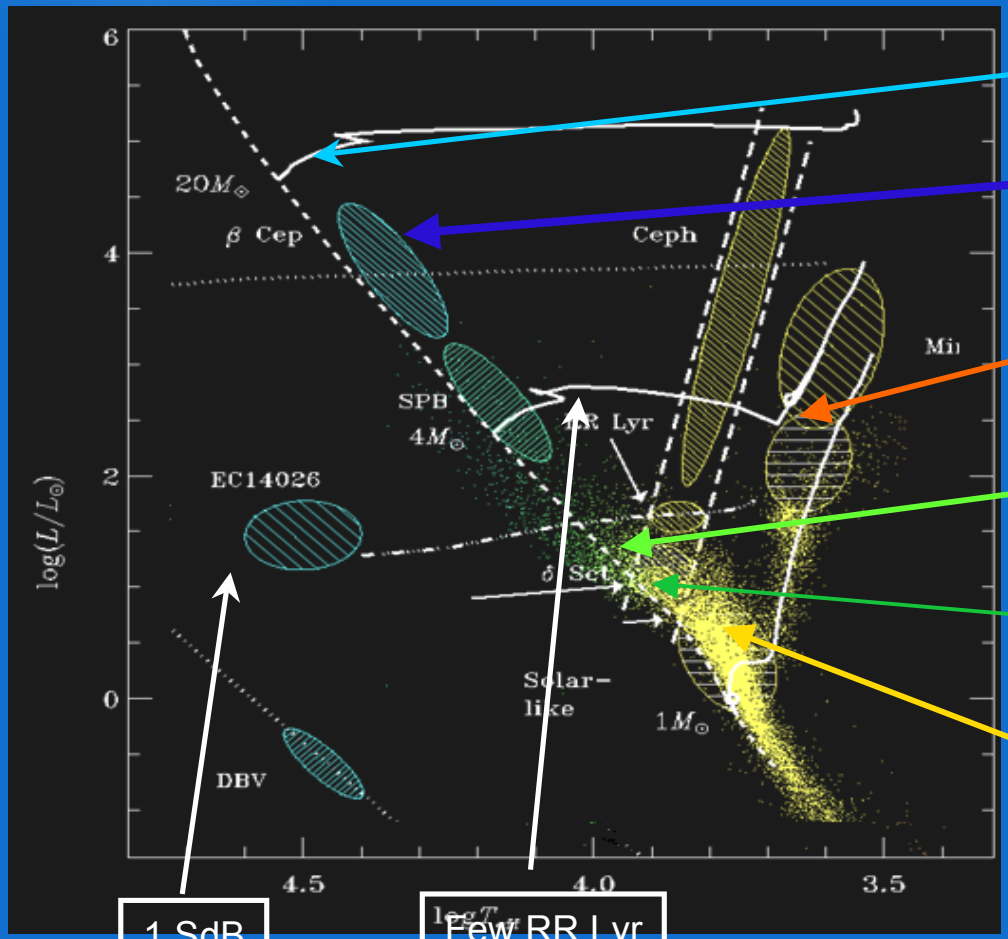

Eclipsing
Normalized Flux


Normalized Flux
HJD − 2450000


Eclipse
Intensity
Variable
Normalized Flux
CoRoT Date

The seismology targets

114 up to now + exofield….



8 O stars

16 B stars, 2Beta Ceph, 3 Be

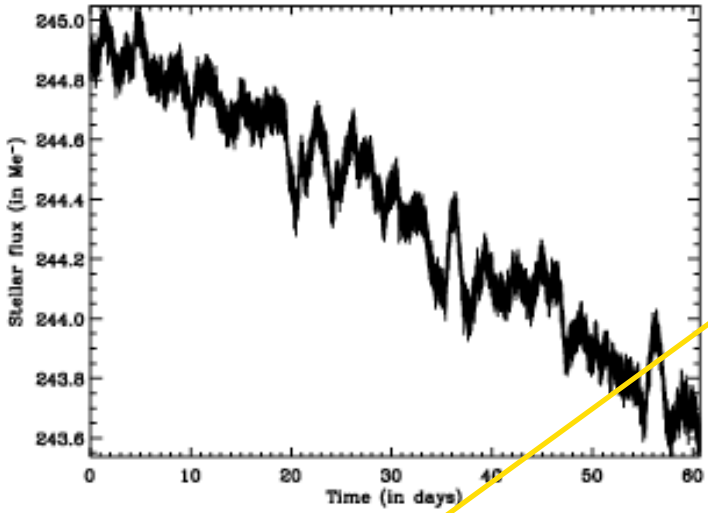
18 giants (K,G,F)

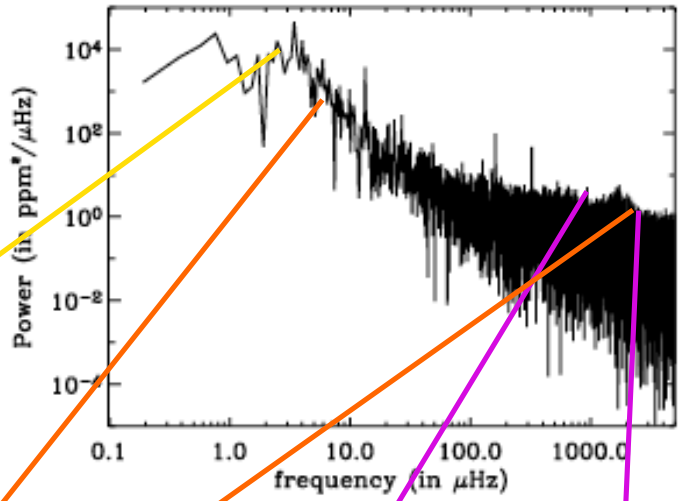
17 A/early F stars ? 2 Am, 8 Ap,

9 Delta Scuti, 3 known gam Dor

15 solar-like puls. cand. (one observed twice)

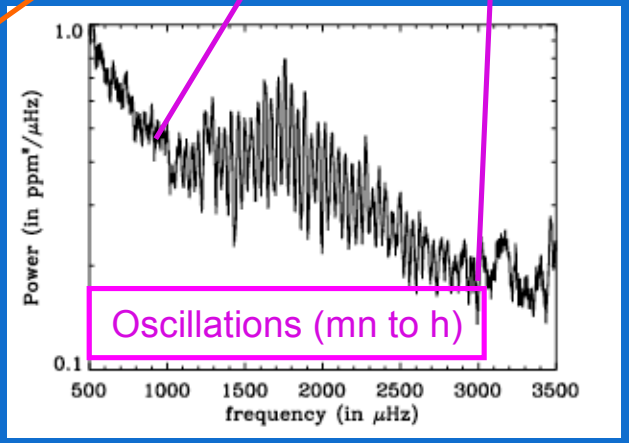
Analysis of the light curves in the Fourier space





Rotation (days)

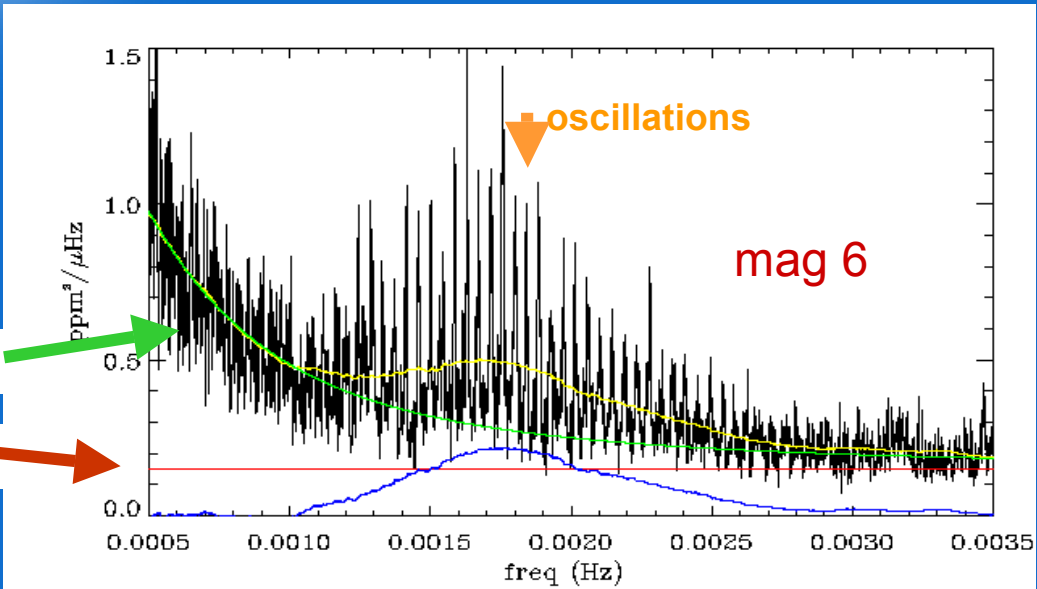
Granulation,
super granulation…
Magnetic activity

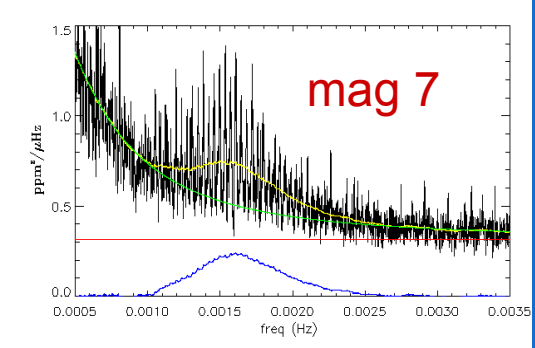


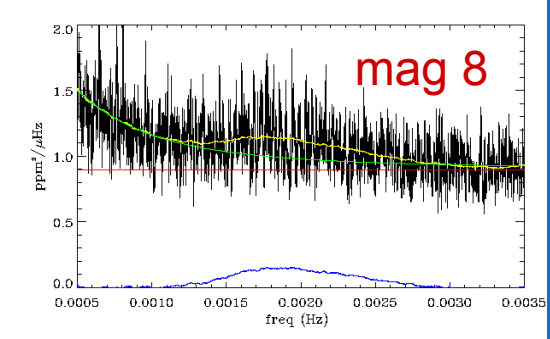
Detection of solar like oscillations in Solar analogs

granulation

White noise



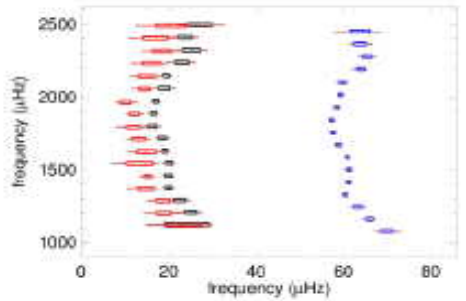




Spherical harmonics
n, l, m
Comb structure
n ~15 à 30
Around 1 to 3 mHz

Large separation $\Delta\nu$
small separation $\delta\nu$

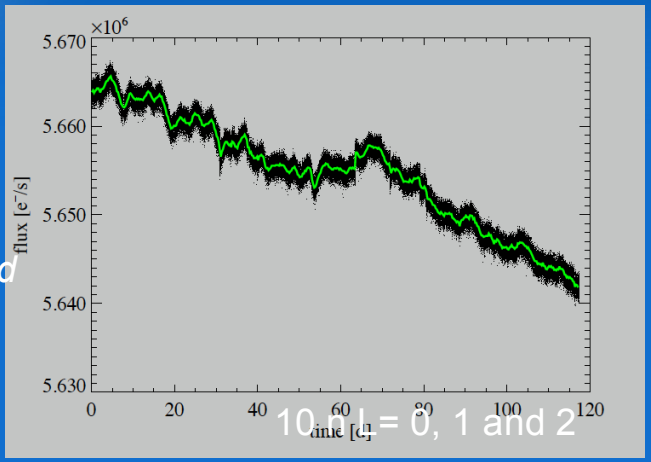
The double comb structure
And the « echelle diagram »



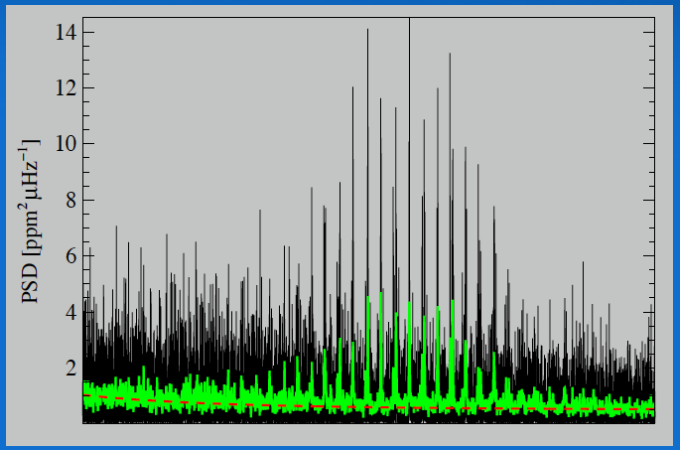
Michel et al. Science 2008
Benomar et al. A&A 506, 2009

In Cooler solar analogs

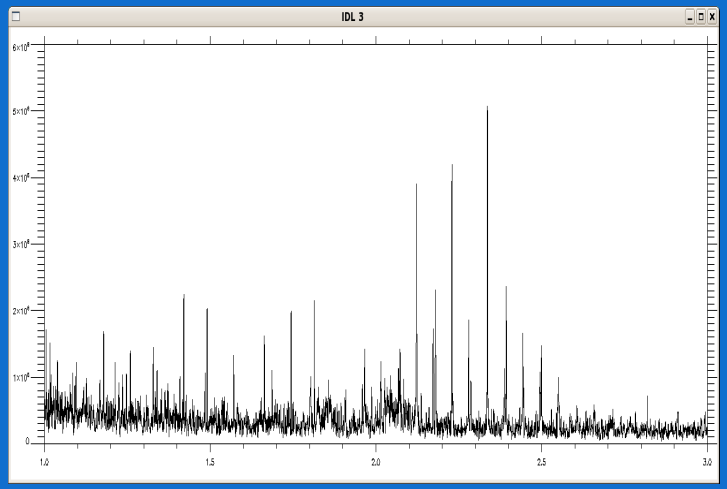
HD 52265
metal rich G0V star
Hosting a planet
Ballot et al. A&A submitted



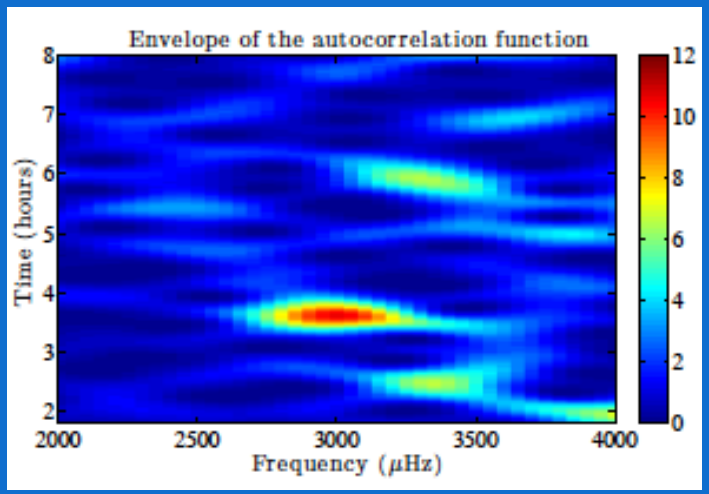
10 l l = 0, 1 and 2



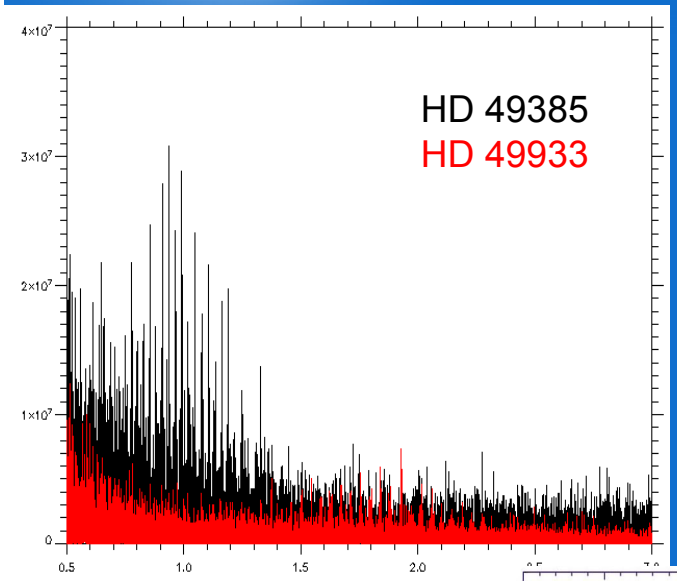
HD 43587, F9V, just observed now!



HD 46375, K0V, hosting a 3days planet
Δν ~135 μHz (Gaulme et al, A&A accepted))

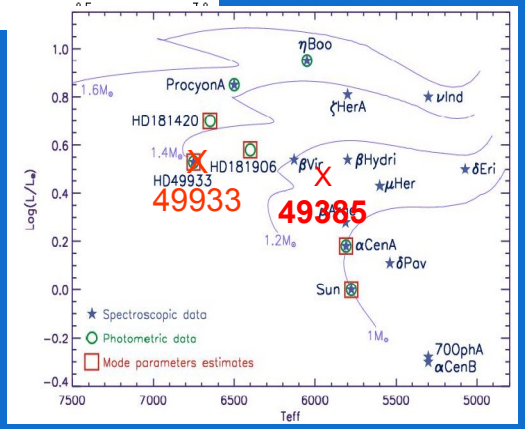


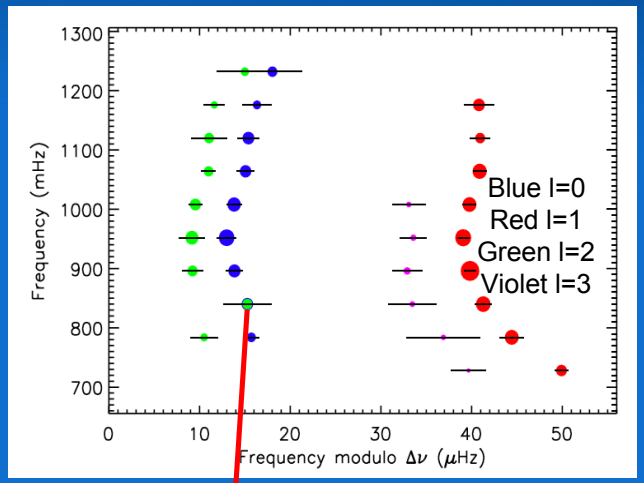
Off the MS



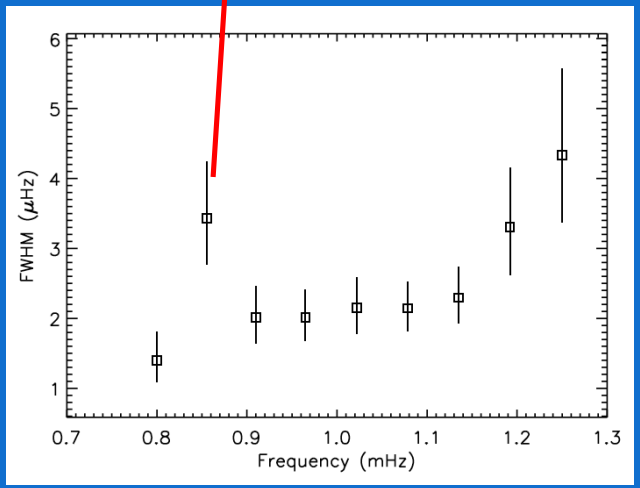
Large amplitudes
Brighter than the Sun
Vconv higher
Same T

Life time of the modes higher



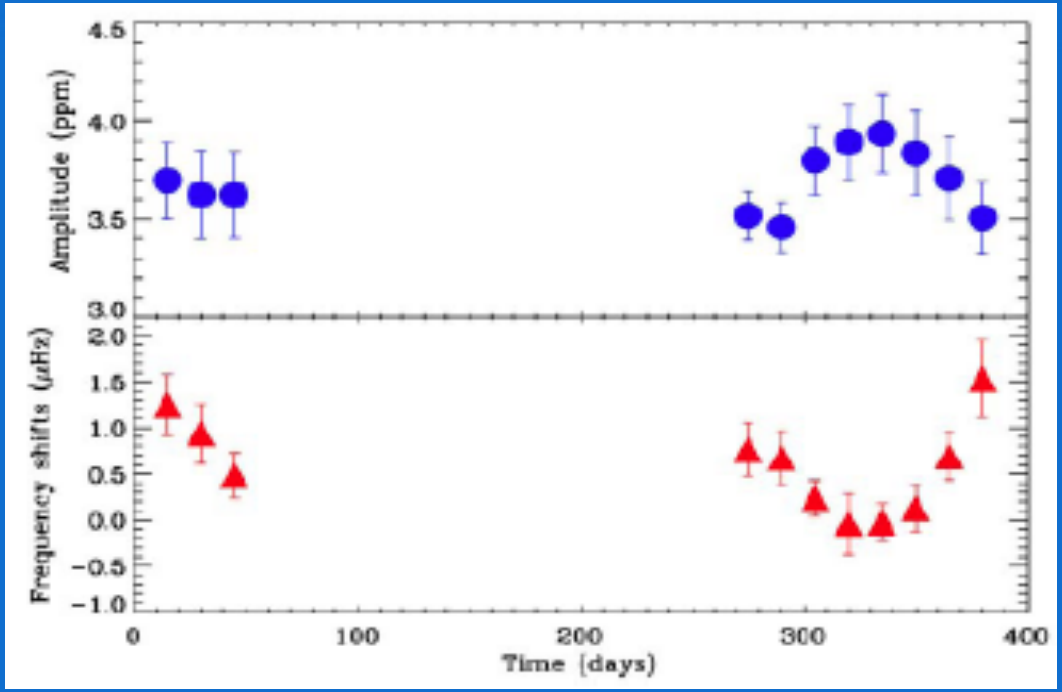


l=1 associated to a mixed mode l=2



Deheuvels et al. A1A accepted

A stellar cycle?



HD 49933, F5V, 1.2 Mo, Rotation period 3.4 days

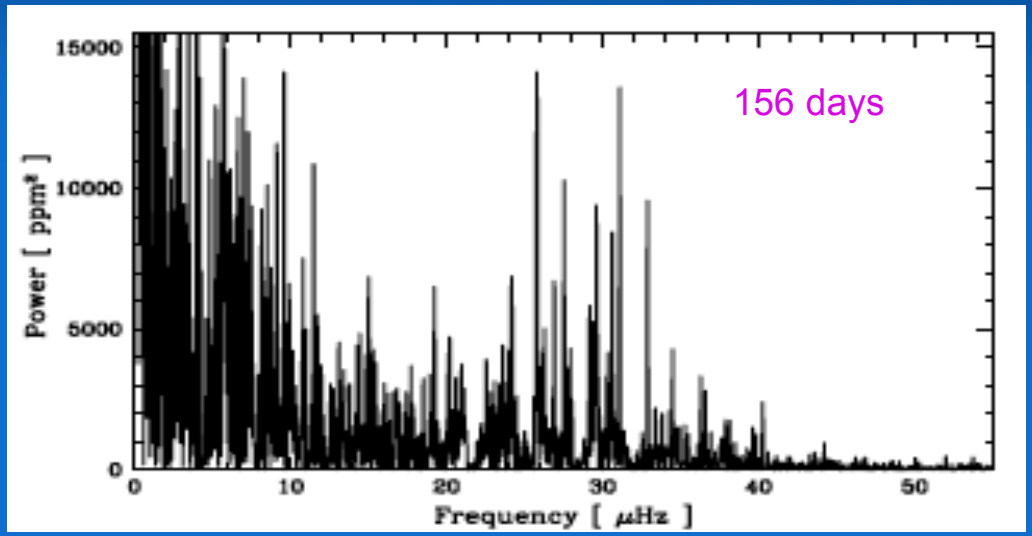
Observed twice for 400 days, Modulation of around 120 days

Garcia et al., Science accepted

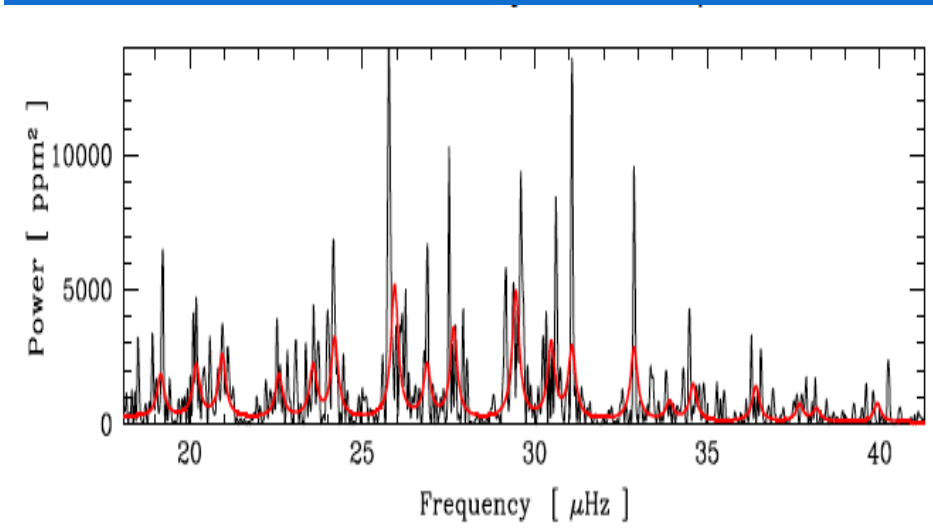
Solar like oscillations in a Red Giant

Teff= 4750 K, L= 70 Lo
Very slow rotator

At very low frequency: ~ 30μHz



Detection of the comb structure

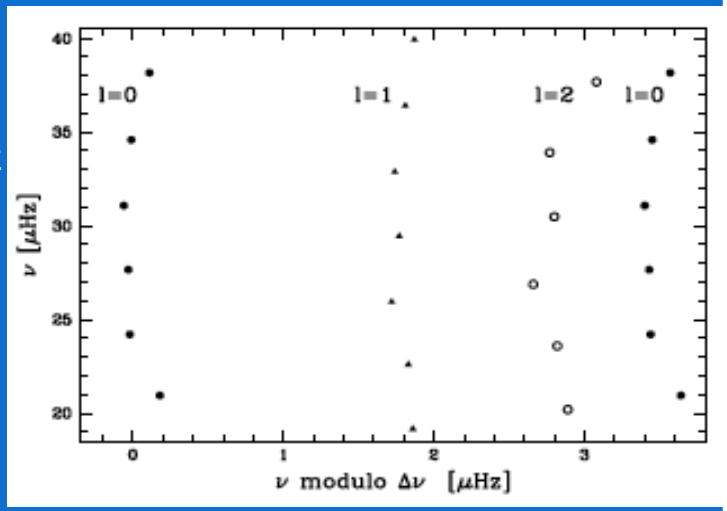


l=0,1,2

Δν= 3.47 mHz

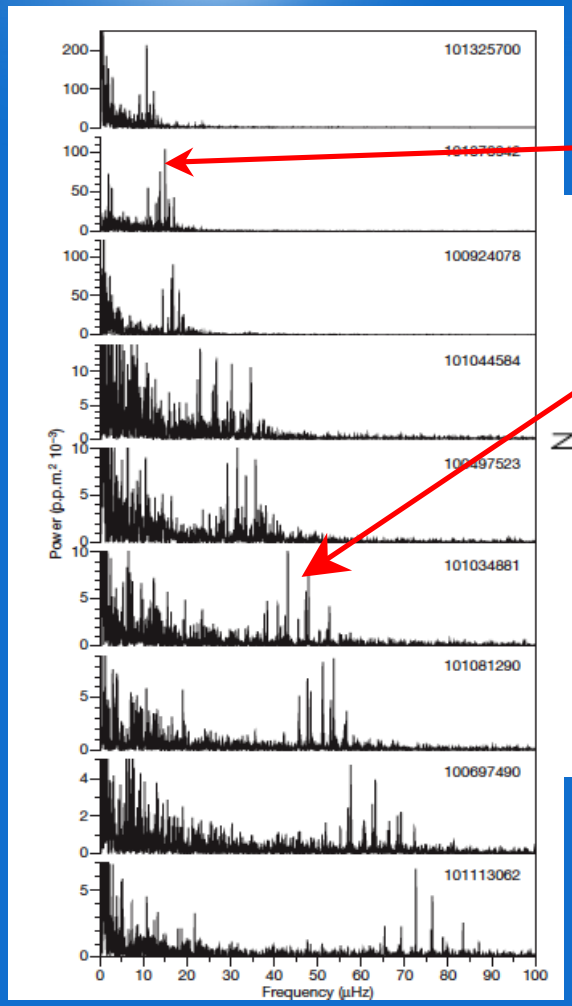
δν = 0.65 ??

Mode lifetime
14.7 days

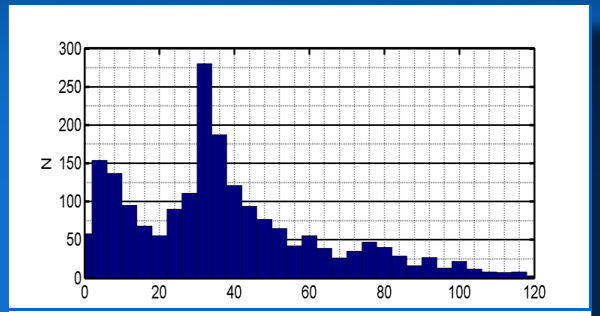


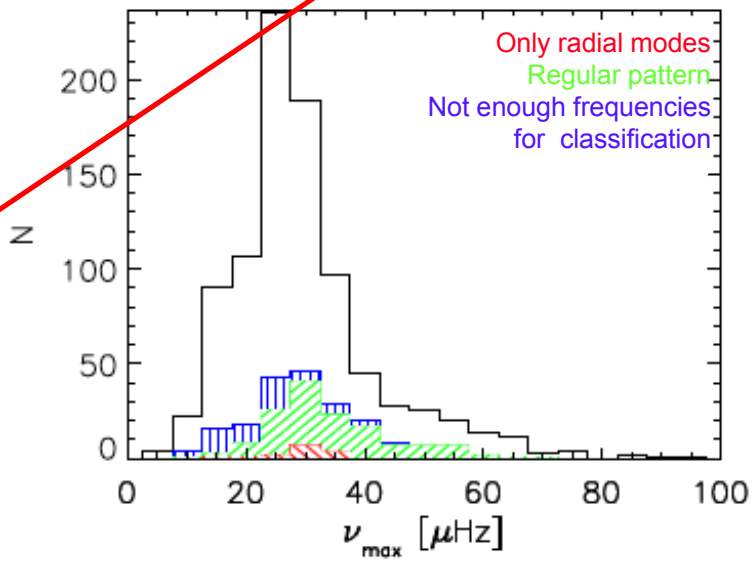
Carrier et al. A&A, 506 2009

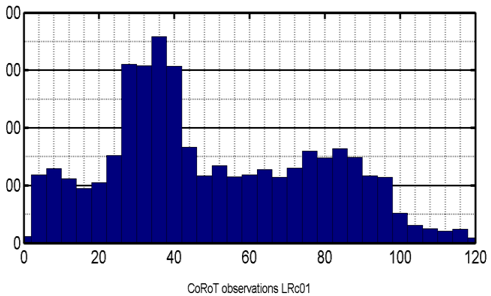
A new Stellar Formation Rate indicator

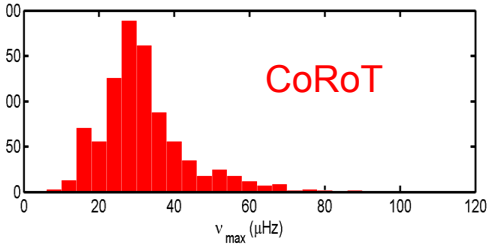


Statistics on ν_{max}





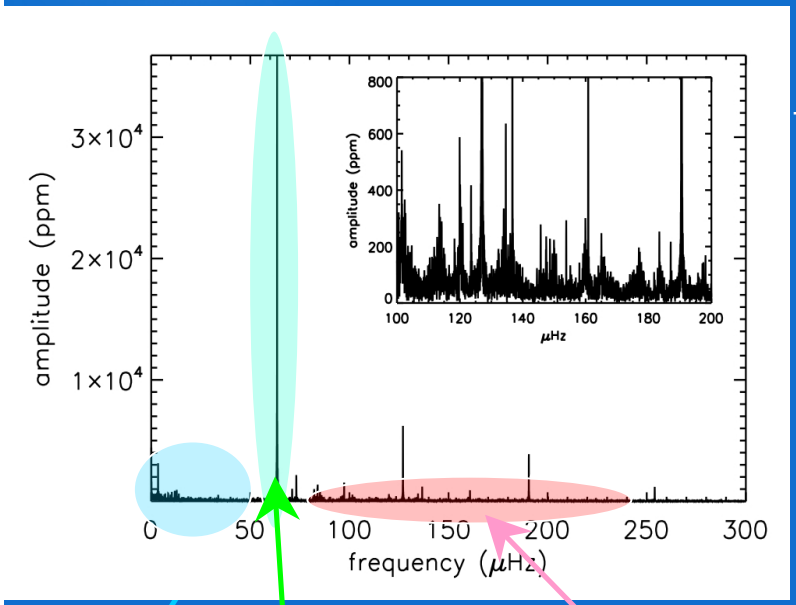




Determination of Mass and Radius ($\Delta\nu$, ν_{max})
Non uniform, unimodal distribution
Compared to models of synthetic populations

De Ridder et al. Nature 2009, Miglio et al. A&A 2010, Mosser et al. A&A submitted

Hot stars and solar like oscillations



B1 V
Teff ~ 10 000

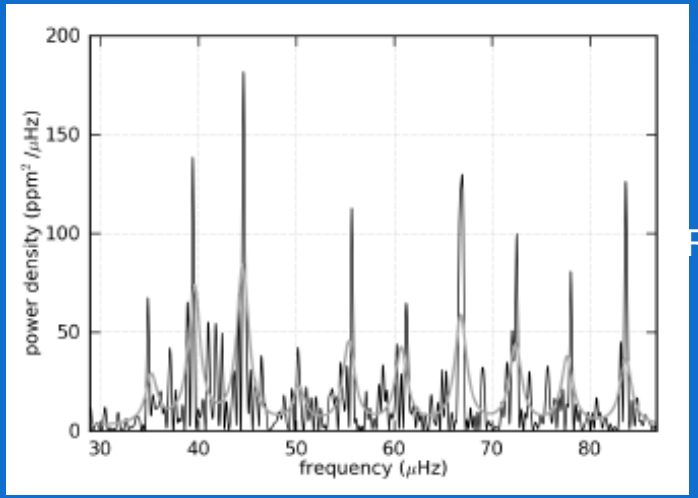
Gravity modes?

Auto excited Beta ceph

Solar like P modes

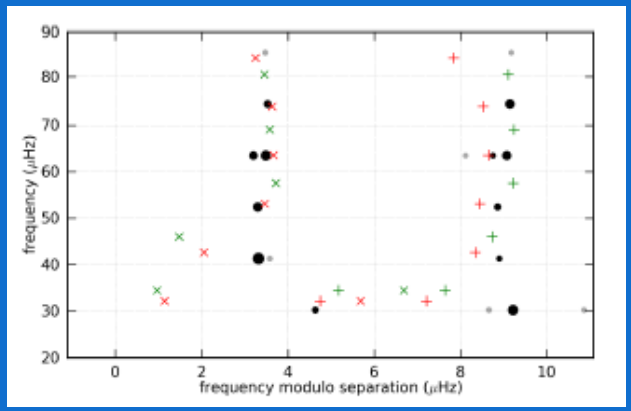
Deep interior, He ionisation zone, convective region

Belkacem et al. , Science, 2009



0 8.5 V
Teff= 35 000

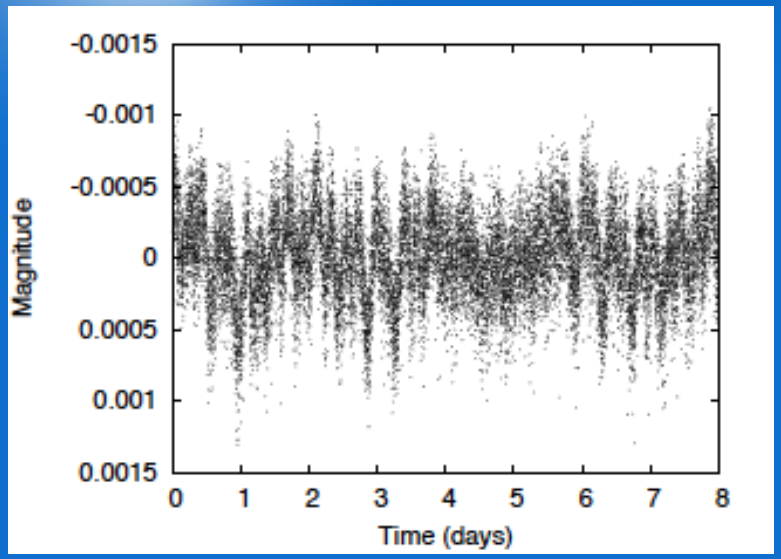
NGC 2244
Rosetta nebula
1,6 Myr

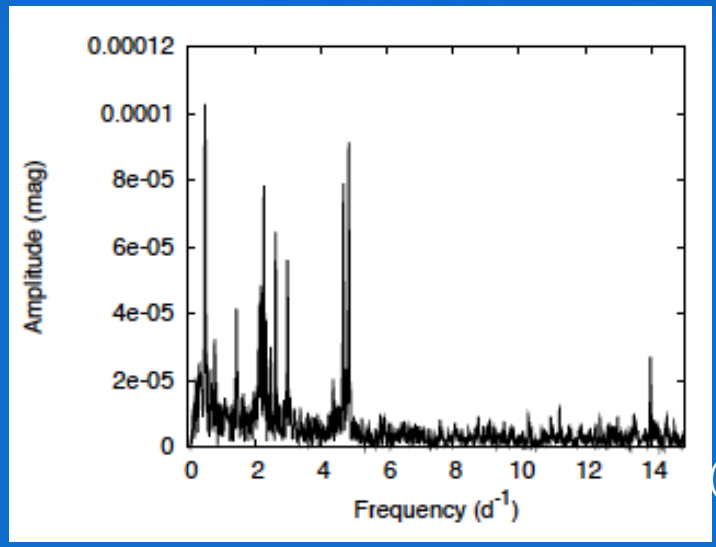


Red 30 Mo
Green 34 Mo

Degroote et al.A&A submitted

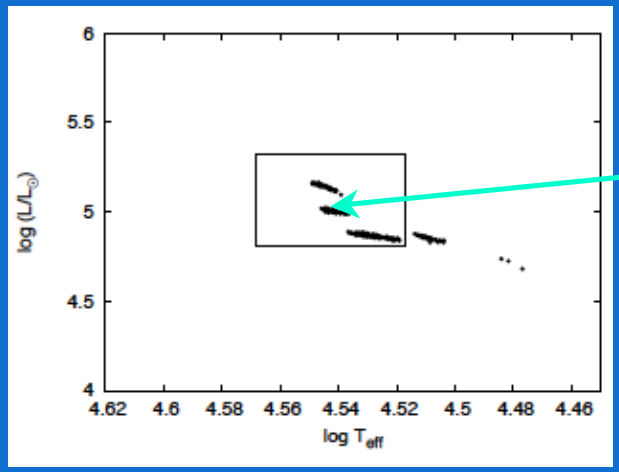
The Beta Cephei instability strip ?





67
Frequencies

(1c/d= 11.6 μHz)



The best model (seriously improved by seismology)

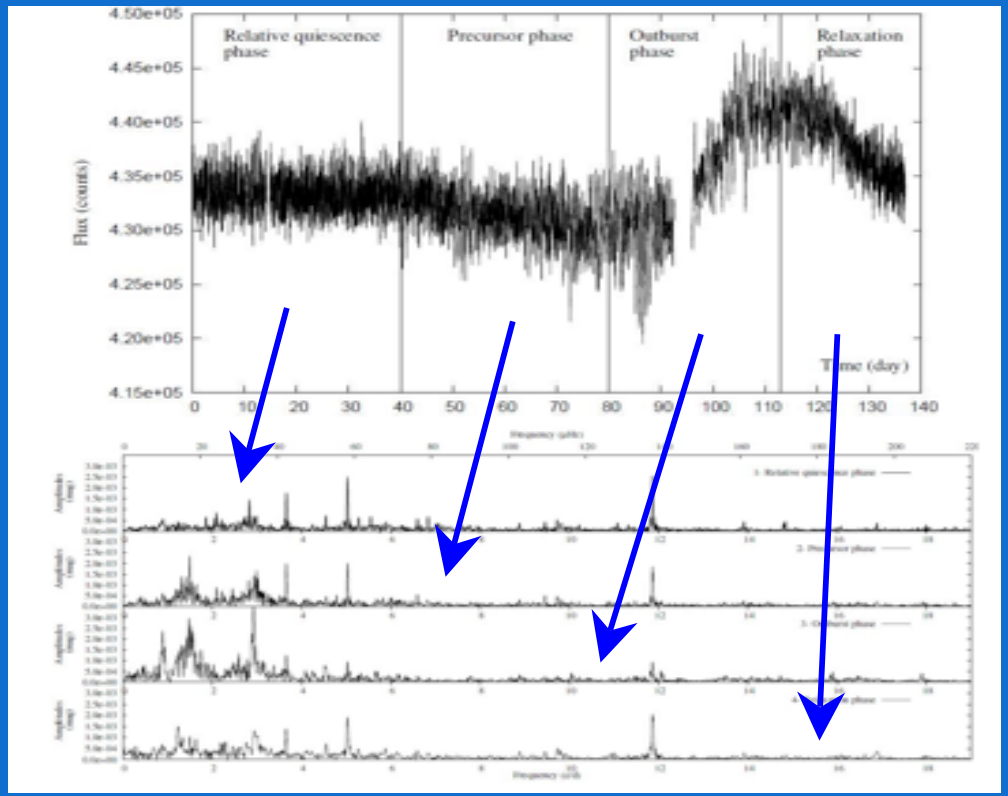
But these modes are not excited!!!

-->> Revision of the physics of the models….

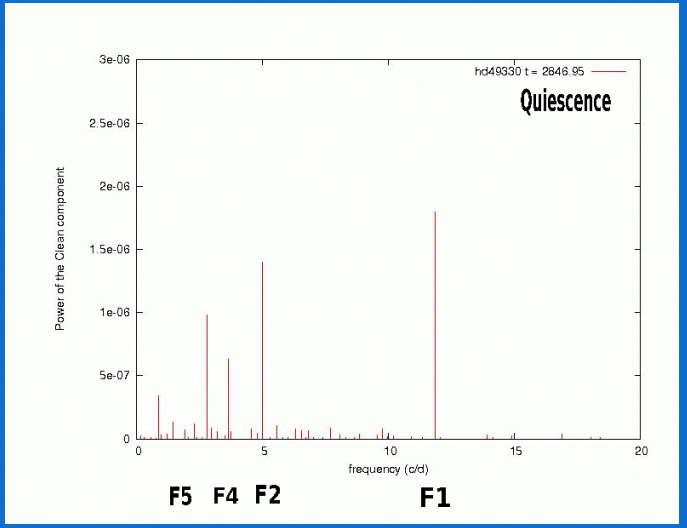
Briquet et al. A&A 2010 accepted

A Be star with a burst

HD 49330
156 days
V= 8.5



Enveloppe / pulsation
Interaction ?

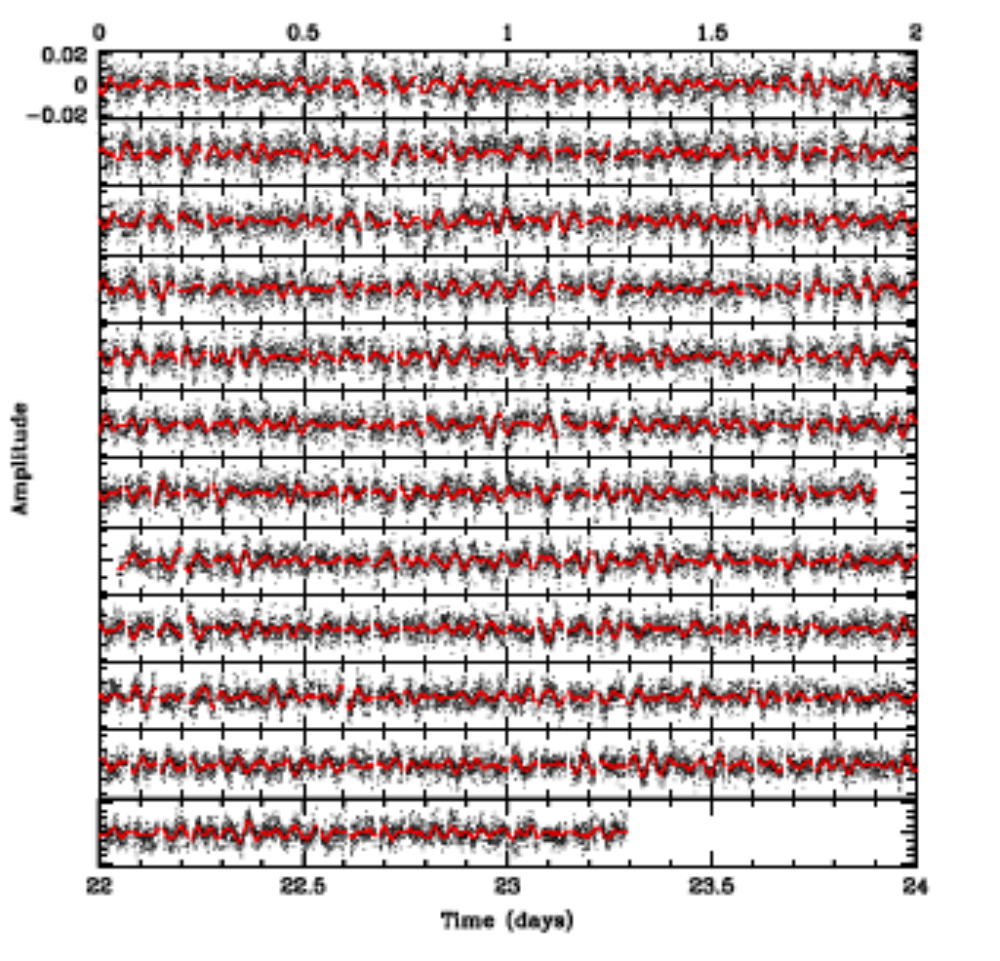


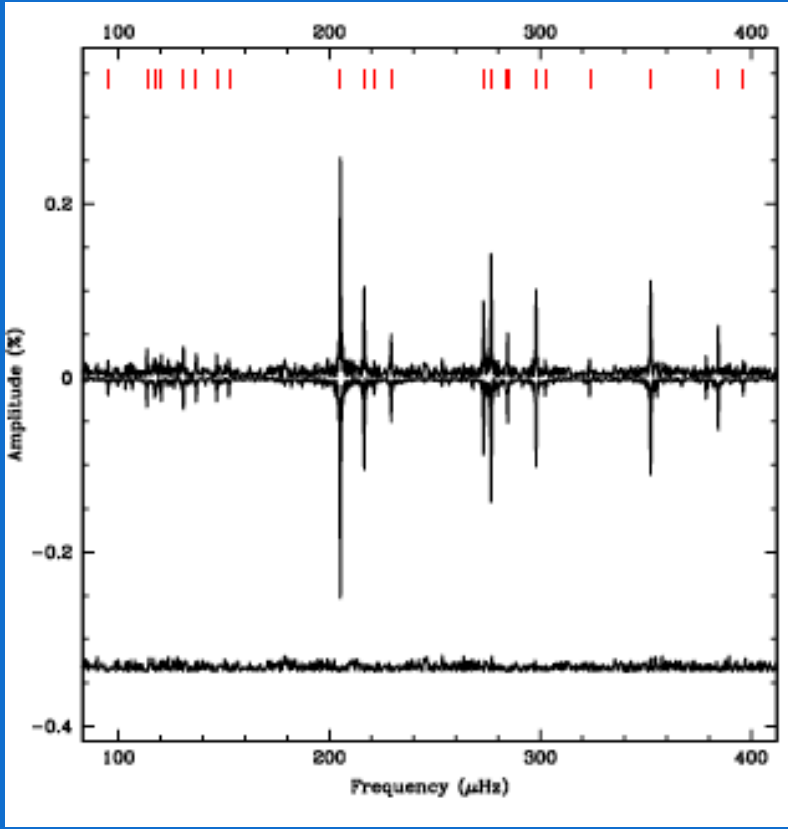
Huat et al. A&A 506,2009, Floquet et al. A&A 2010

An old hot B subdwarf

Very faint, (V=14.9)
observed in the exoplanet field

24 frequencies (6 from the ground)
g modes



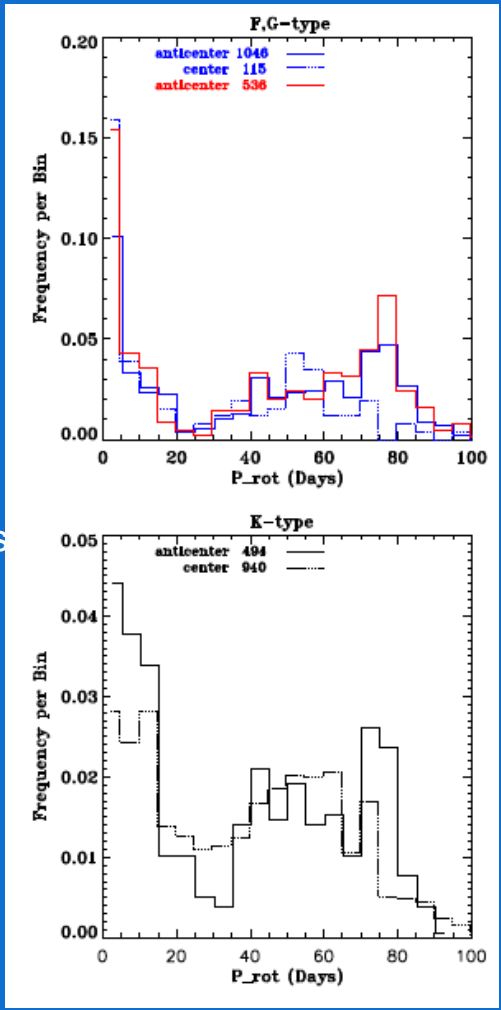


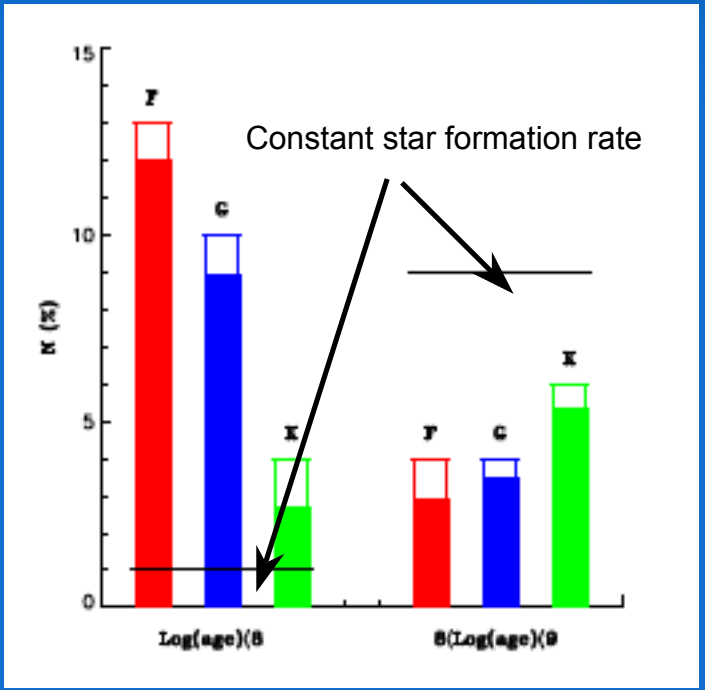
Charpinet et al. A&A L, submitted

Rotation distribution of young stars

11275, FGK dwarfs

3000 confirmed periods





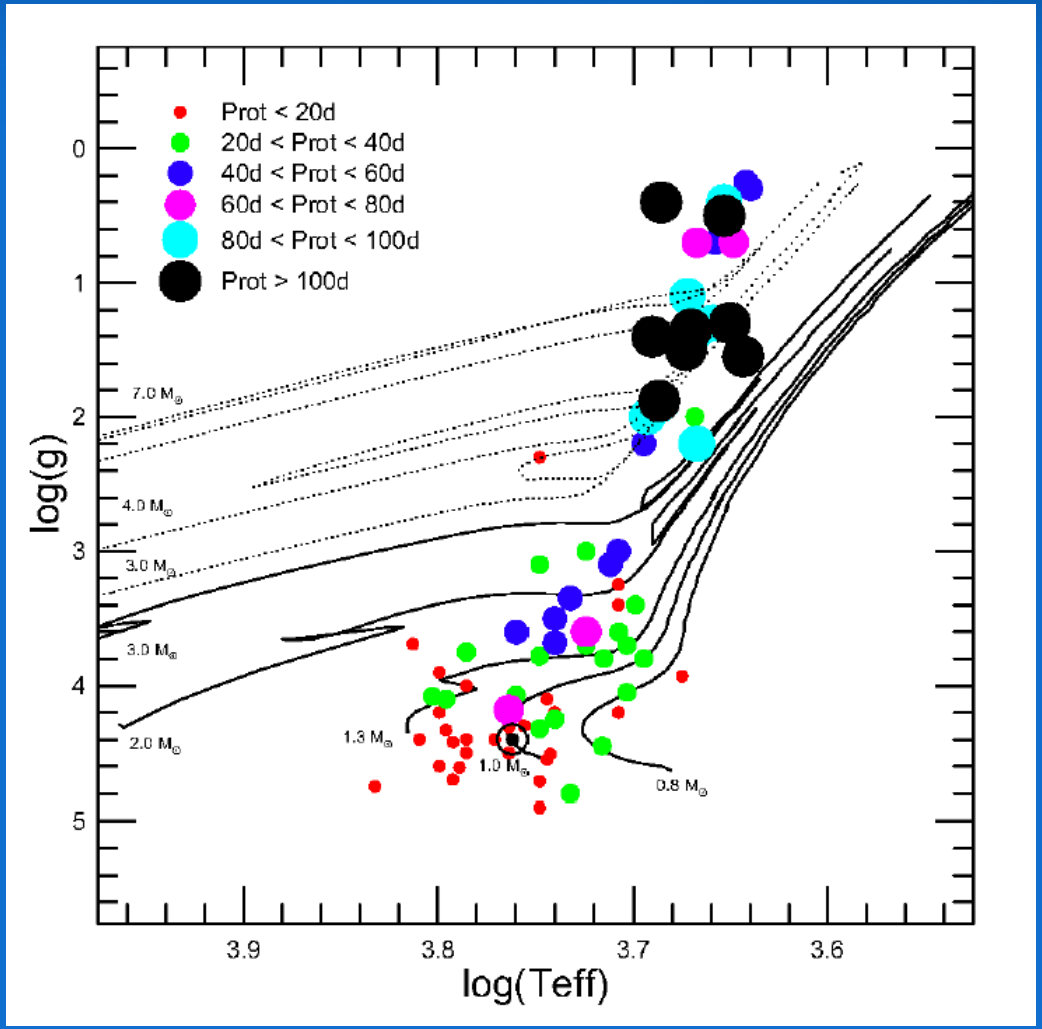
Age from gyrochronology
P < 20days

Not compatible with a constant star formation rate
Excess of young stars (also seen in Xrays)

Affer et al. A&A 506, 2009

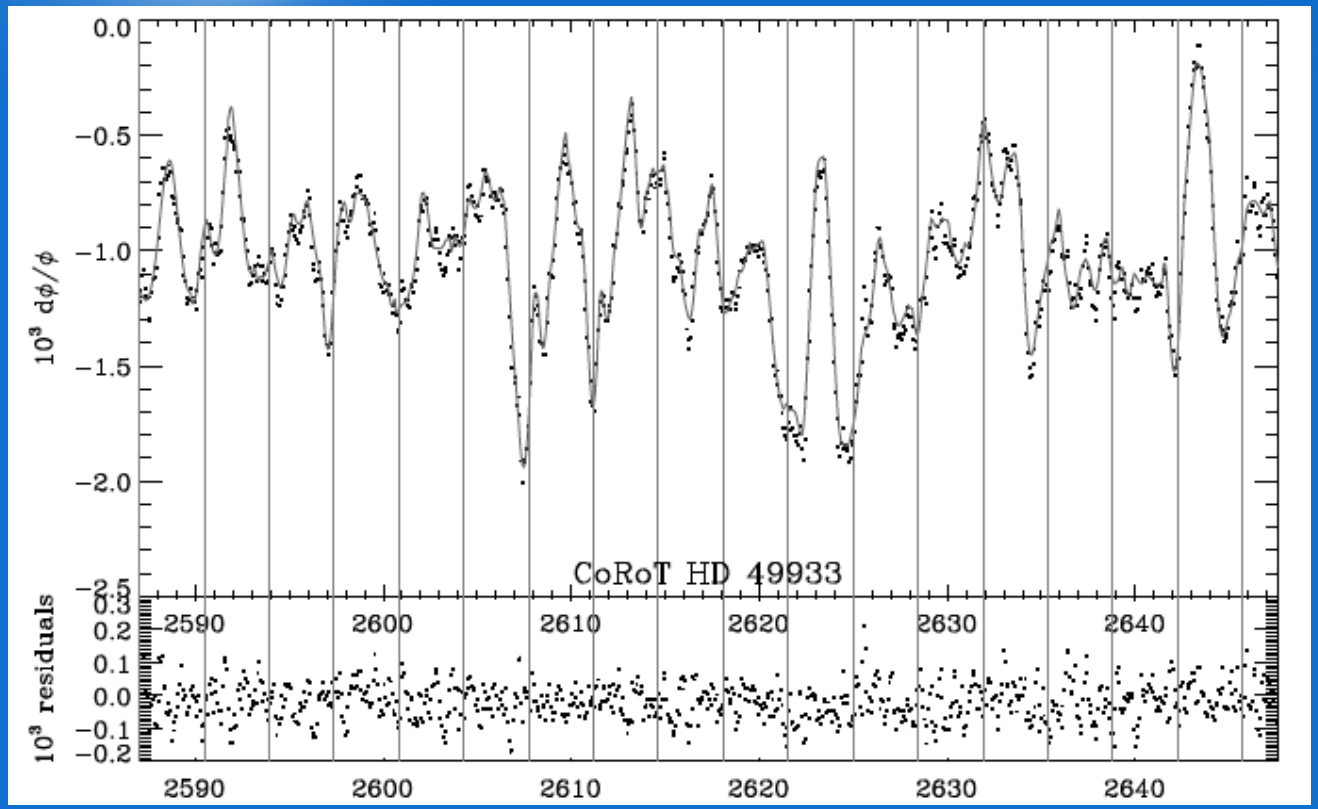
The Sun in time

Extended program
of spectroscopic observations
To obtain the
Fundamental parameters



Dias de Nascimento eta., submitted

Spot modeling of an F5V star

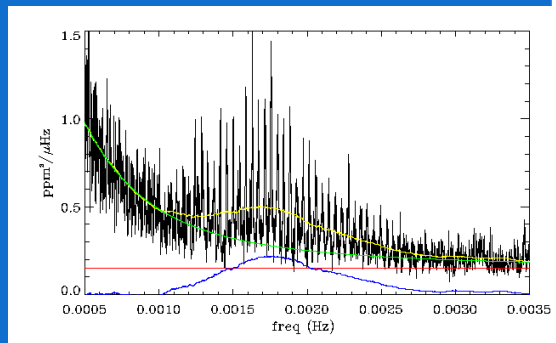


P rot: 3.35 days

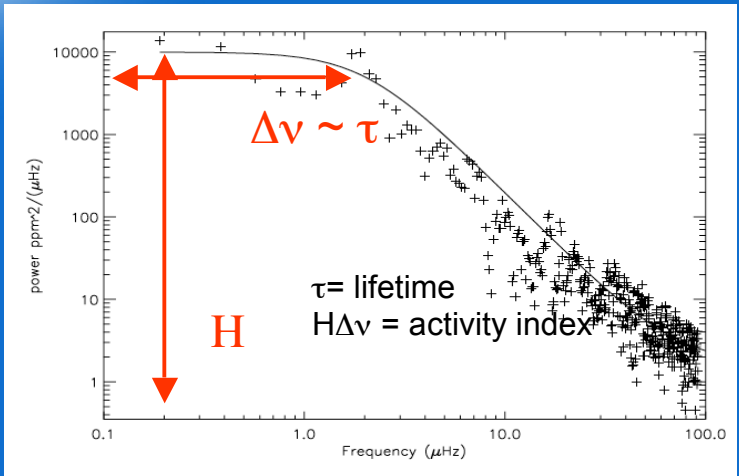
Spot life time: 2.5 to 3.5 days

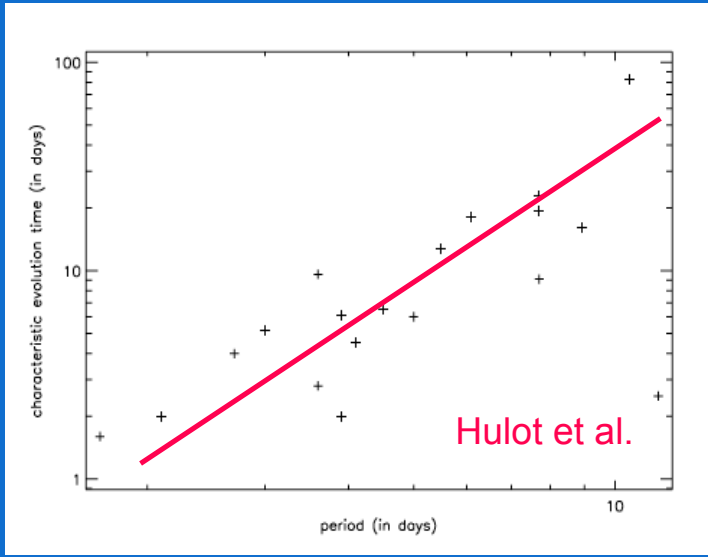
Surface of the spots 3%

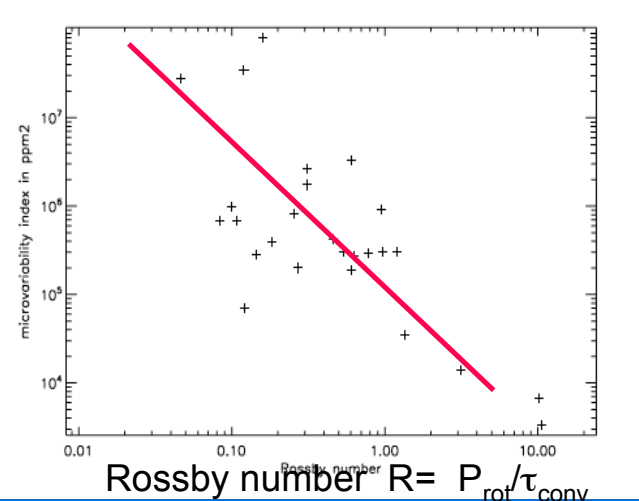
Inclination 55°



Lifetime of spots, rotation and activity index







Rossby number R= P_{rot}/τ_{conv}

$H \sim R^{-1.5}$

$\tau \sim P^2$?

The CoRoT exoplanet programme

From light curves
to complete
planet characterisation……

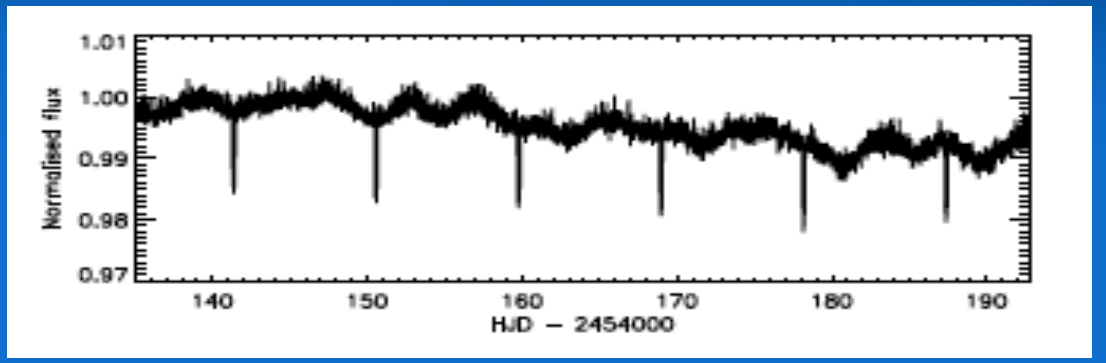
A long way to go…….

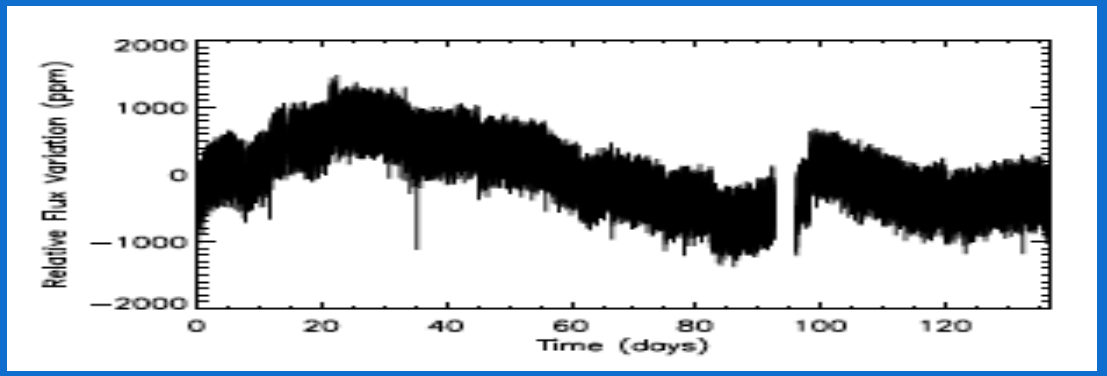
10 000 targets

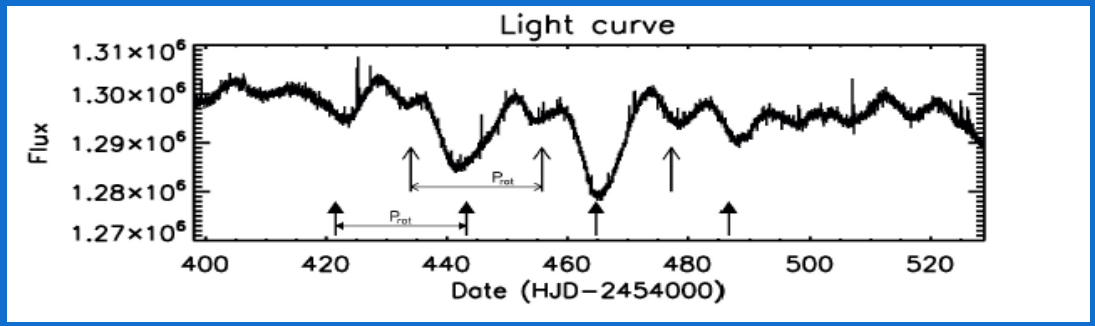
300 candidates

50 selected for FU obs

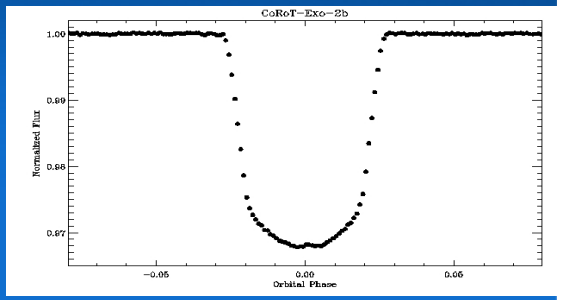
2 to 4 planets !







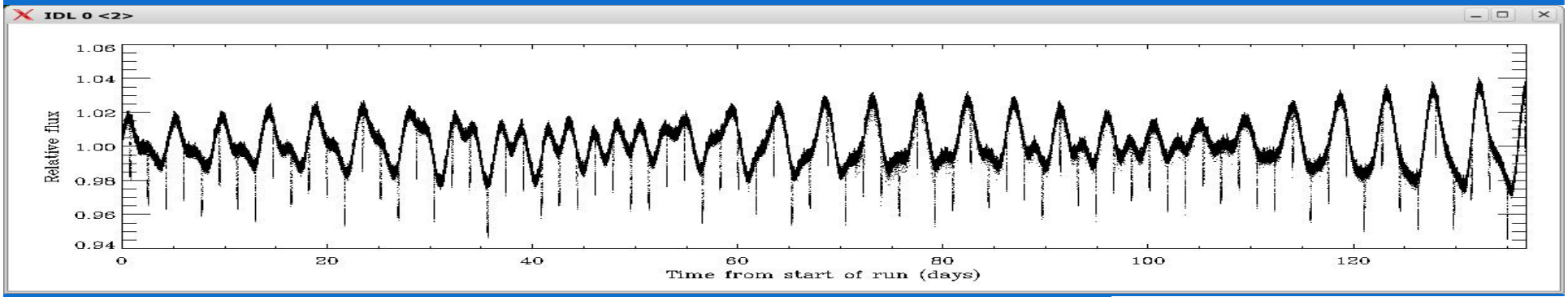
Hot jupiters around very active stars



CoRoT - 2

81 transits successifs; Periode: 1.742996 j; Rayon: 1.465 R_J

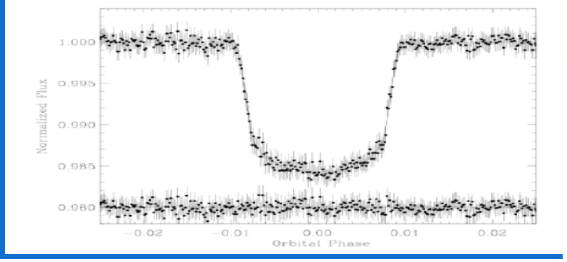
Masse: 3.31 M_J; Rotation de l'étoile 4.5 j

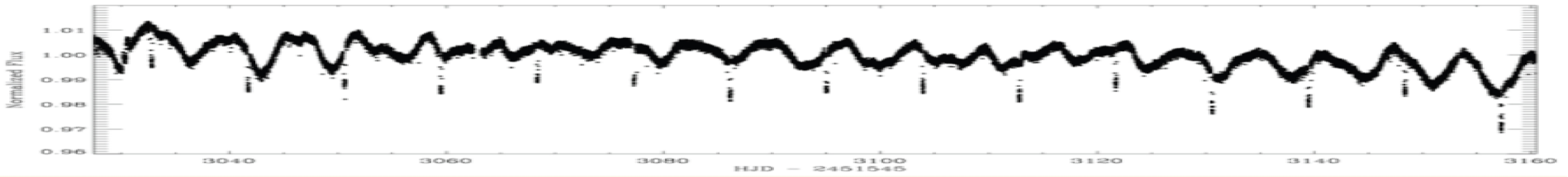


CoRoT - 6

15 transits successifs; Periode: 8.88 j; Rayon: 1.5 R_J

Masse: 3.3 M_J; Rotation de l'étoile 6 j

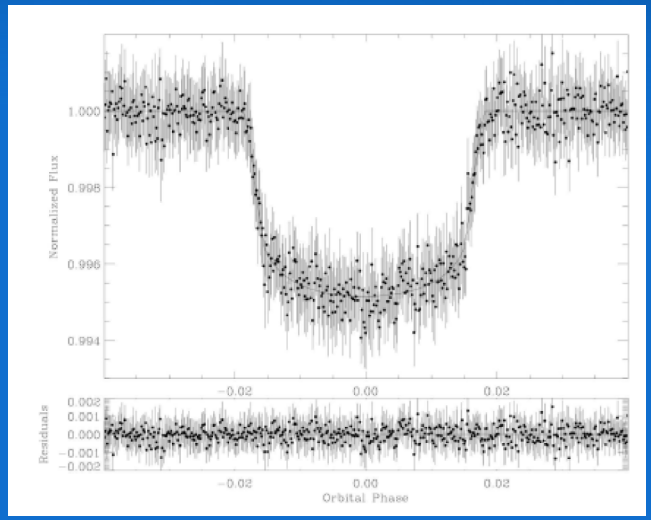


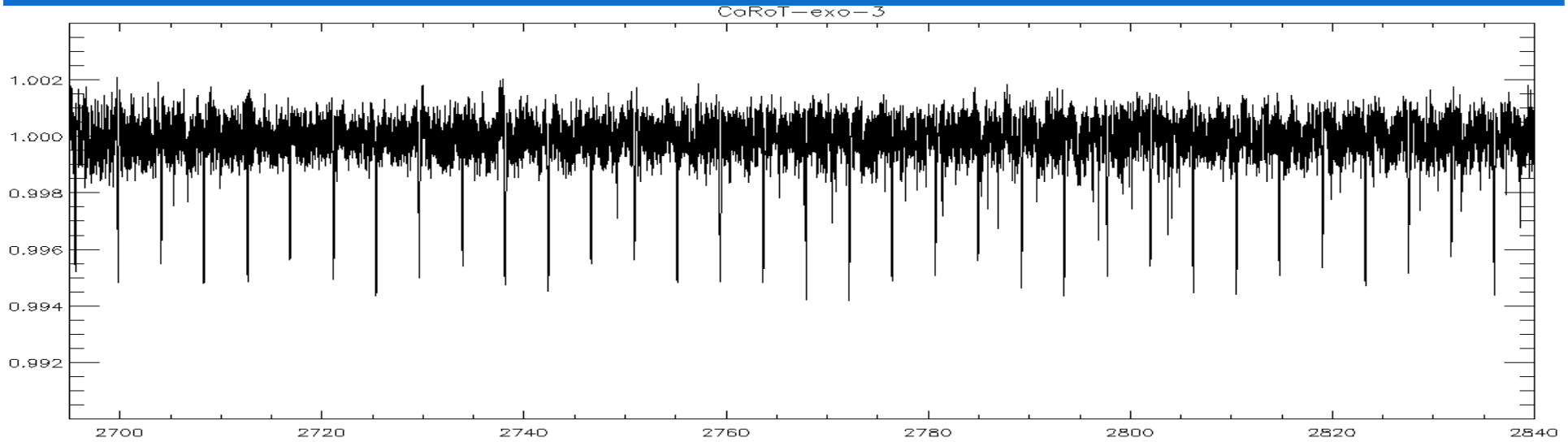


Between stars and planets

CoRoT- 3b

34 transits
Periode 4.26 j
Rayon: 1.01
Masse: 21.66
Rotation de l'étoile ~ 4 j



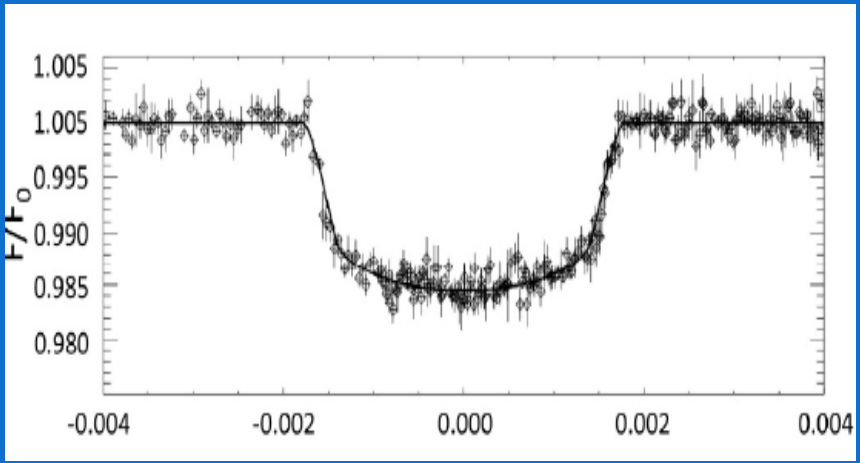


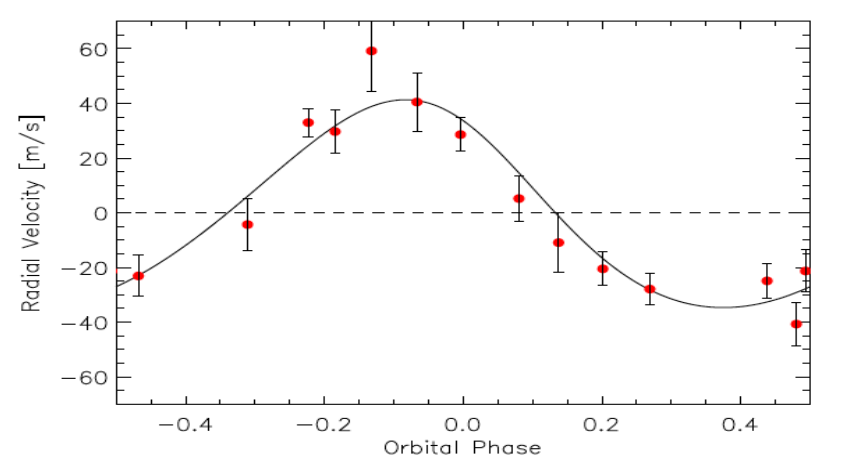
A temperate gaseous planet

CoRoT- 9

1.5 transit + WISE Photometry+ Harps coralie spectroscopy..

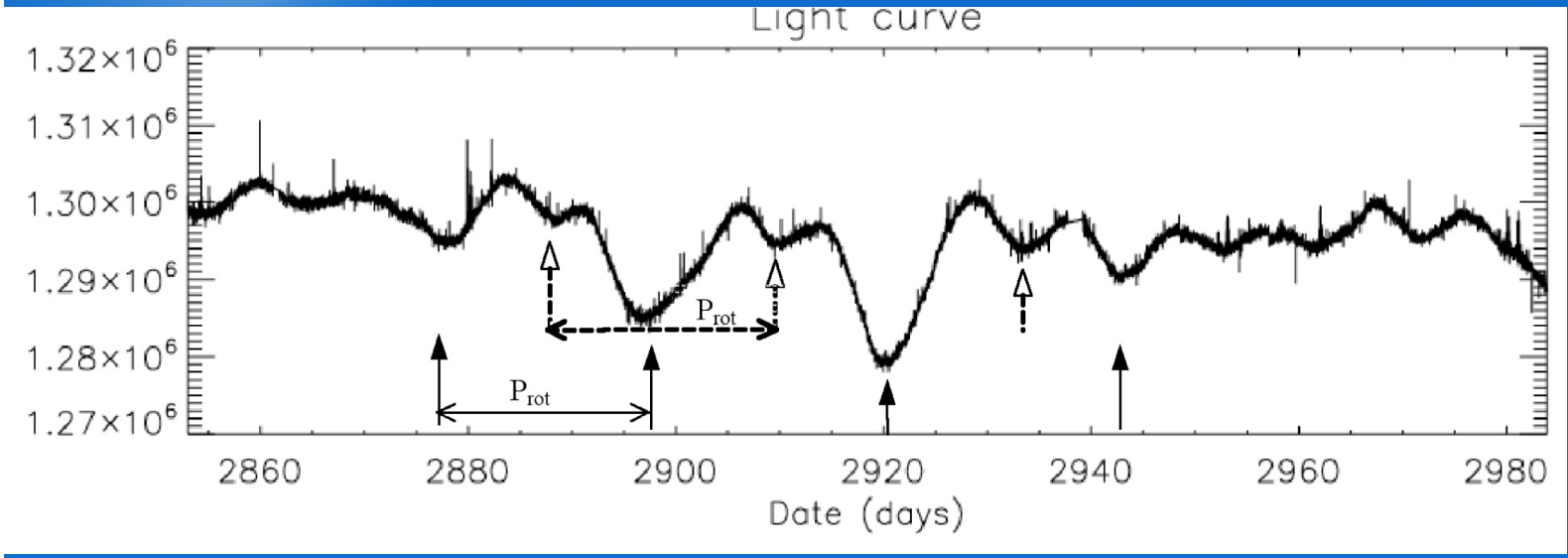
Period 95 .27 days (145 days of observations)
Transit duration 8.8 hours
Eccentricity 0.11
G3V, not active, 0.9 Ms,
Rp= 1.1 Rjup, Mp= 0.84 Mj, Tsurf= 350K, H+ He+ 20mE rocks



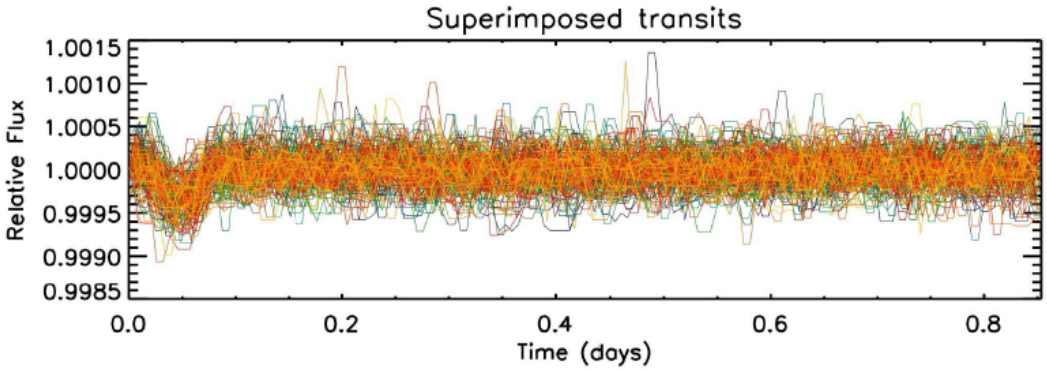


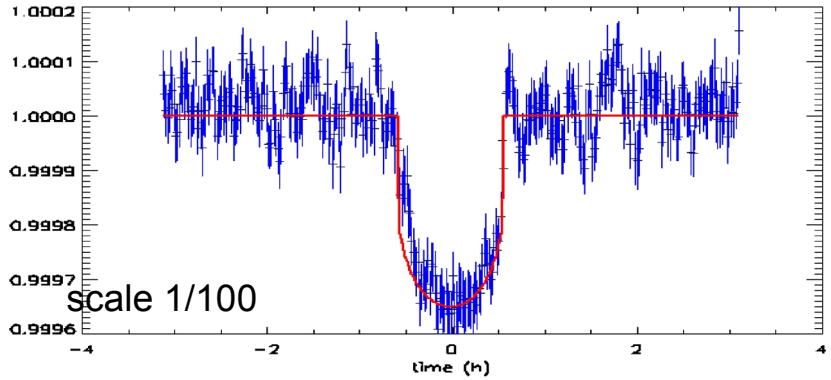
The smallest one

CoRoT-7b



~ 170 transits
Period: 0.85 j
P rot: 23 j
R= 1.7 Rearth

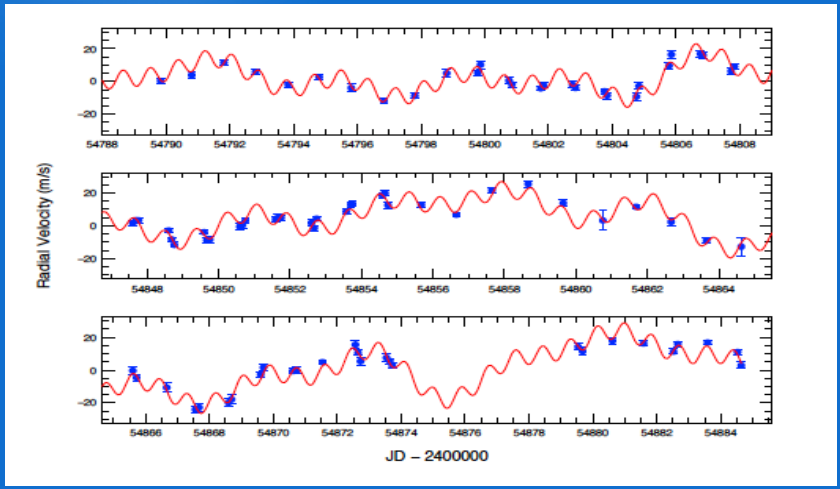




Stellar activity and planet confirmation

CoRoT-7b A nightmare!

110 nights with HARPS:



Strong noise due to stellar activity……
Spot modeling confirms

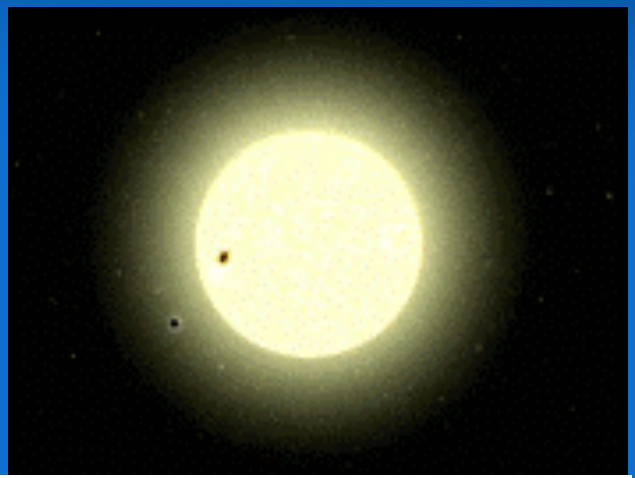
0.85 days period exists, amplitude: 5m/s

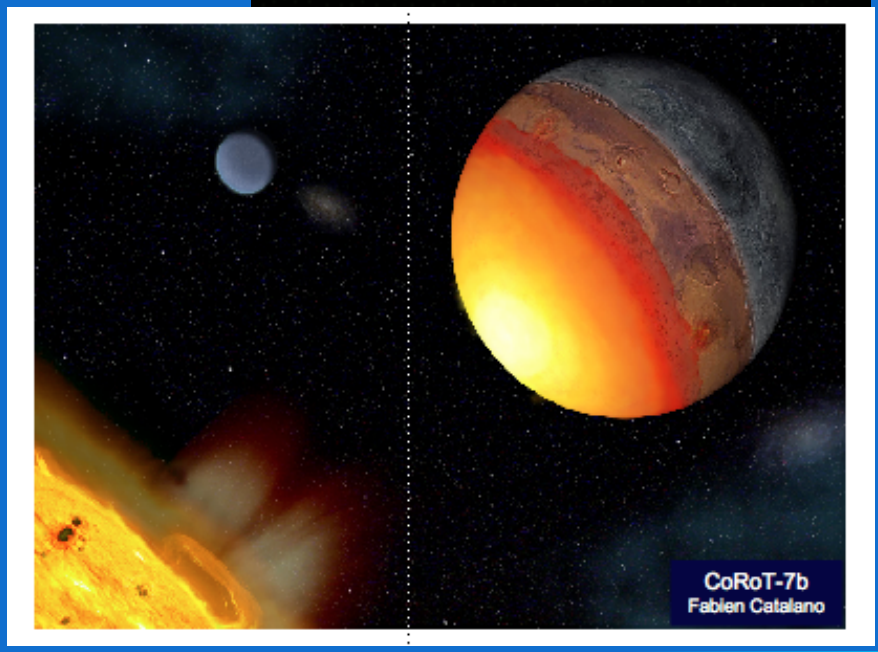
M= 4.5 $M_\oplus$

Density ~ 5

Silicates + water ?

second périodicité: 3.7 days, hot Neptune M= 9$M_\oplus$





Conclusion…..???????????

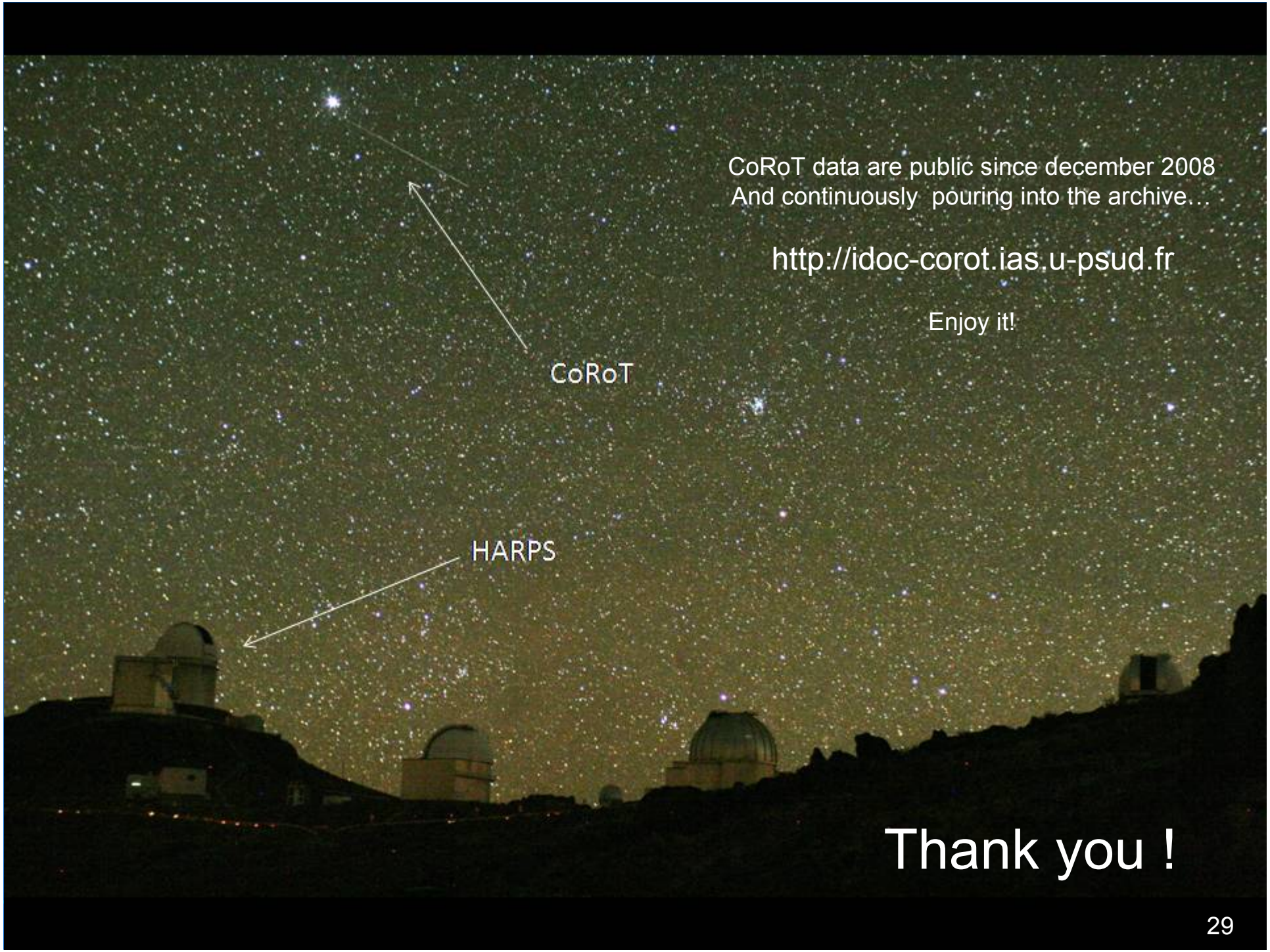
1- Stars can be better understood
Looking carefully at their time dependant properties
* Seismology techniques
* Non coherent behaviors

They are very diverse, more complex than the Sun,
and more complex than we thought
Models have to be revised and improved

2- Planetary systems are also very diverse
Transit observations, complemented by spectroscopy
-->> some insight on their physics (density)
Models have to be revised and improved

The major difficulty for the detection of small planets
Is the stellar variability

3- Stars and planetary systems have to be studied together



CoRoT data are public since december 2008
And continuously pouring into the archive…

http://idoc-corot.ias.u-psud.fr

Enjoy it!

Thank you !