

Les révélations de la révolution: Revelations of the micromag revolution

Don Kurtz

Jeremiah Horrocks Institute of Astrophysics
University of Central Lancashire





CoRoT - technical update



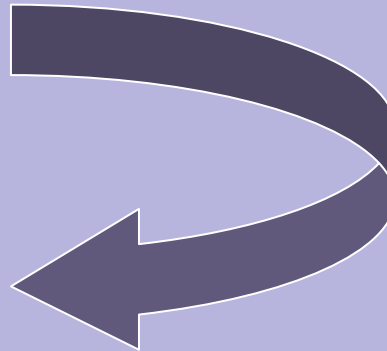
Olivier Vandermarcq

Jusq'ici ca va bien

“No problems so far”

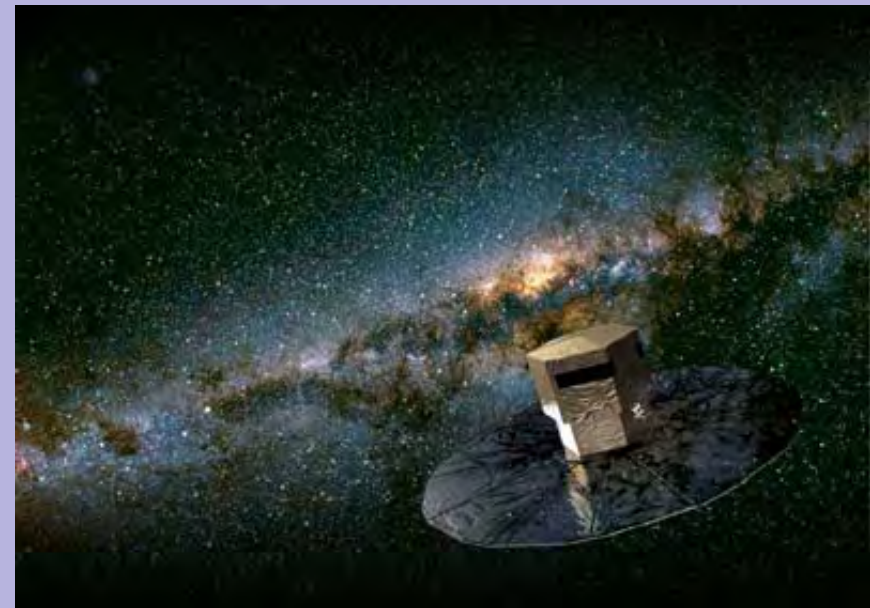
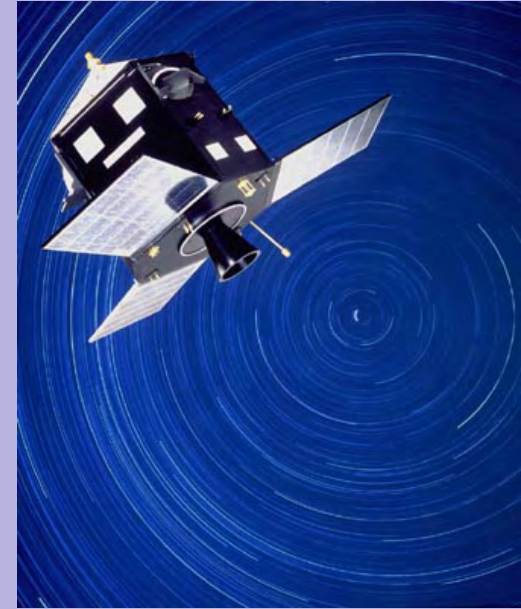
Revolutions

- Hipparchus: 1°
- Tycho: $1'$
- $f = 60$
- Kepler's Laws
- Newton's Laws

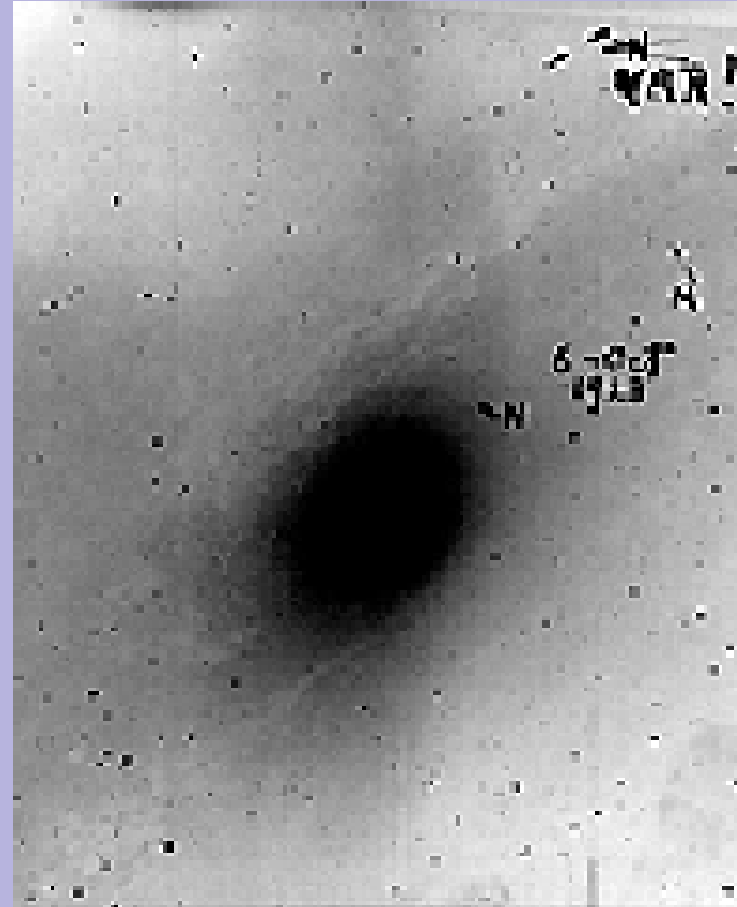


Revolutions

- Hipparcos: 1 mas
- Gaia: 1 μ as
- $f = 1000$



Revolutions



Revolutions

Spiral Galaxy NGC 3370

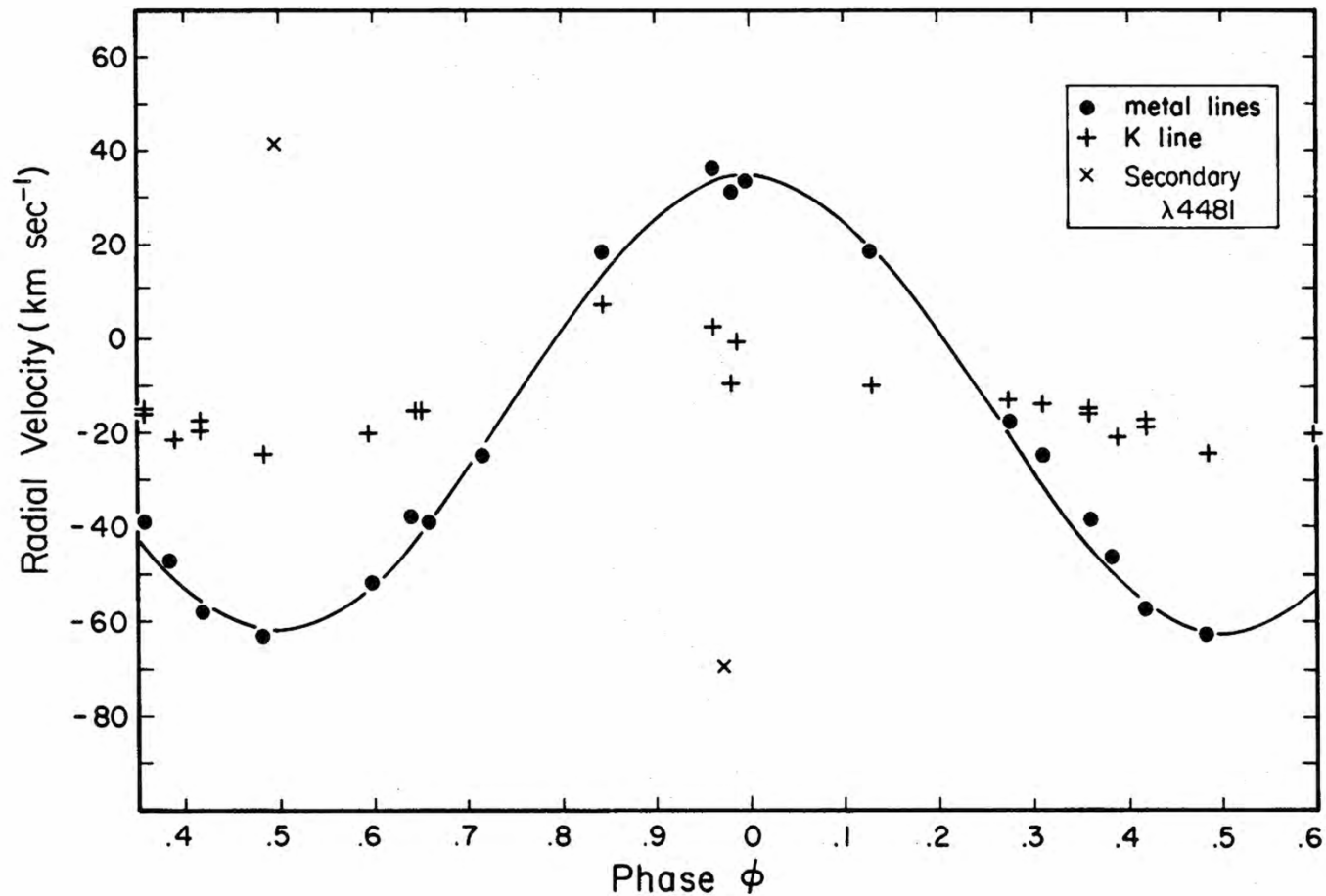


Hubble
Heritage

NASA, The Hubble Heritage Team and A. Riess (STScI) • Hubble Space Telescope ACS • STScI-PRC03-24

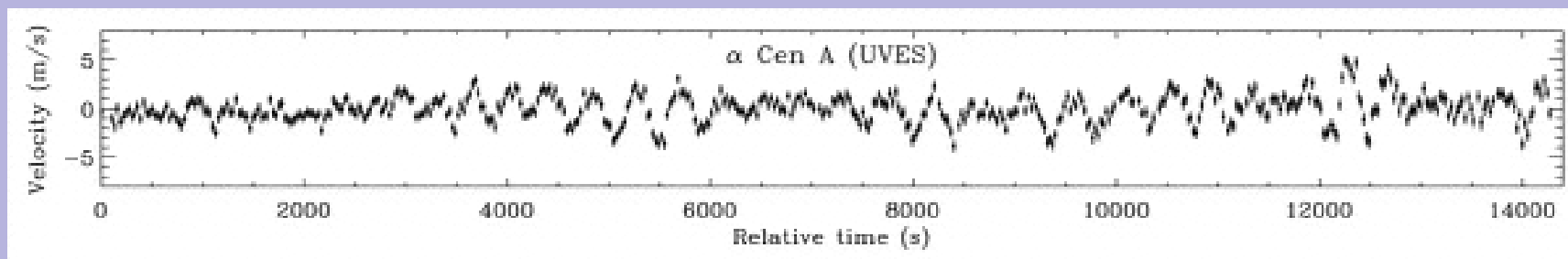
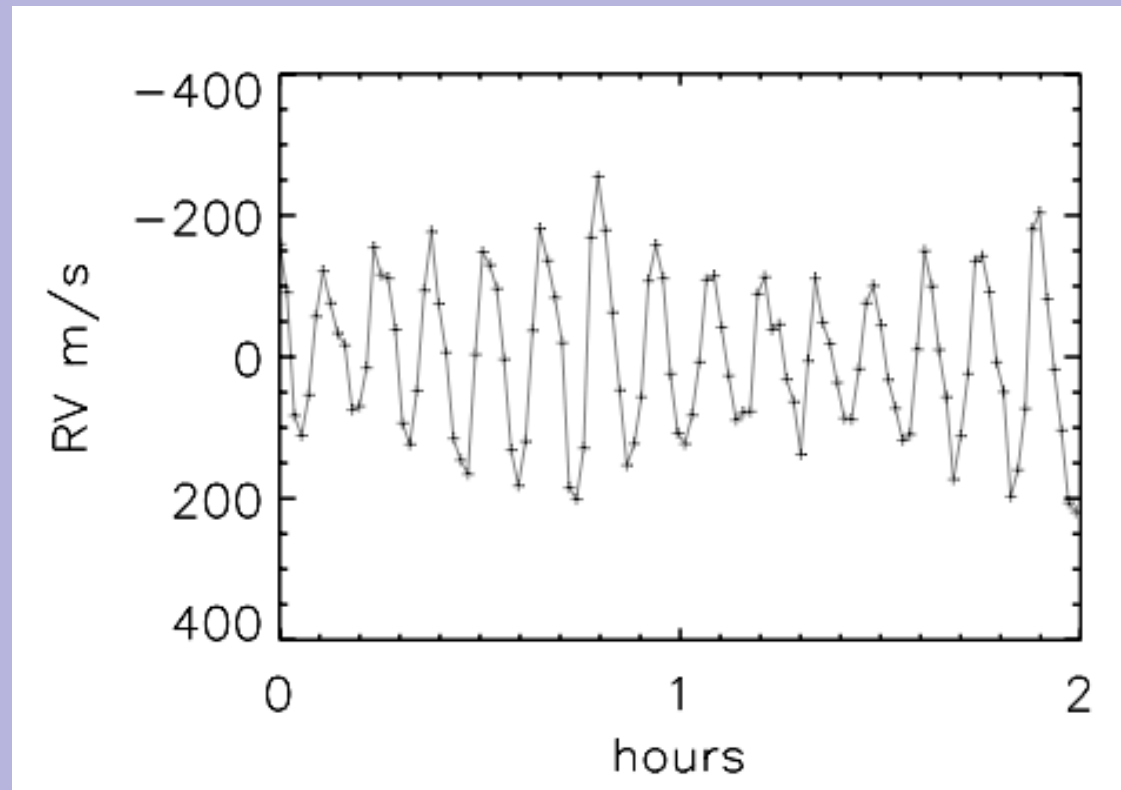
Revolutions

THE NATURE OF 32 VIRGINIS



Kurtz, D., Breger, M., Evans, S., Sandmann, W., 1976, ApJ, 207, 181

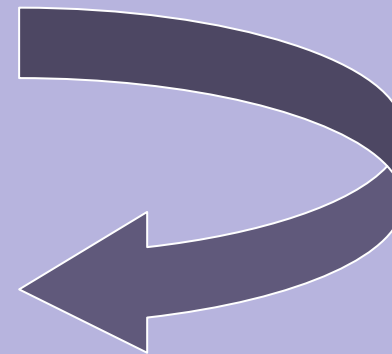
Revolutions



Butler, P., Bedding, T., Kjeldsen, H., et al., 2004, ApJ 600, L75

Revolutions

- Stars:
- RV 1970 = 500 m s^{-1}
- RV 2009 = 20 cm s^{-1}
- $f = 2500$
- Exoplanets
- Asteroseismology of solar-like stars



MARC PIRCHNER

“Does COROT give a new
way of seeing the universe?”

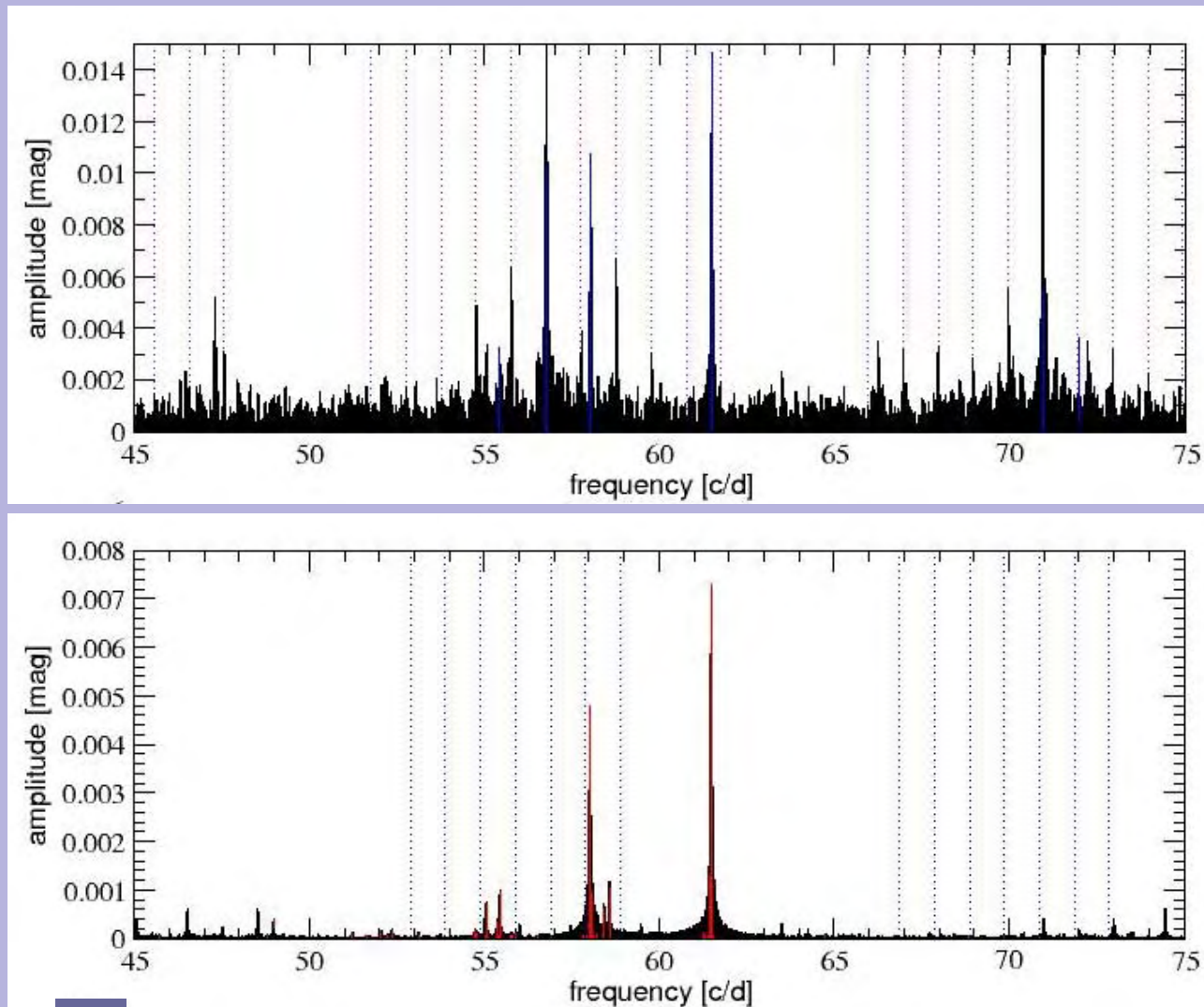
MARC PIRCHNER

“Does COROT give a new way of seeing the universe?”

Yes -

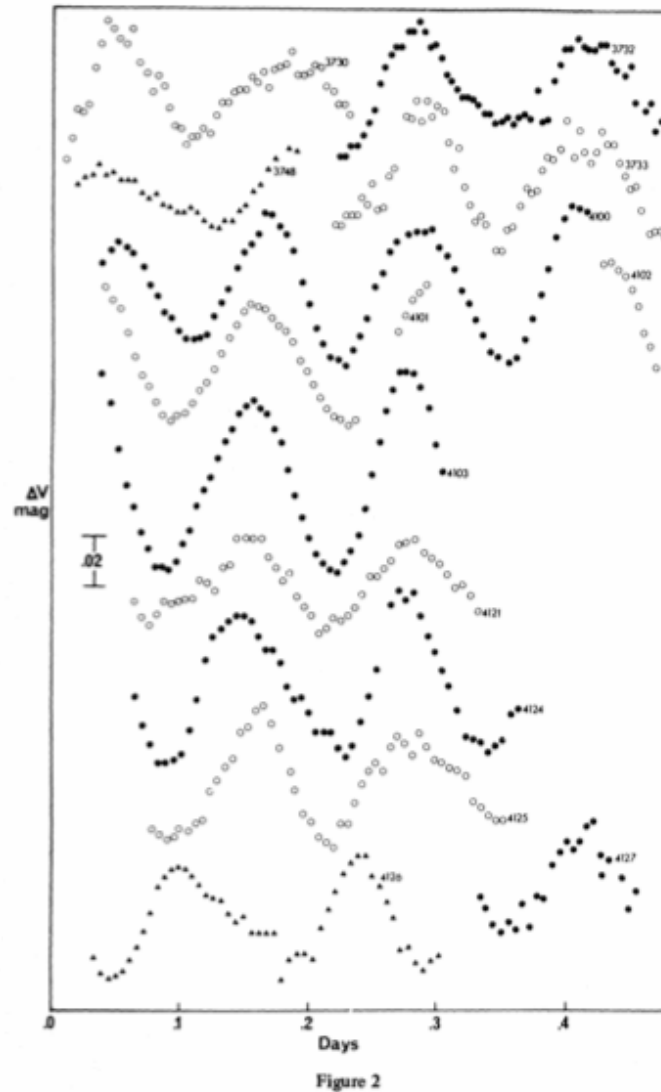
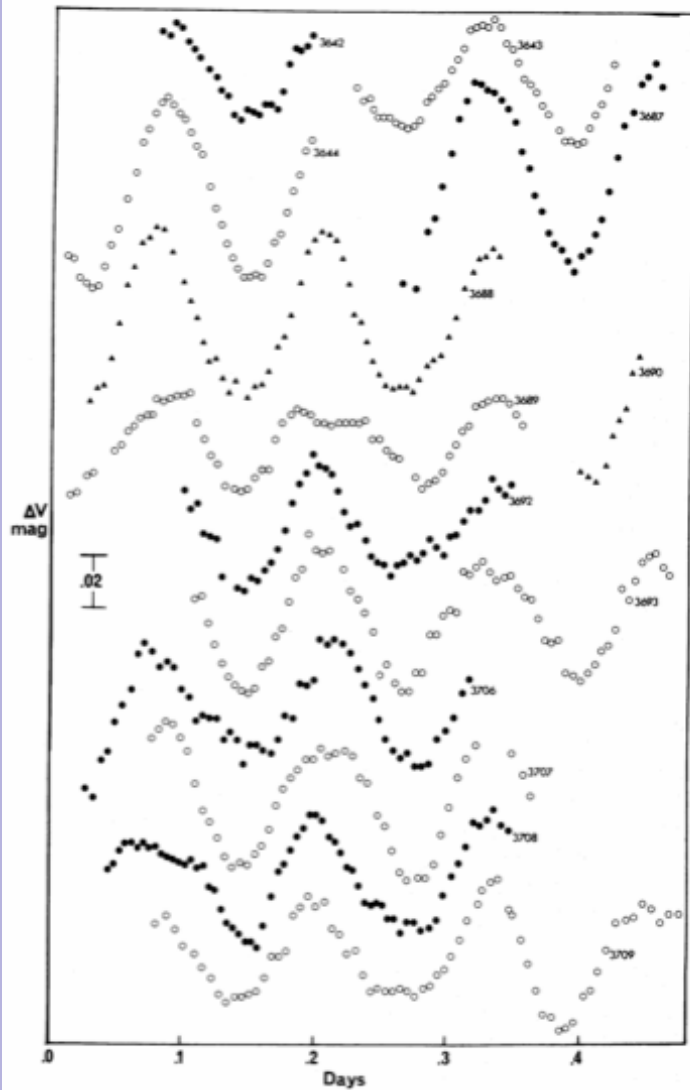
Duty cycle
precision

MOST & CoRoT



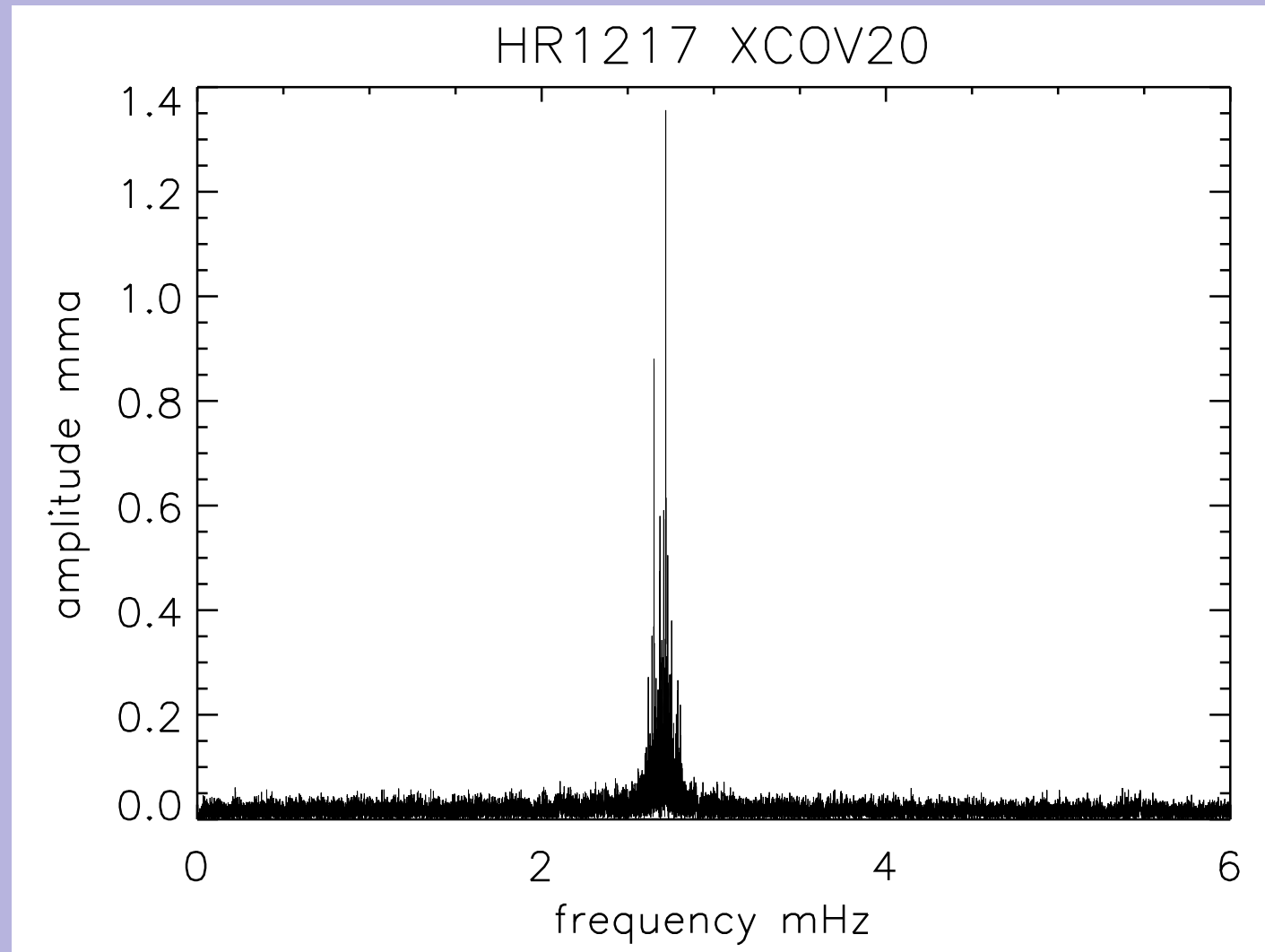
Konstanza
Zwintz

HD 188136

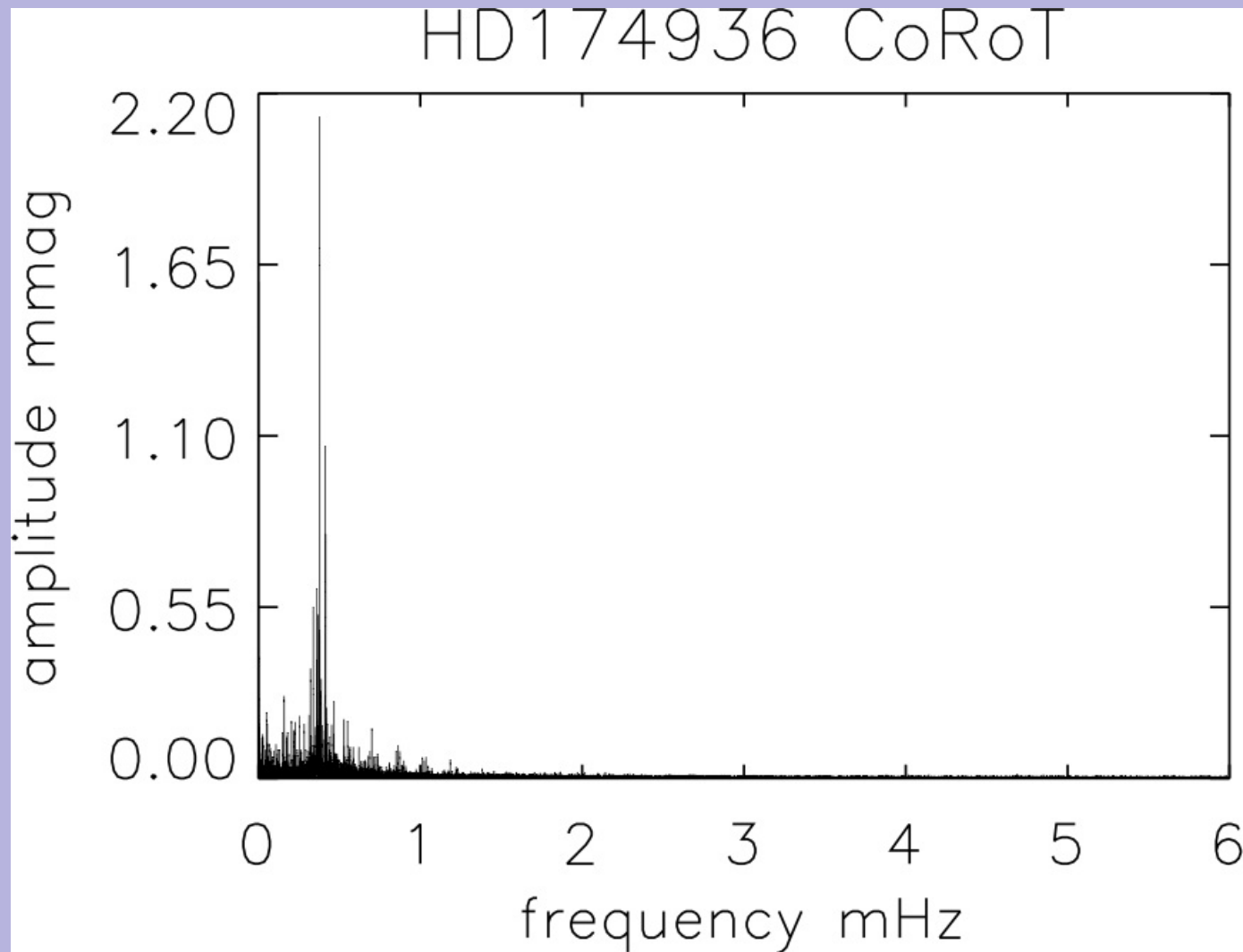


Kurtz, D., 1980,
MNRAS, 193, 29

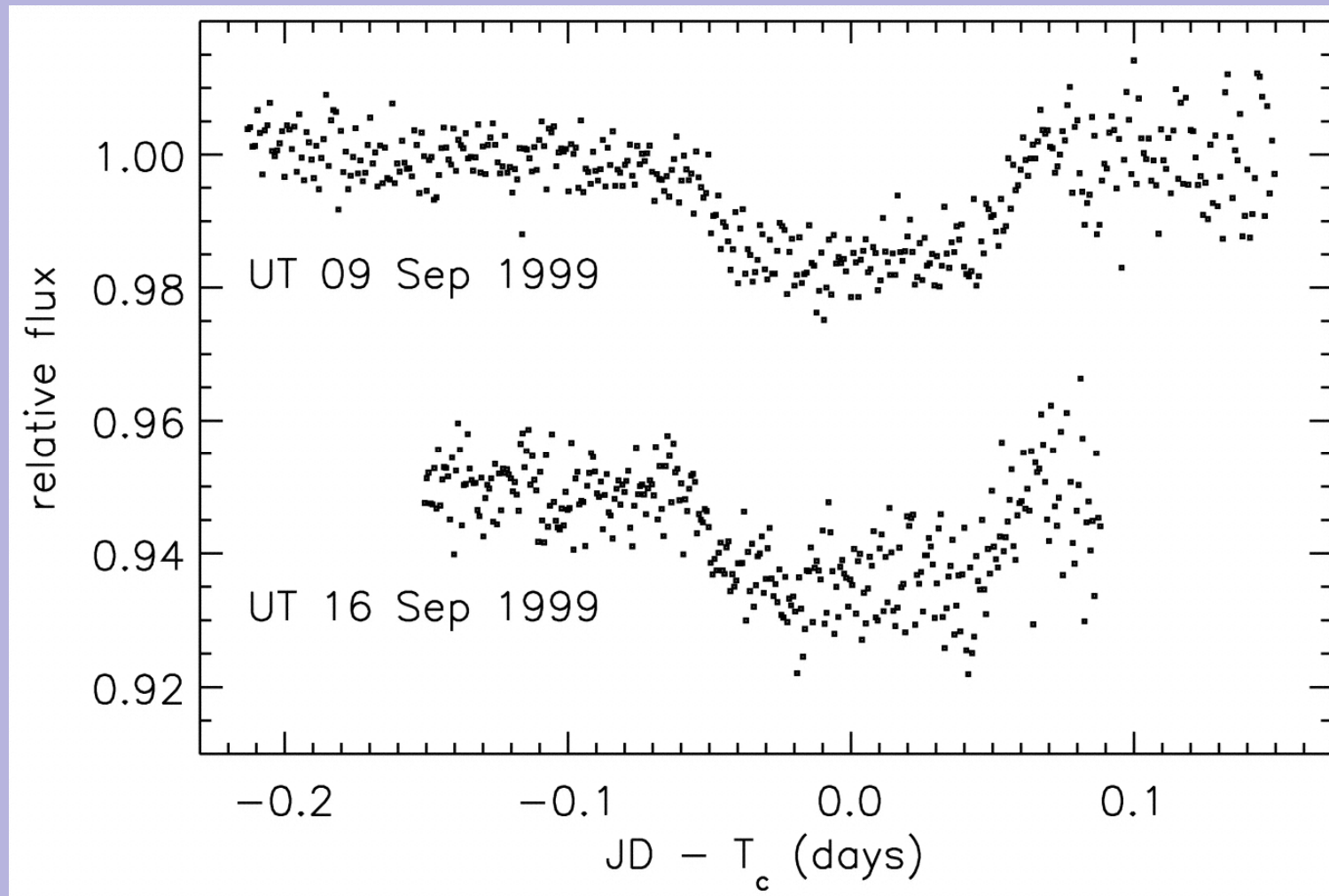
Ground 2004: $\sigma_A = 14 \mu\text{mag}$



CoRoT: $\sigma_A = 1.5 \mu\text{mag}$

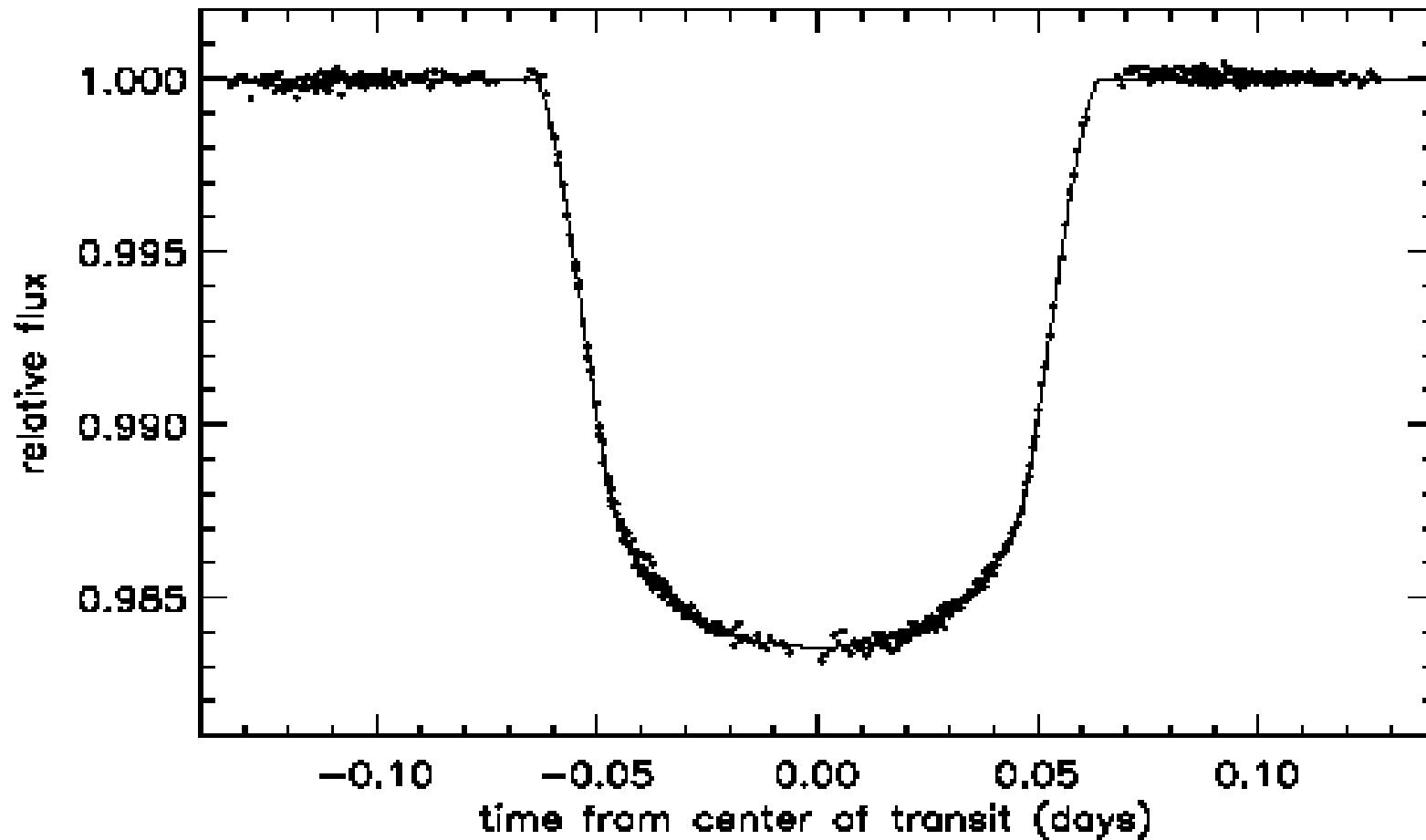


HD 209458



Charbonneau, D., Brown, T., Latham, D., Mayor, M., 2000, ApJ, 529

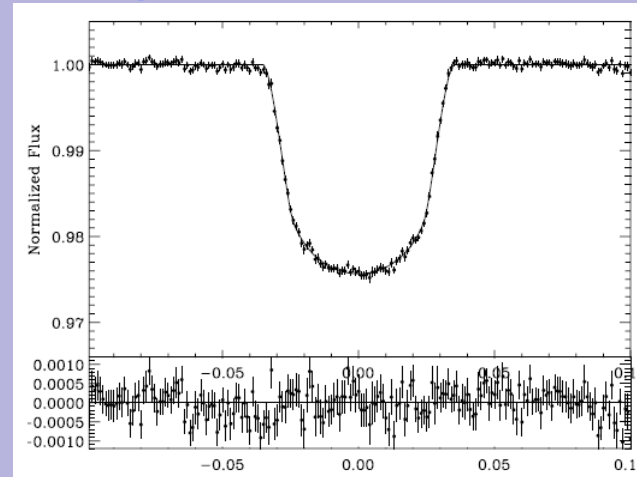
Eric Agol - HST transit data



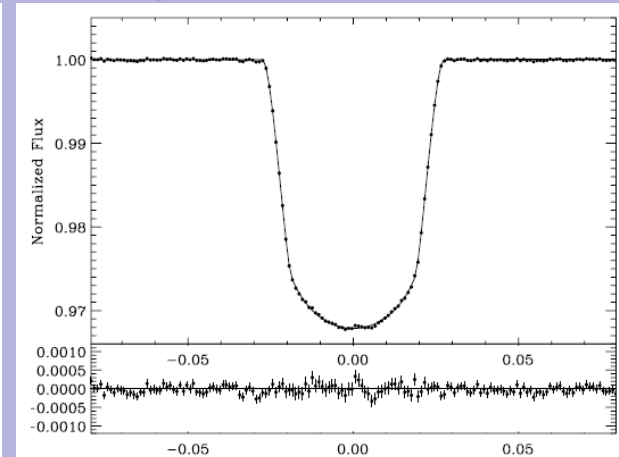
CoRoT exoplanets

Heike Rauer

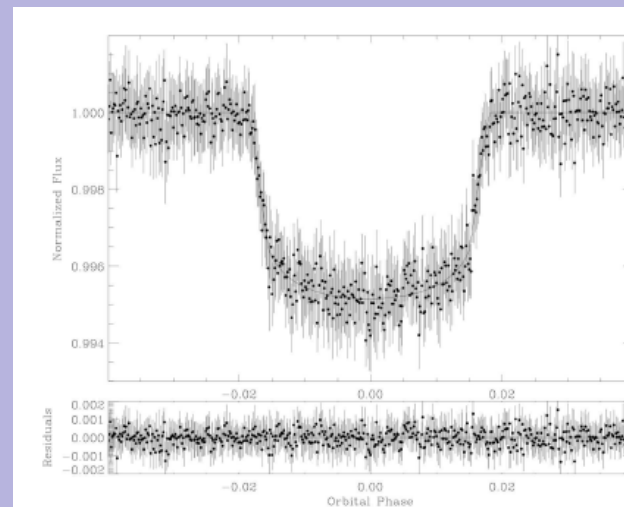
CoRoT-Exo-1b



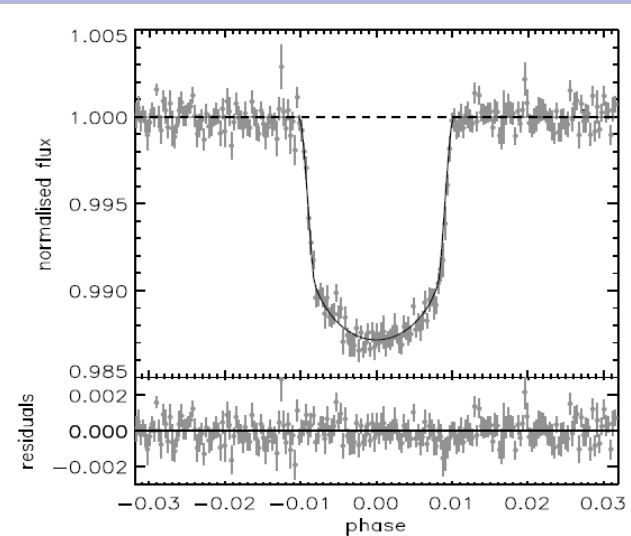
CoRoT-Exo-2b



CoRoT-Exo-3b



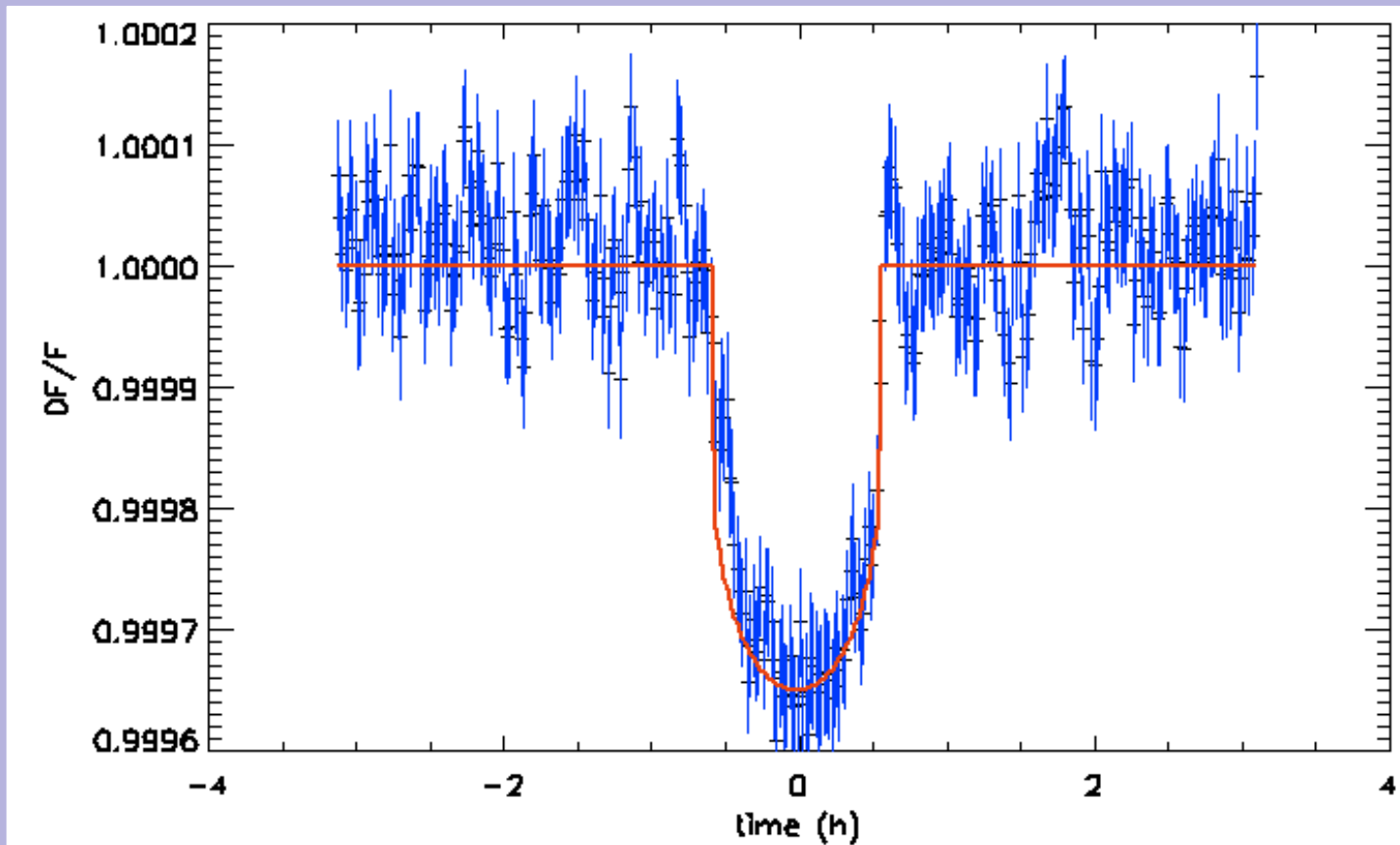
CoRoT-Exo-4b



5 February 2009

First CoRoT International Sym

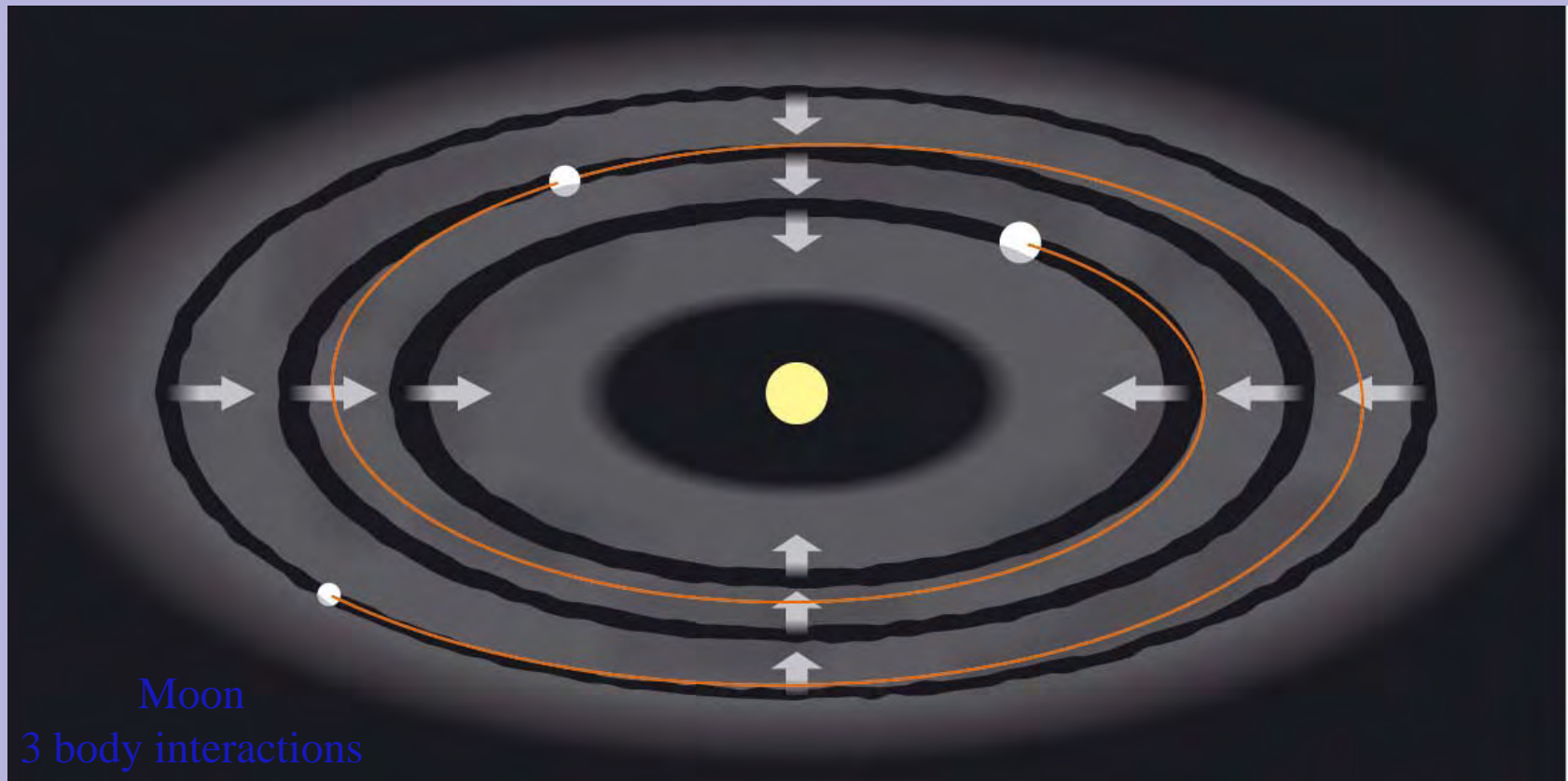
Hans Deeg - exo 7b





Caroline Terquem

...too complicated; the initial conditions are not defined.
“We are being driven by observations.”



Planet modelling

Guenter Wuchterl: “Making good planets is hard!”

General Theory of planet formation

“Can we catch up with observations?”
Yes, we can!”

Planet modelling

Diana Valencia:

“It is a matter of time
before the first ... radius
of a super-earth is obtained”

naturenews

Published online 3 February 2009 | Nature | doi:10.1038/news.2009.78

Corrected online: 3 February 2009

Corrected online: 3 February 2009

NEWS

Tiniest exoplanet found

Satellite spots a planet less than twice the width of Earth.

Geoff Brumfield

A European satellite has spied the smallest and fastest-orbiting extrasolar planet to date, bringing astronomers closer to finding a habitable planet outside our Solar System.

The Convection, Rotation and Planetary Transits (CoRoT) mission, a French Space Agency (CNES) satellite that scans for exoplanets ? planets outside our Solar System ? has spied a rocky planet whose radius is slightly less than twice that of Earth. At 5.7 Earth masses, the planet is not the lowest-mass extrasolar planet ever found, but the mass and radius measurements suggest a density similar to that of earth.

"It's much more Earthlike than previously found planets," says Suzanne Aigrain, a researcher at the University of Exeter who is part of the CoRoT team. The results were announced today at a CoRoT symposium in Paris.



The exoplanet has a density close to that of Earth's.

CoRoT

CoRoT exo 7b

CoRoT exo 7b =

Caliterra

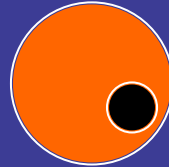
Caliterra

Daniel Rouan: “pretty hot!”

Astronomical Sources of false alarms

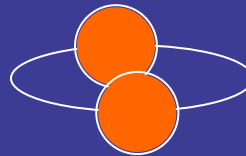
We look for:

PLANETS

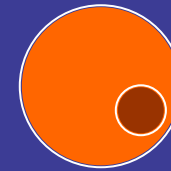


Confusion from:

- **UNDILUTED BINARIES**



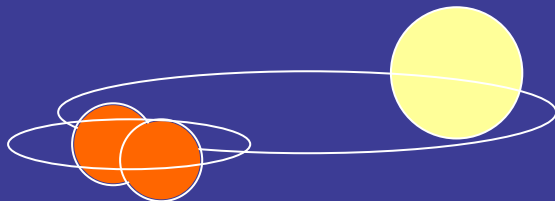
Grazing Eclipsing Binaries



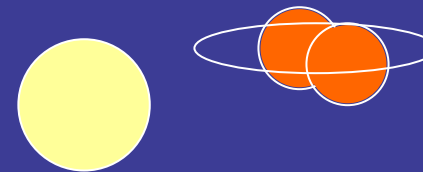
Eclipses of stellar components
with large mass ratio

- **DILUTED BINARIES**

Eclipsing Binaries with deep eclipses + light from a bright 3rd star → shallow eclipses

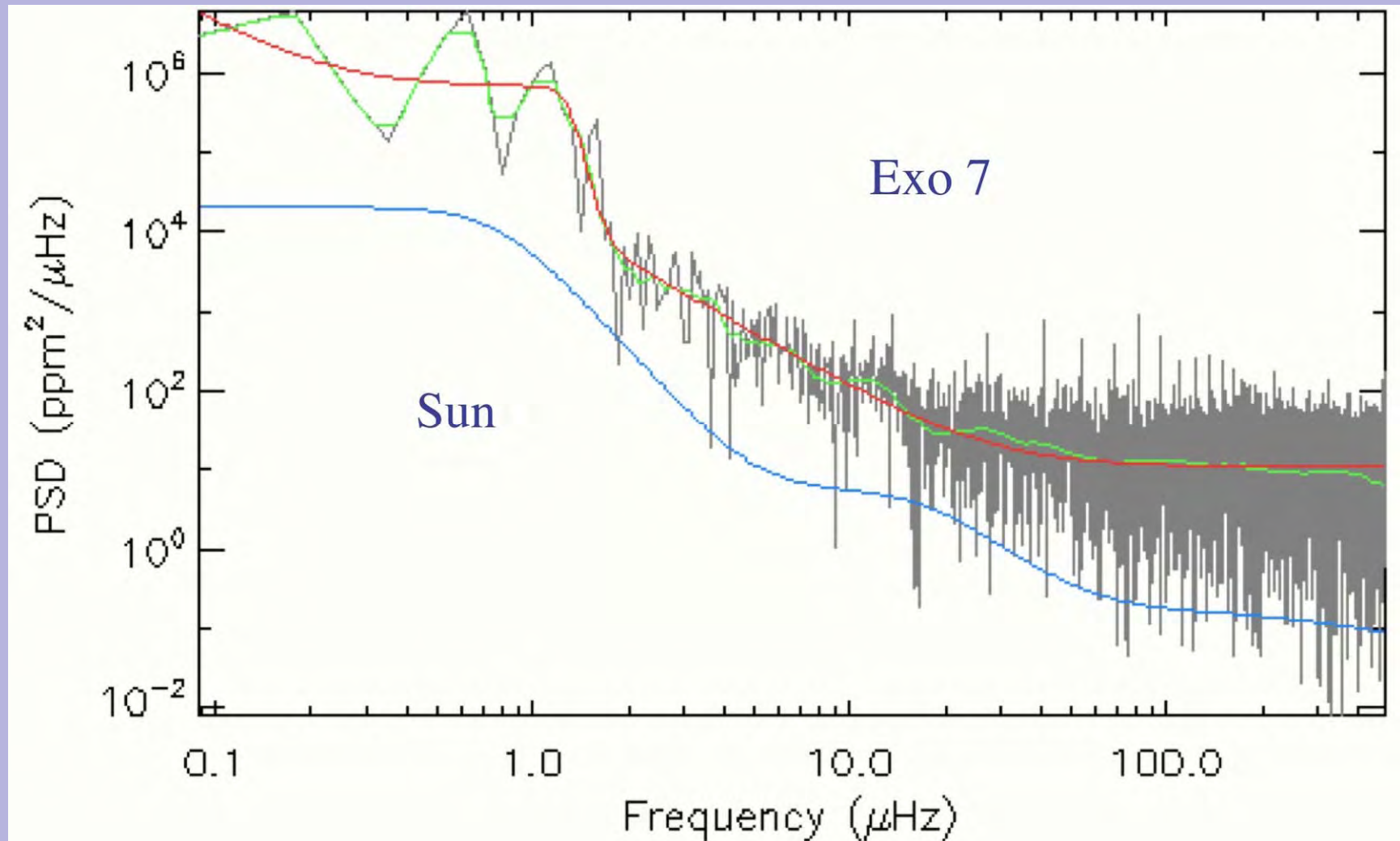


Eclipsing Binaries in triple system



Eclipsing Binaries +
unrelated (fg/bg) star within psf

Suzanne Aigrain



Suzanne Aigrain

- The Sun is special
- 100s of stars are more active than the Sun
- Is intelligent life viable around more active stars?
- Bill Borucki: “We find the same thing.”
- “This is terrible! [anon]
- Marc Giampapa: “Activity influences the evolution of planetary atmospheres.”

Granulation and activity

Fabio Favata:

“Pre main sequence eclipsing binaries are precious”

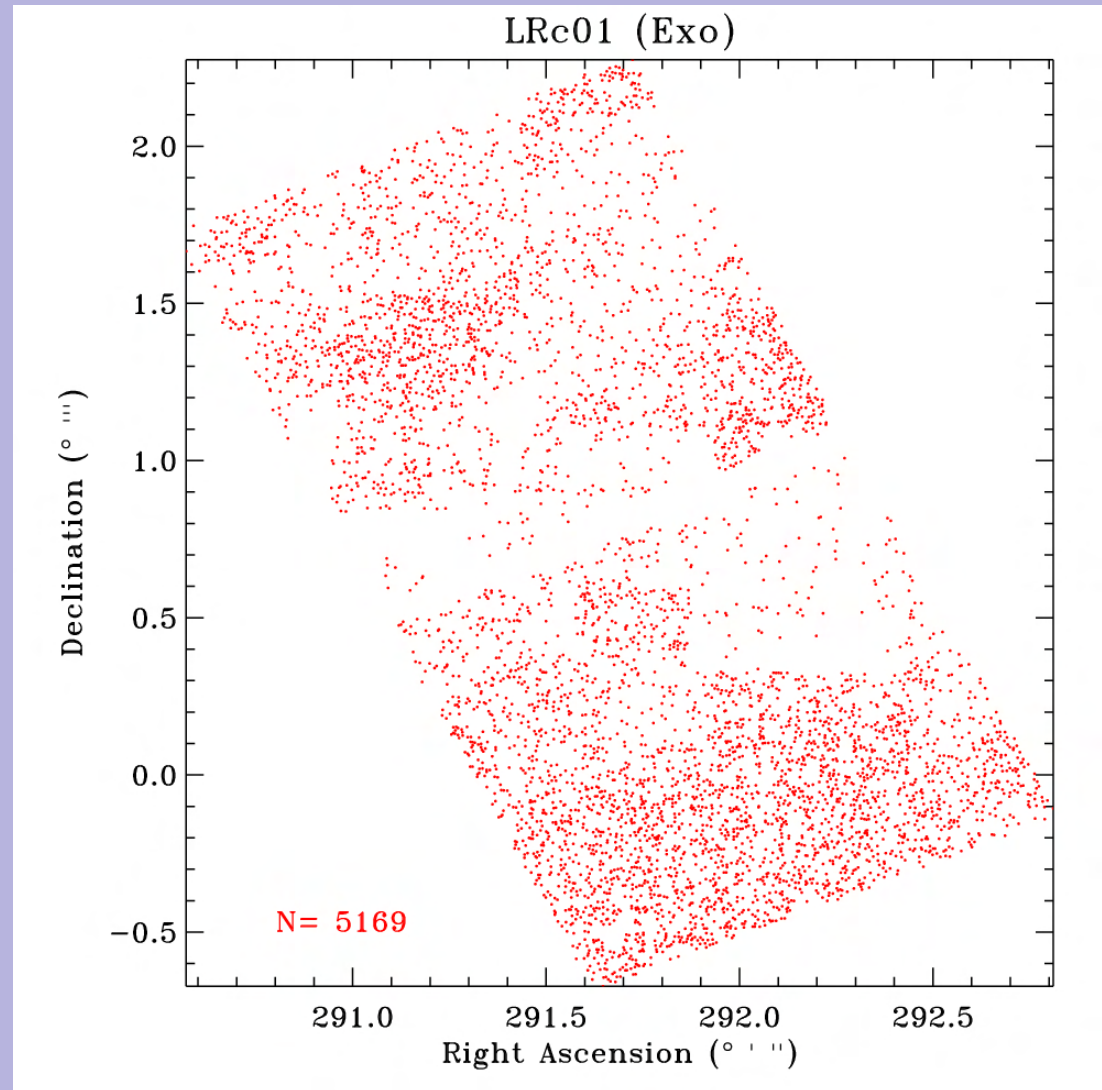
“CoRoT is a real treasure trove!”

Annie Baglin:

“Should CoRoT return to NGC2264?”

Rotation - Laura Affer

10,000 stars



Pierre Barge

“Follow-up observations are absolutely necessary.”

Dave Latham: “... followed up 700 stars and published
14 planets - ground-based.”

CoRoT stars are relatively faint.
Kepler stars will be relatively faint.
What is the lesson for planet-finding?

Ground-based follow-up

- FU spectroscopy - Carla Maceroni
 - photFU - Hans Deeg

Ground-based follow-up

- Caution!

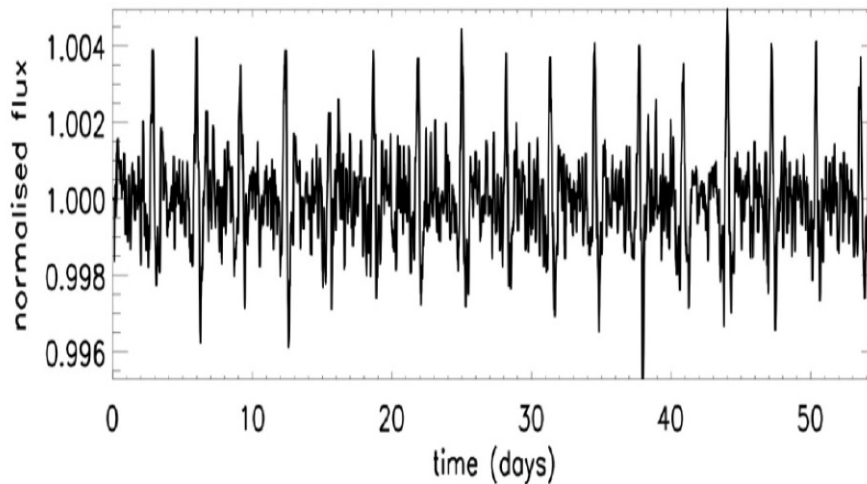
SNAFU

What goes 999, clump; 999, clump; ...?

What goes 999, clump; 999, clump; ...?

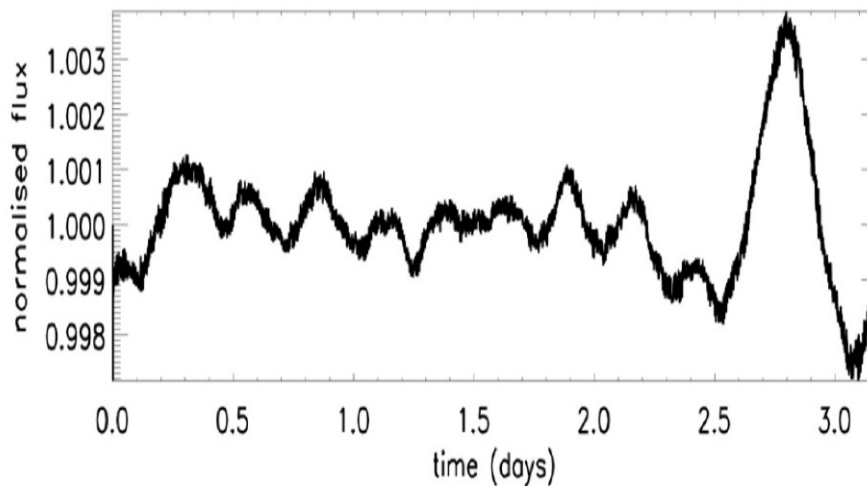
A millipede with a wooden leg.

Stephania Carpano

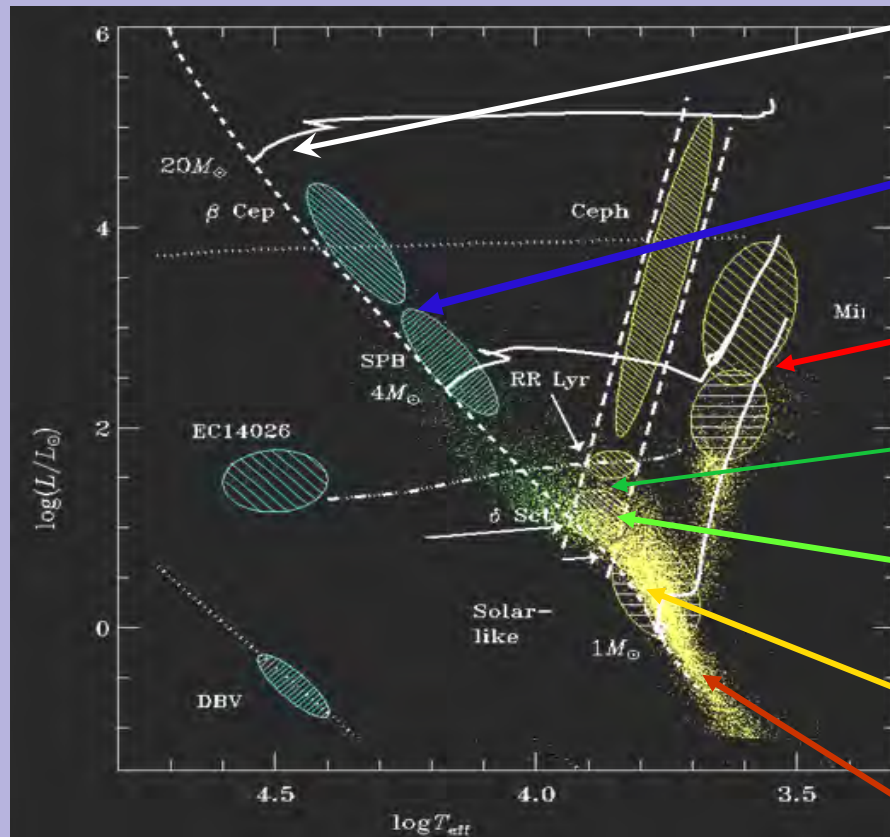


“What is it?”

“I don’t know!”



Seismology Targets already observed



7 O

12 B stars,
1 β Ceph,
5 Be

10 giants (G,F)

7 δ Scuti,
2 known γ Dor +1

17 A/early F stars ?
3 Am, 7 Ap,

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

3 KM ?

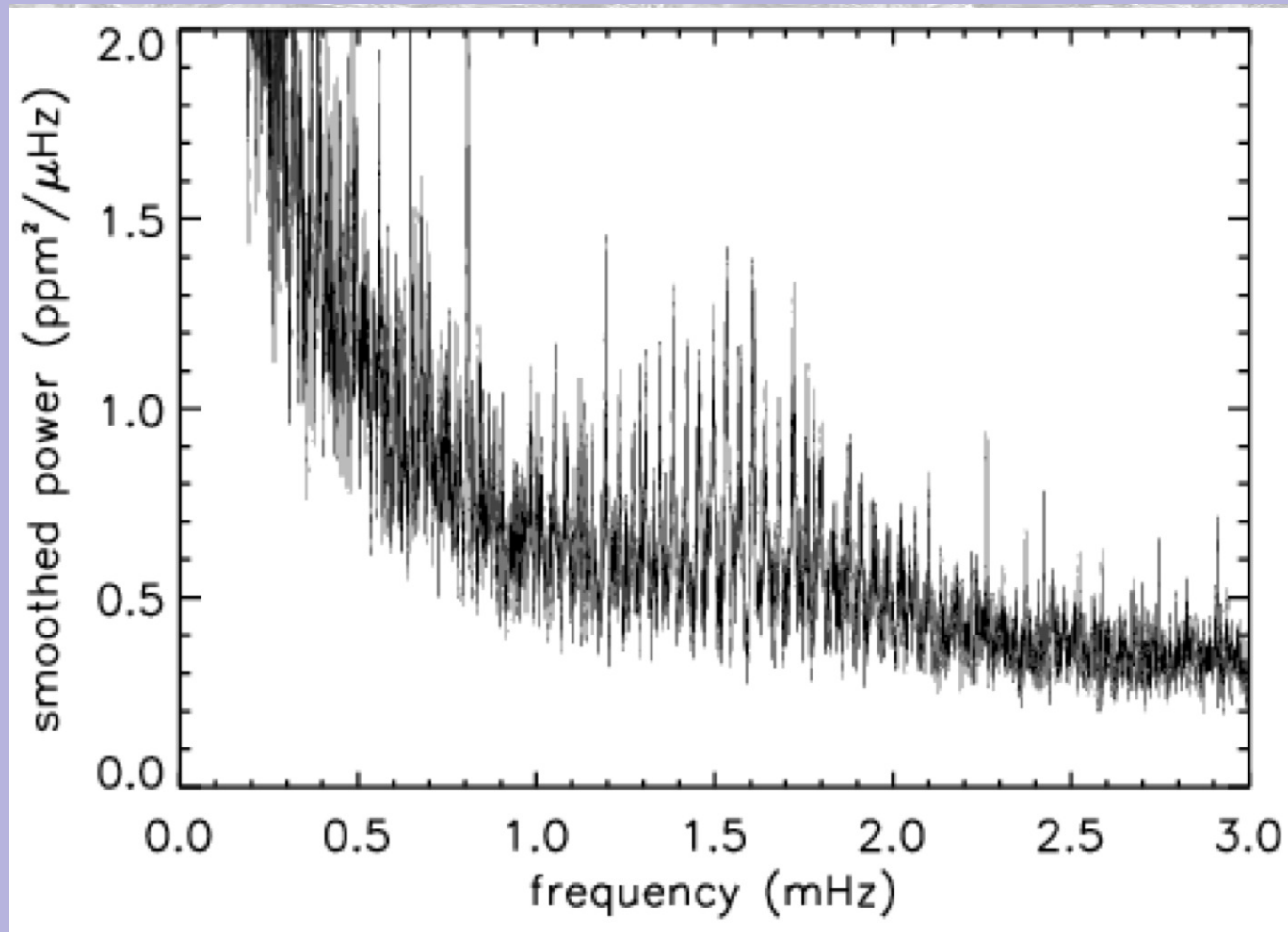
Conny Aerts

“The great harvest of CoRoT is
going to be asteroseismology
in the exo field.”

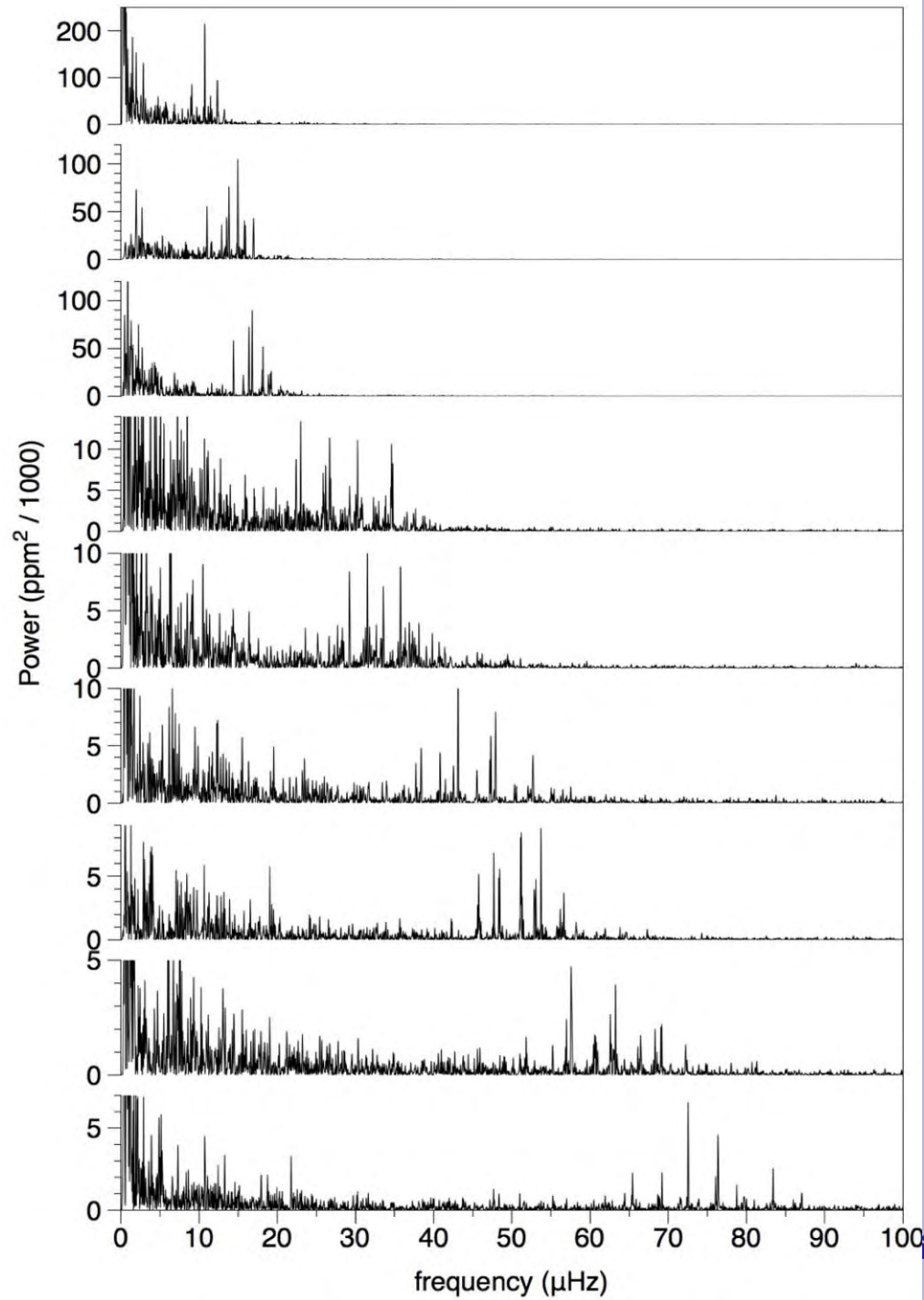
Red Giants

- Asteroseismologists are delighted with the CoRoT solar-like oscillations in red giants.
- Why?

Caroline Barban



Joris de Ridder



Claude Catala

“I am very, very happy we were so inefficient in eliminating red giants from the exofield!”

delta Sct stars: Dream come true or nightmare?

Eric Michel:

“We are looking at stars as we never have before.”

“We gain a factor of 100”

100 peaks, then 2000 peaks -

“we could go lower”

Ennio Poretti: “We reached the limit from the ground
[with 75 frequencies]”

delta Sct stars: Dream come true or nightmare?

Arlette Noels:

“We are so fortunate that theory cannot explain the observations. It would be so boring otherwise.”

Marx-Antoine Dupret:

“We will not solve the delta Sct stars anytime soon.”

delta Sct stars

- Mode lifetimes
- Frequency variability
- Amplitude variability
- Phase variability
- Window patterns (90% duty cycles)
- Combination terms
- Rapid rotation
- Dream or nightmare?
- Will there ever be an inverse study?

Jean-Paul Zahn

Can we expect similar results from asteroseismology
[as we have from helioseismology]?

Yes, but ...

Only low l modes;
Rapid rotation is a problem.

Modes in rapidly rotating stars

Coralie Neiner: “... model doesn’t work at all!”

Ian Roxburgh: “Nobody knows how to model these stars!”

Daniel Reese:

Island modes; chaotic modes; whispering gallery modes

What match to observations would convince us
that we had correctly identified modes
in a rapid rotator?

Thierry Appourchaux

“We observe the power spectrum only once.”

Ian Roxburgh

“CoRoT stars are not easy
... probably only $l = 0, 1$
... not convinced frequencies are accurate enough
It is dangerous to use frequencies”

Annie Baglin: “You don’t gain by observing longer
[because of mode lifetimes]”

So split the data!

Divide the long runs into independent data sets
and show that
the same frequencies are found.

Better confidence
is more important
than more frequencies.

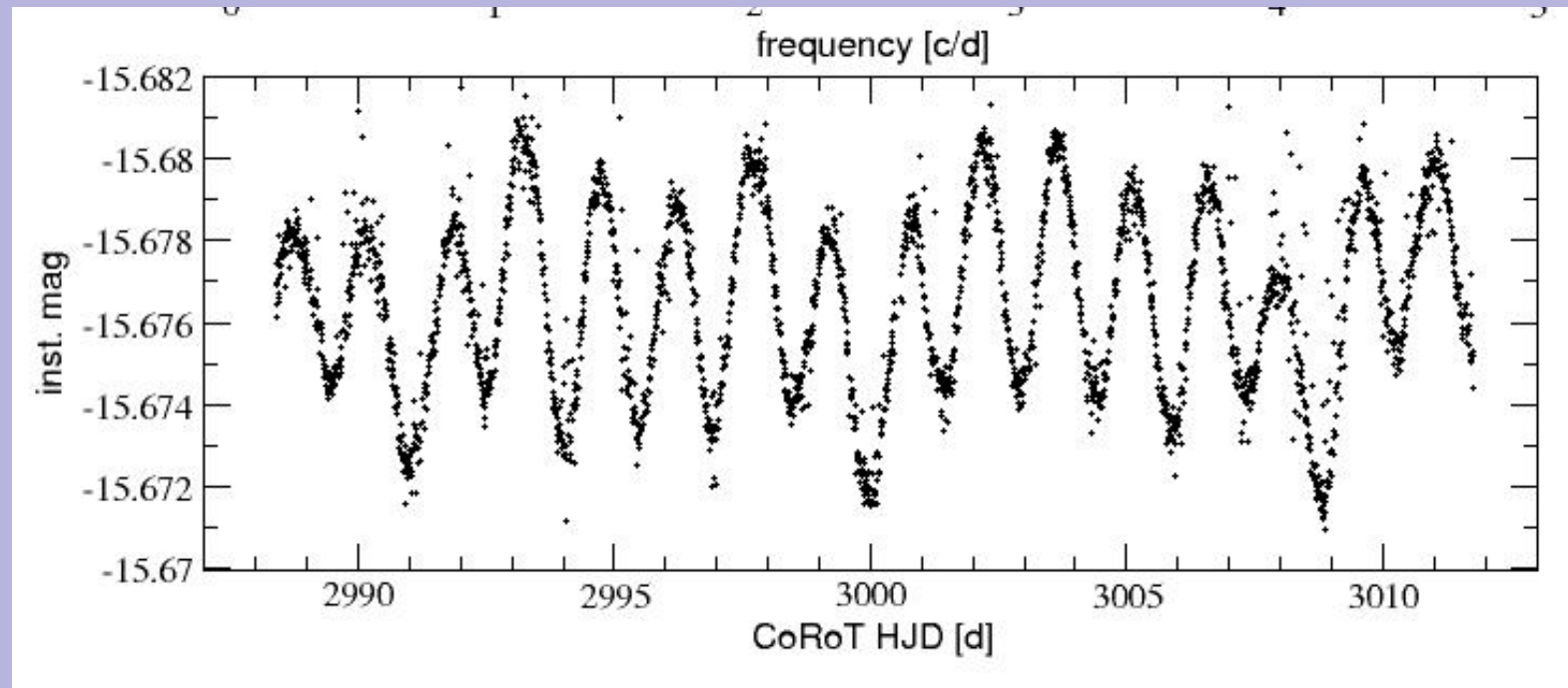
What can asteroseismology tell us?

- Core overshooting - convective core size
- Interior rotation
- Interior structure
- Chemical composition
- Age, mass
- Other fundamental parameters inferred

gamma Dor stars

Constanza Zwintz

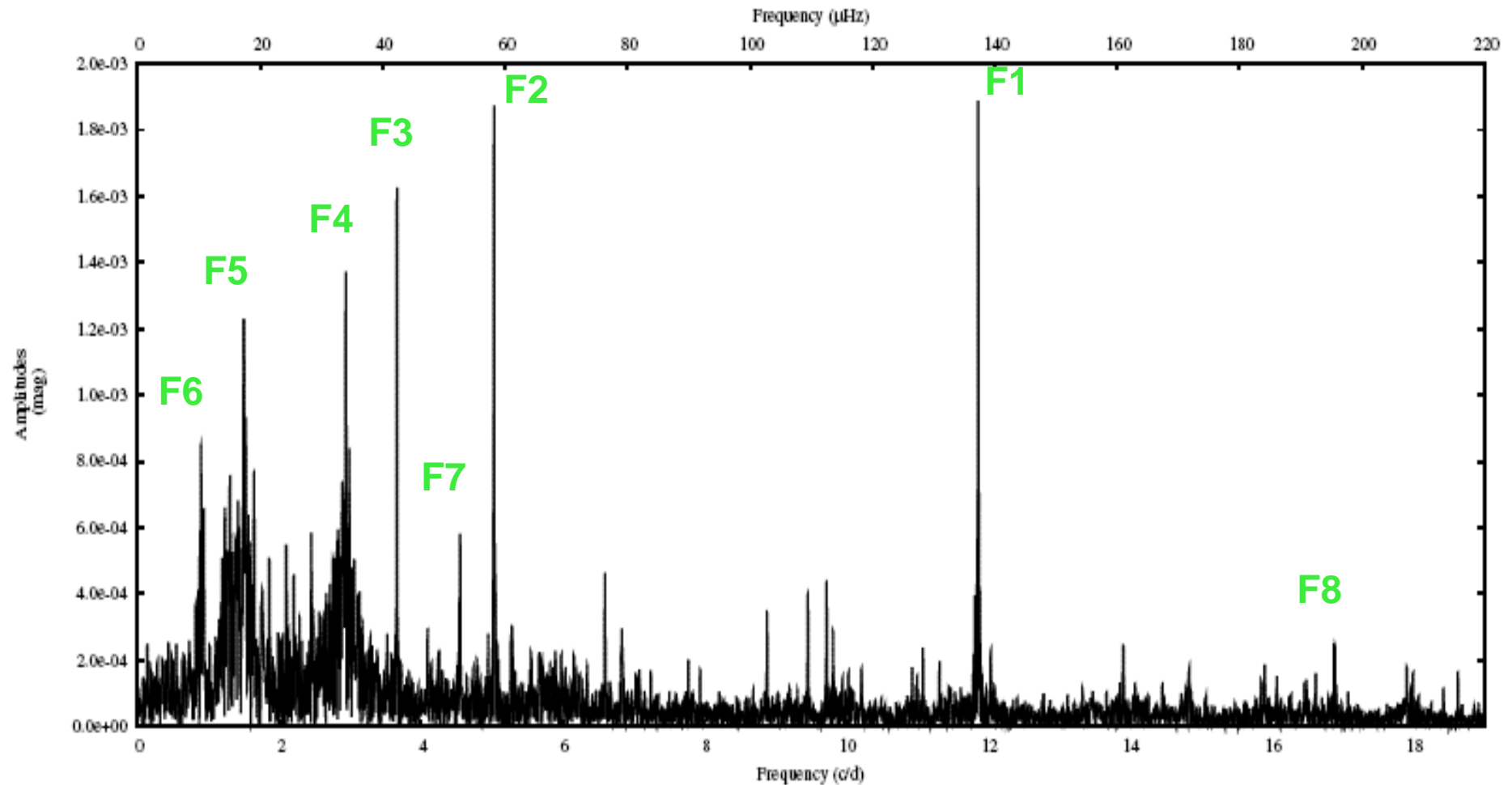
- PMS gamma Dor star in NGC 2264
- Compare PMS and post MS
- g modes test core conditions



Be stars: HD49330

- Be stars observed in outburst
- Anne-Laure Huat: correlation between amplitude changes and outburst
- Is this causal?
- What does it tell us about the formation of Be stars?

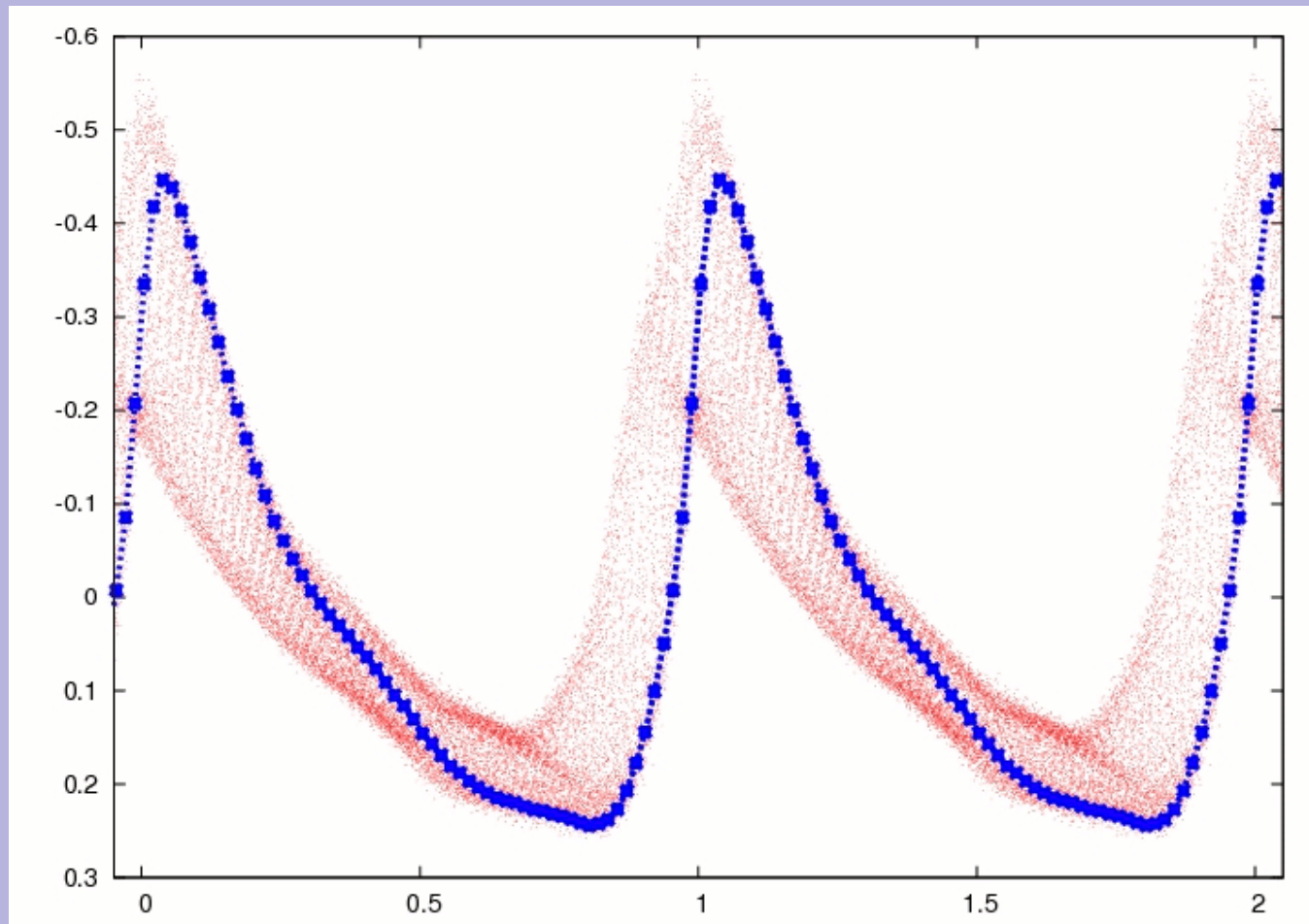
Be stars: HD49330



Blazhko effect

Robert Szabo, Margit Paparo, Miriame Chadid et al.

Blazhko effect



Constant stars

Eric Michel:
Constanza Zwintz:
“They exist!”

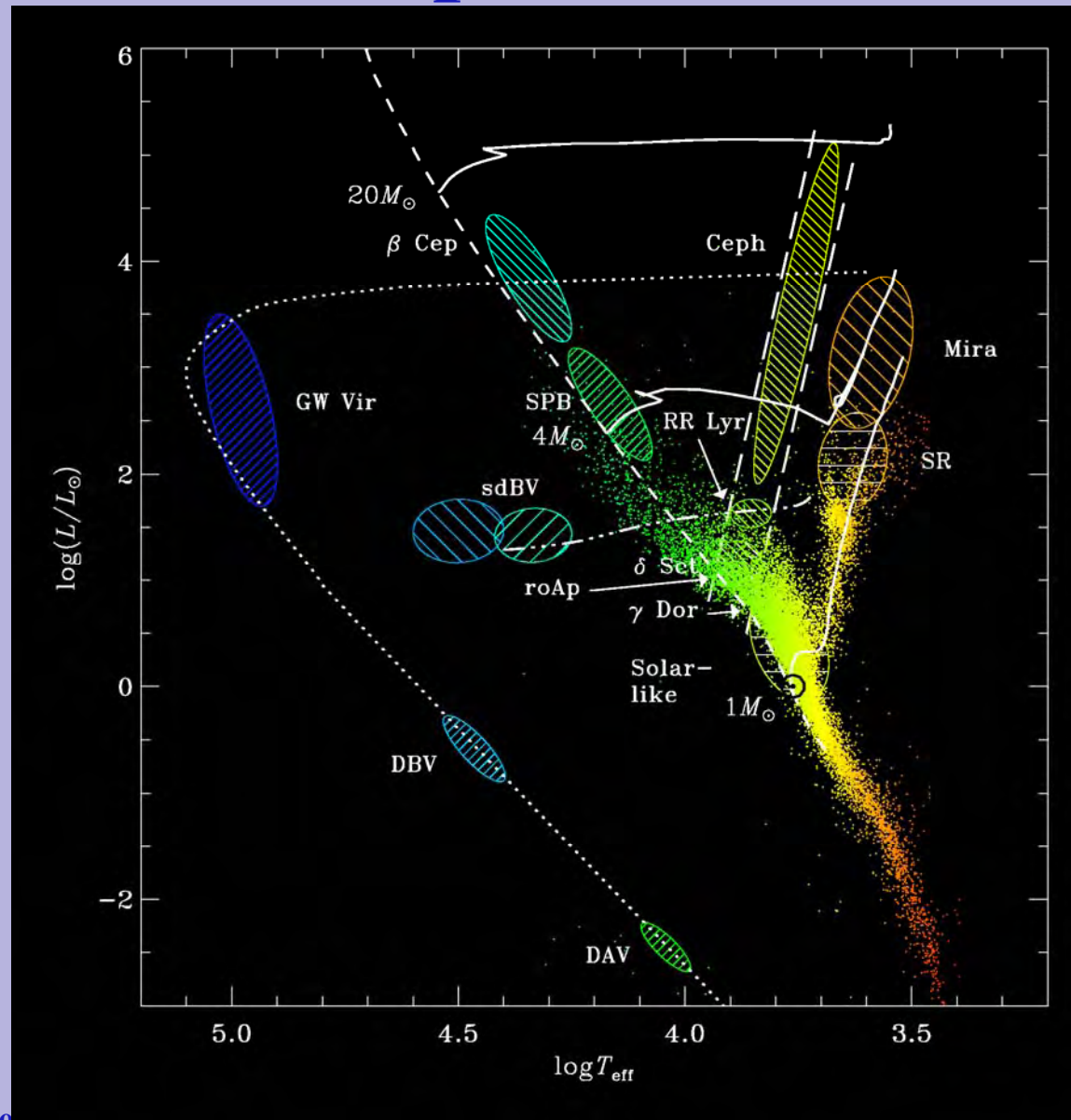
So why do I care?

The timing method

Stephane Charpinet:

“We can use the asteroseismic CoRoT stars as clocks to find exoplanets.”

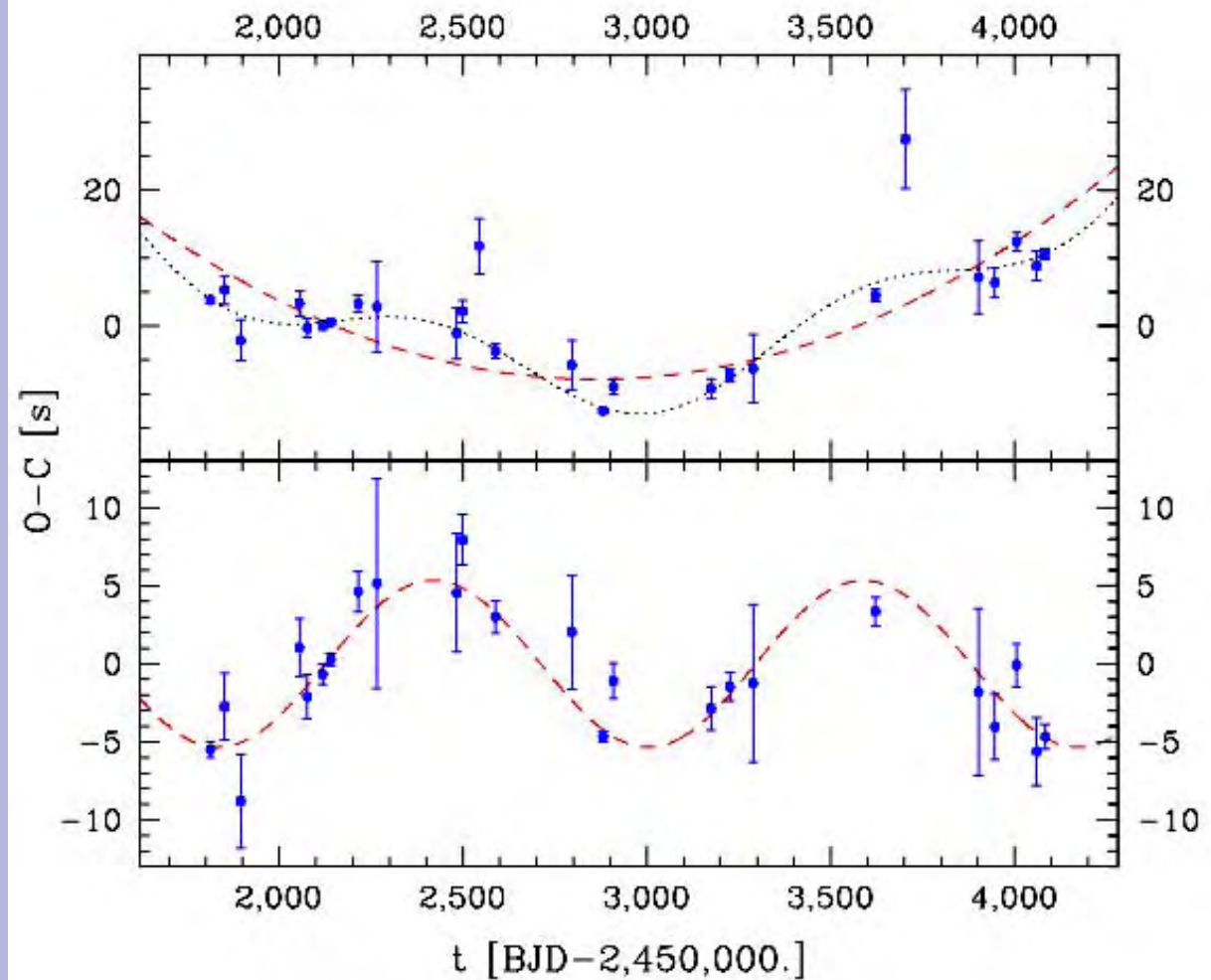
sdBV star and planet - V391 Peg b



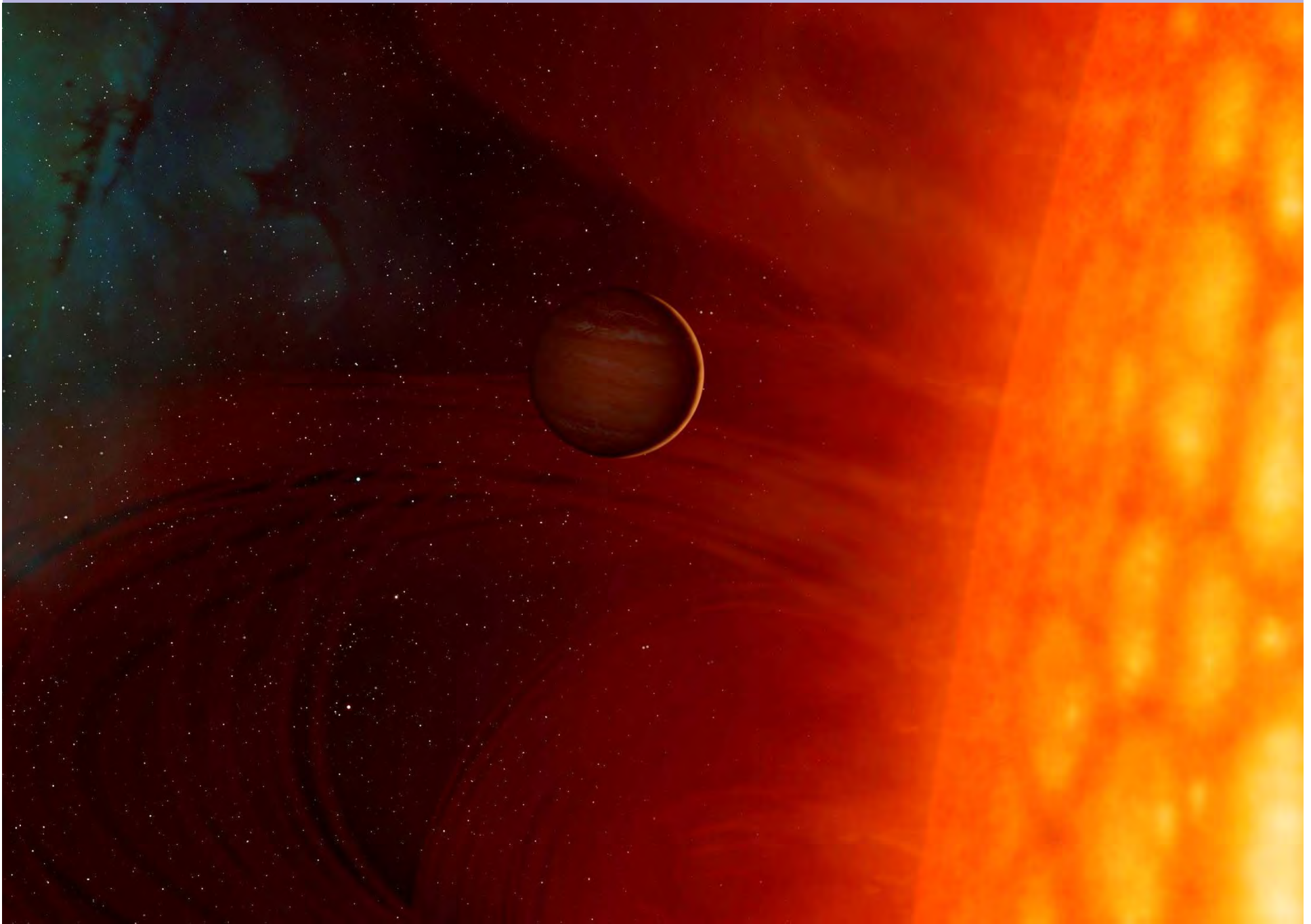
Pulsation timing: a new planet

Silvotti et al.
2007, Nature,
449, 189

V391 Pegasi b

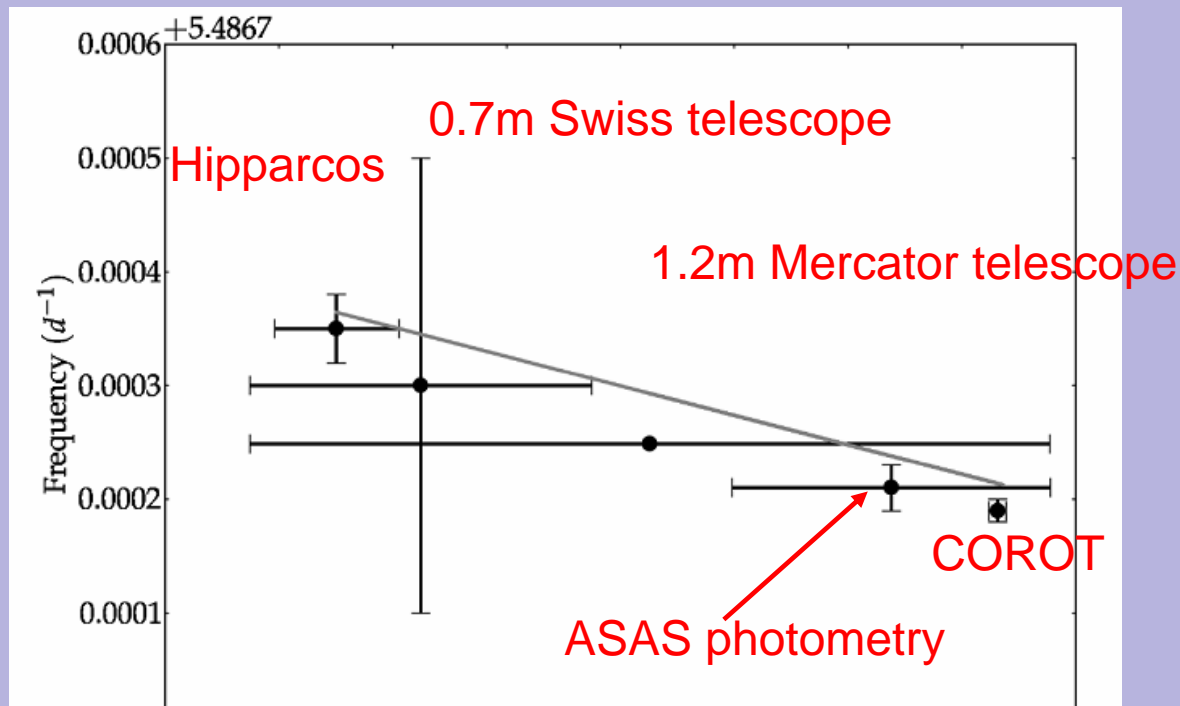


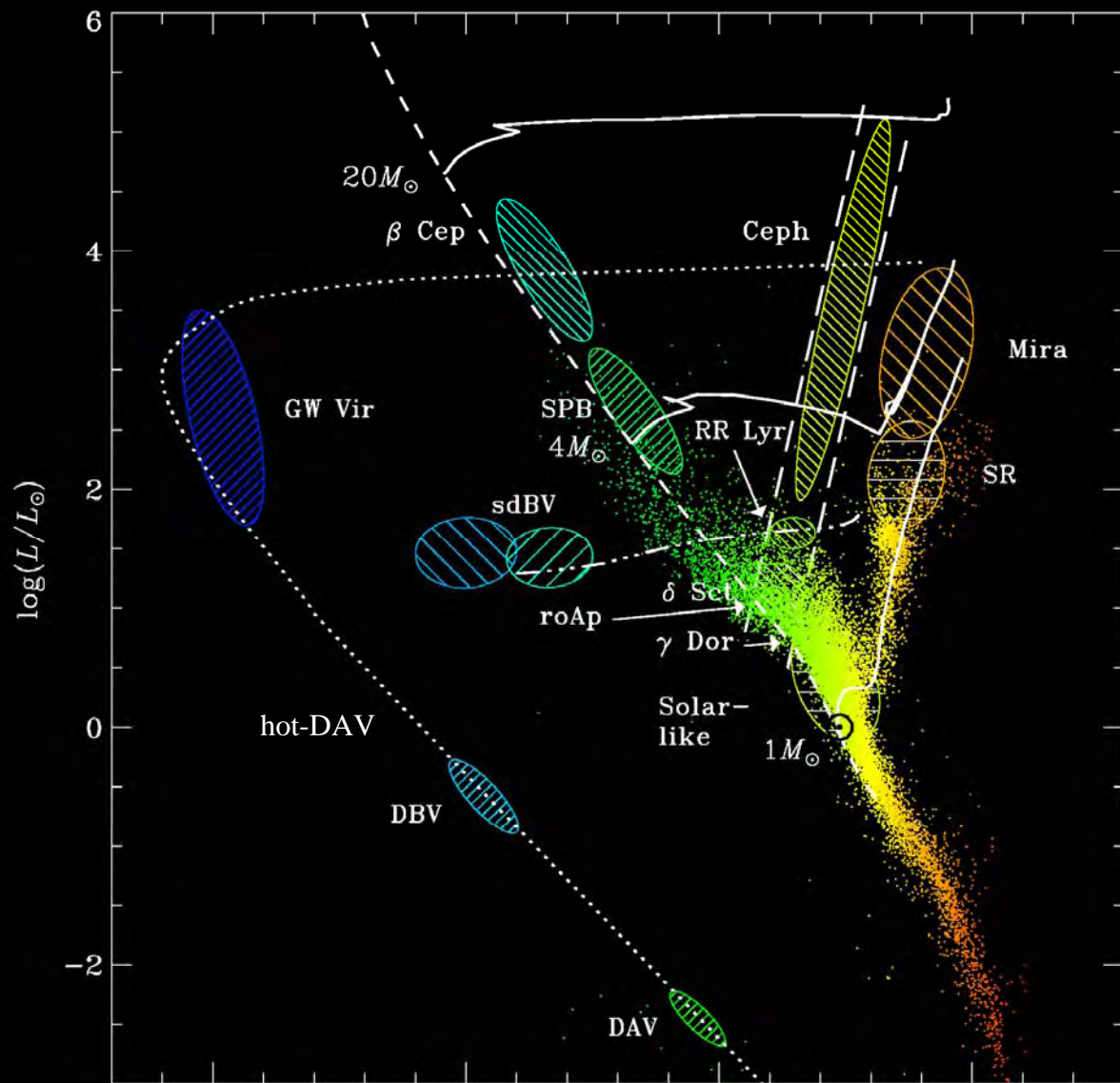
5 February 2009

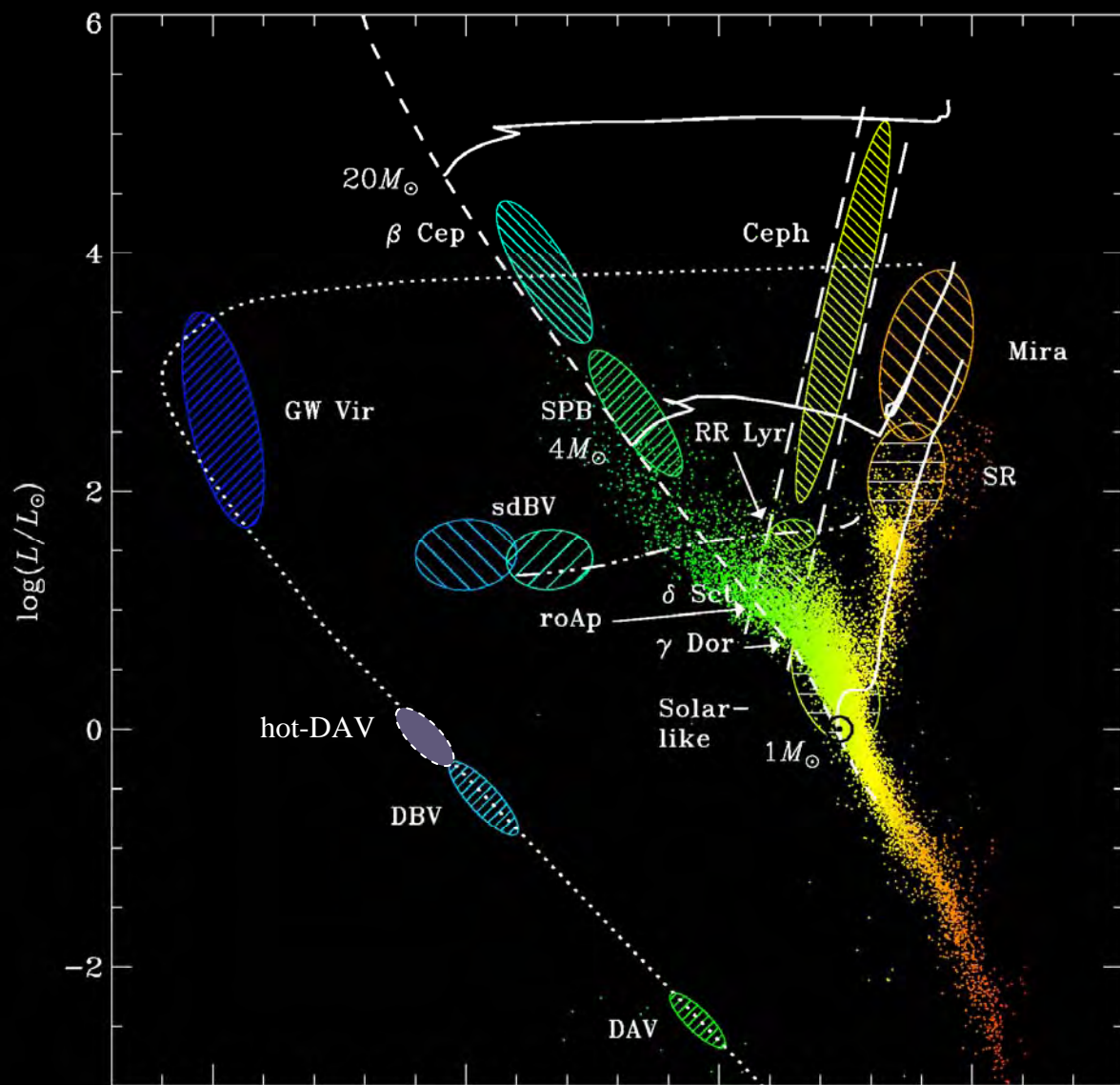


HD180642 = V1449 Aql (THE only β Cephei star main target of CoRoT).

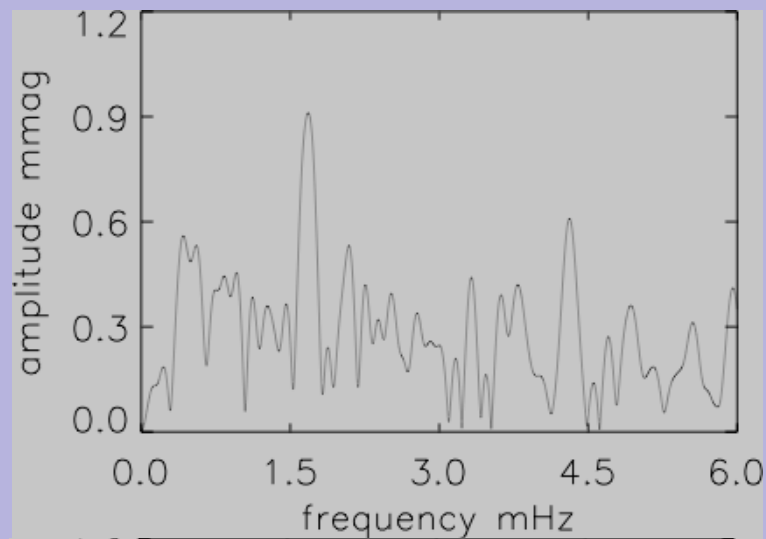
Thoul







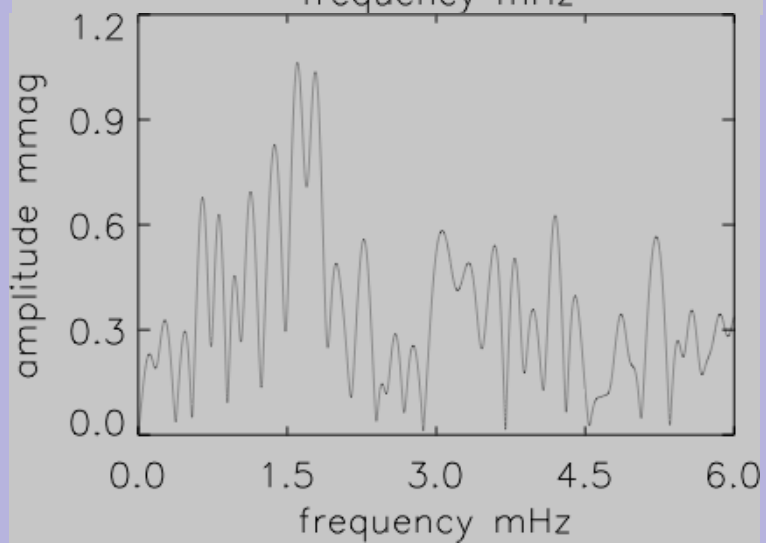
hot-DAV white dwarfs



$$A = 0.90 \pm 0.09 \text{ mmag}$$

$$S/N = 10.0$$

$$P = 10 \text{ minutes}$$



$$A = 1.01 \pm 0.12 \text{ mmag}$$

$$S/N = 8.4$$

$$A = 0.95 \pm 0.12 \text{ mmag}$$

$$S/N = 7.9$$



**Guillaume Joseph Hyacinthe
Jean-Baptiste le Gentil de la
Galasière**

**The worst observing run
in history.**

CoRoT

The best!

CoRoT

The best!

Viva la révolution!

THANKS

ees

g Committee :

t: Chantal DELABARRE, CNES

S (HELAS)

N, Observatoire de Paris - LESIA

R, Colloquium

COUNIL, CNES

MAREC, Colloquium

ERMARCQ (CNES)

Committee :

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RGNE - Observatoire de Paris LESIA

N - Observatoire de Paris - LESIA

E - LAM

SOLI - CNES

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