Waves inside Stars: Observational Evidence

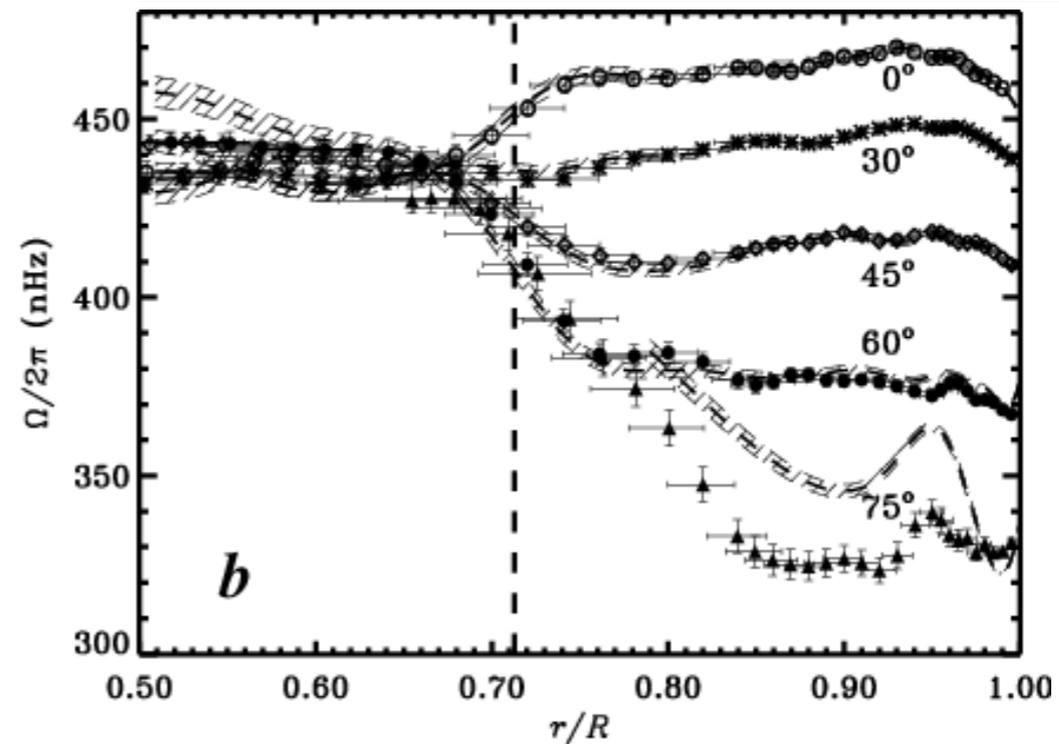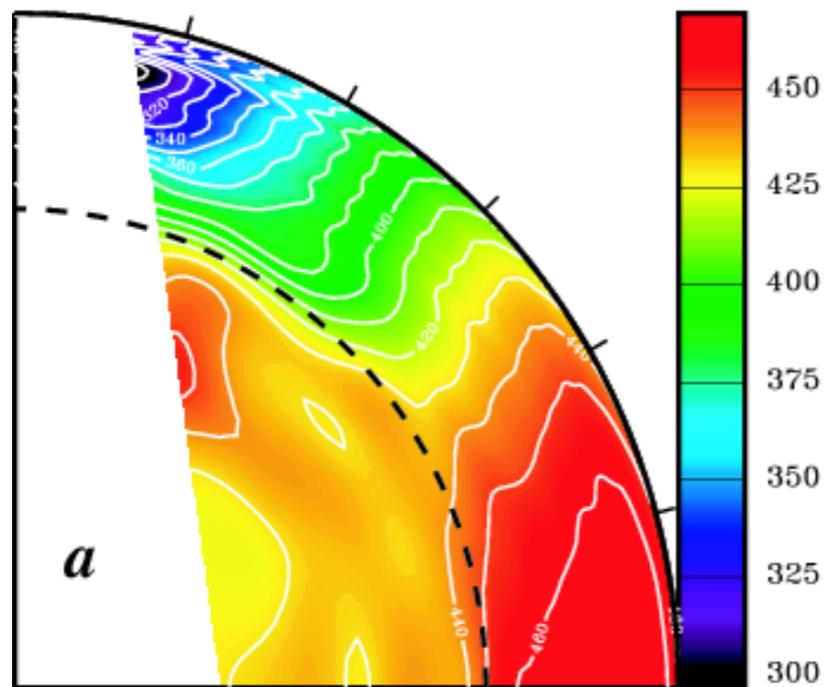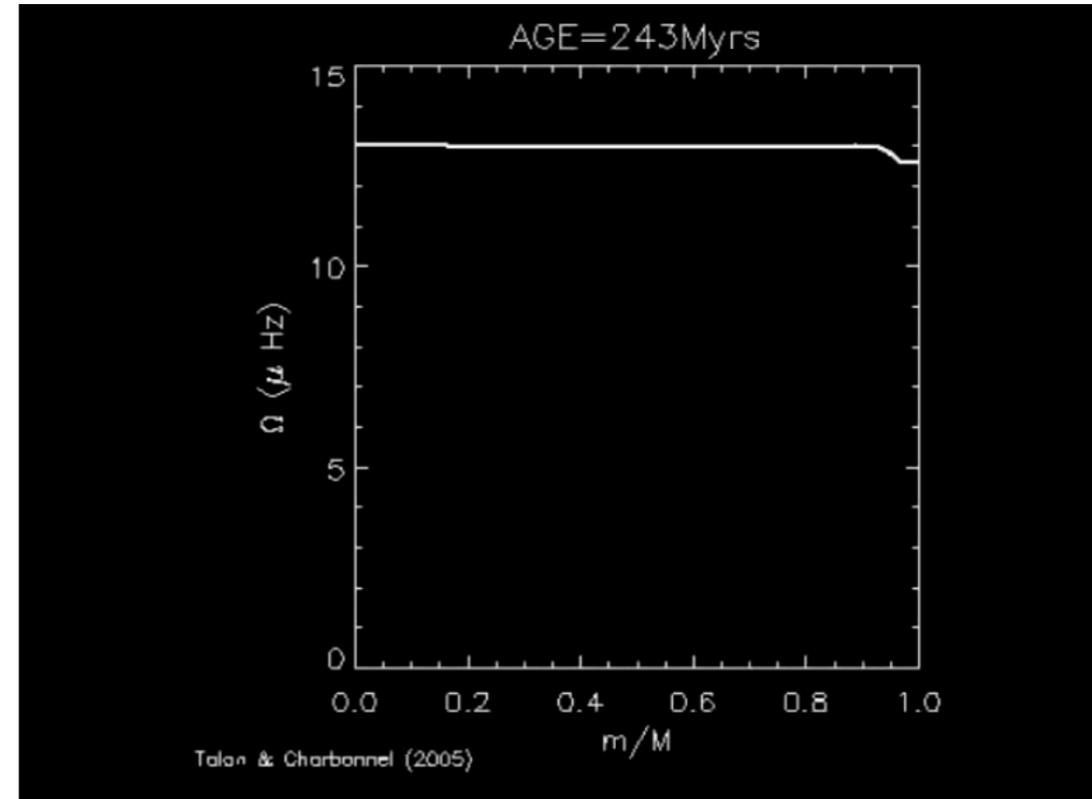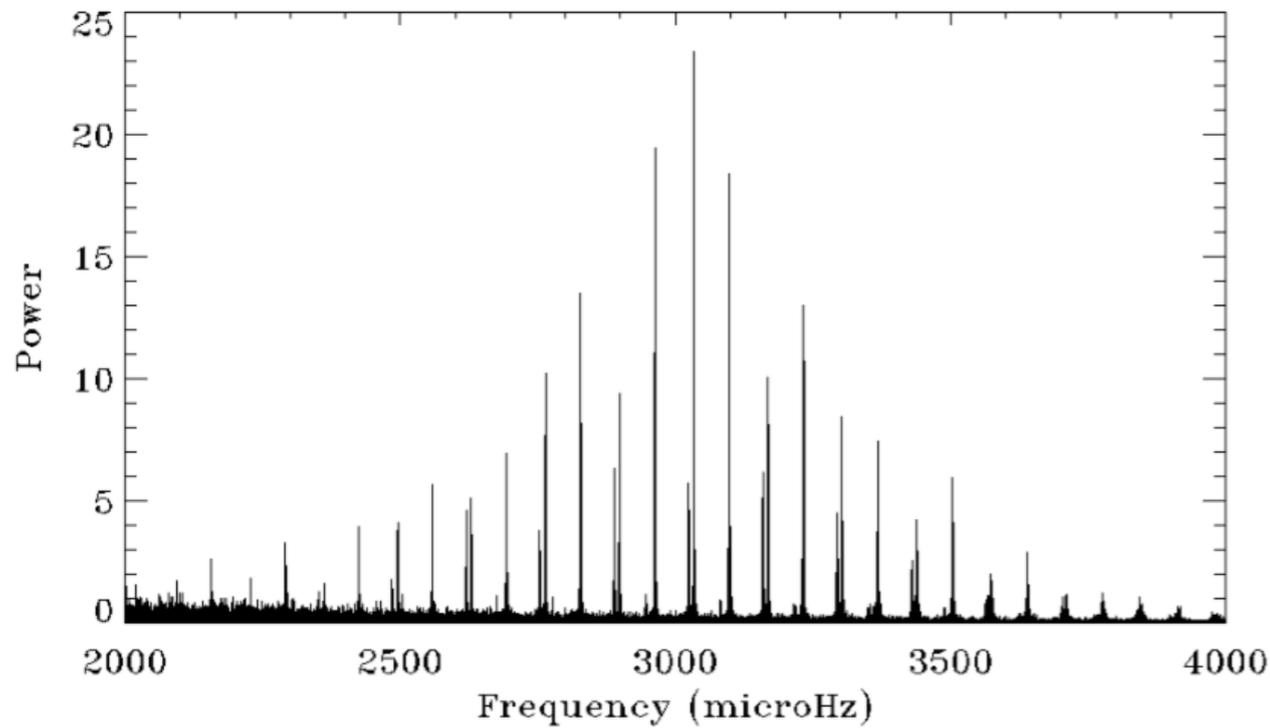## Conny Aerts

Institute of Astronomy, University of Leuven, Belgium

Radboud University Nijmegen, the Netherlands

Freiburg, 31 August 2015
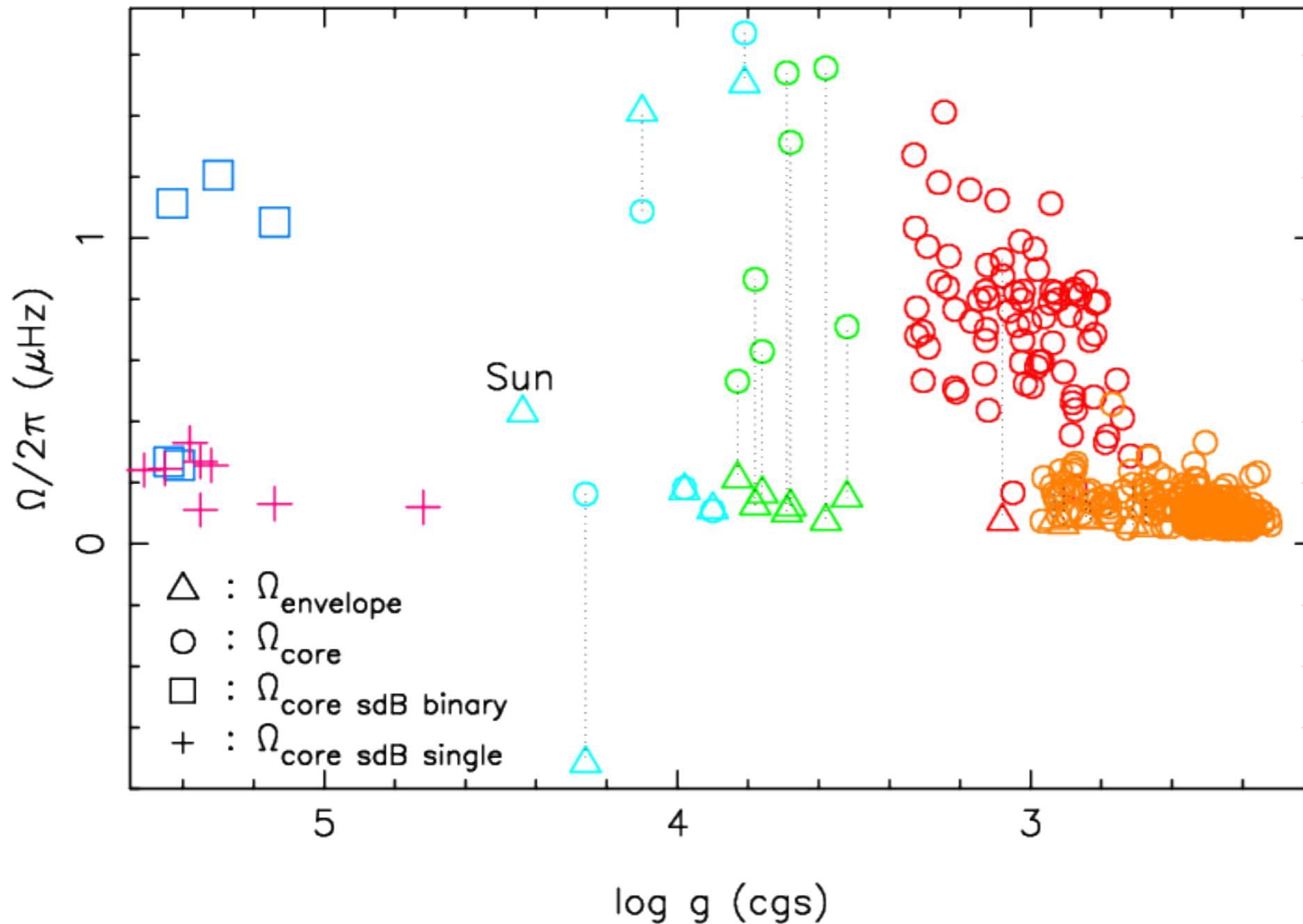
Early studies triggered by helioseismology
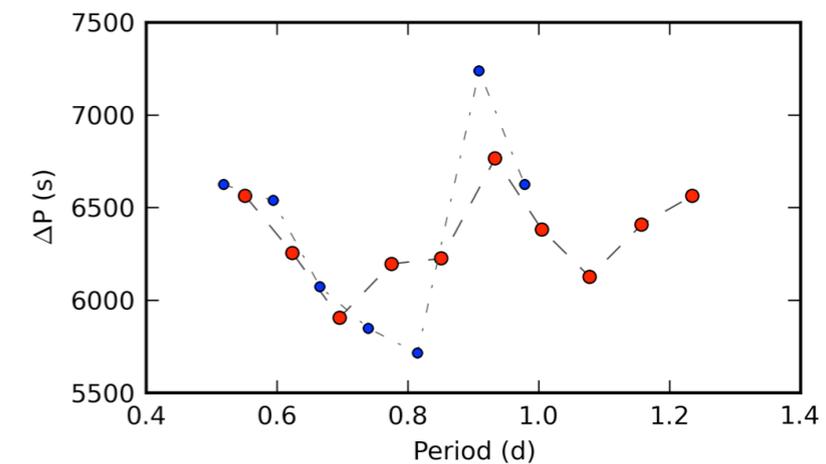

Talon & Charbonnel (2005)

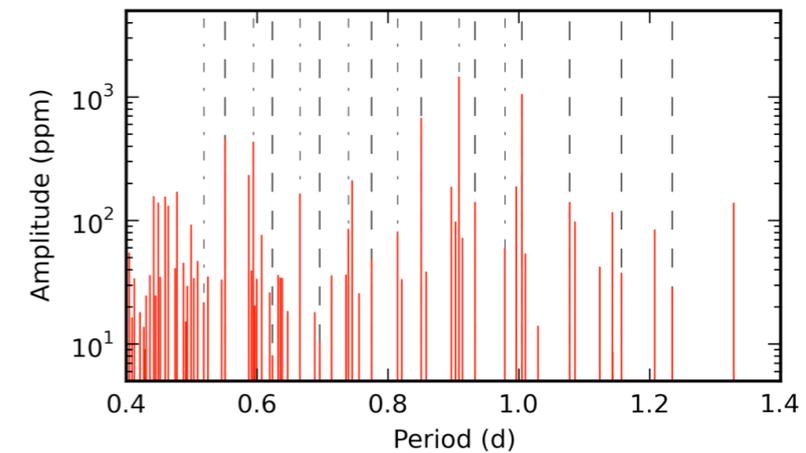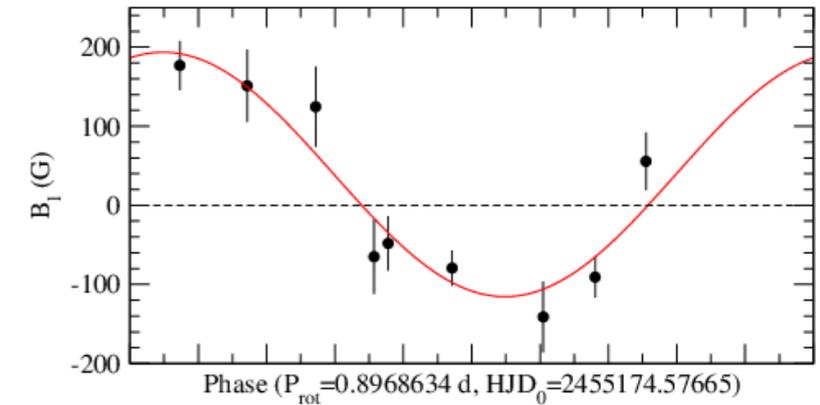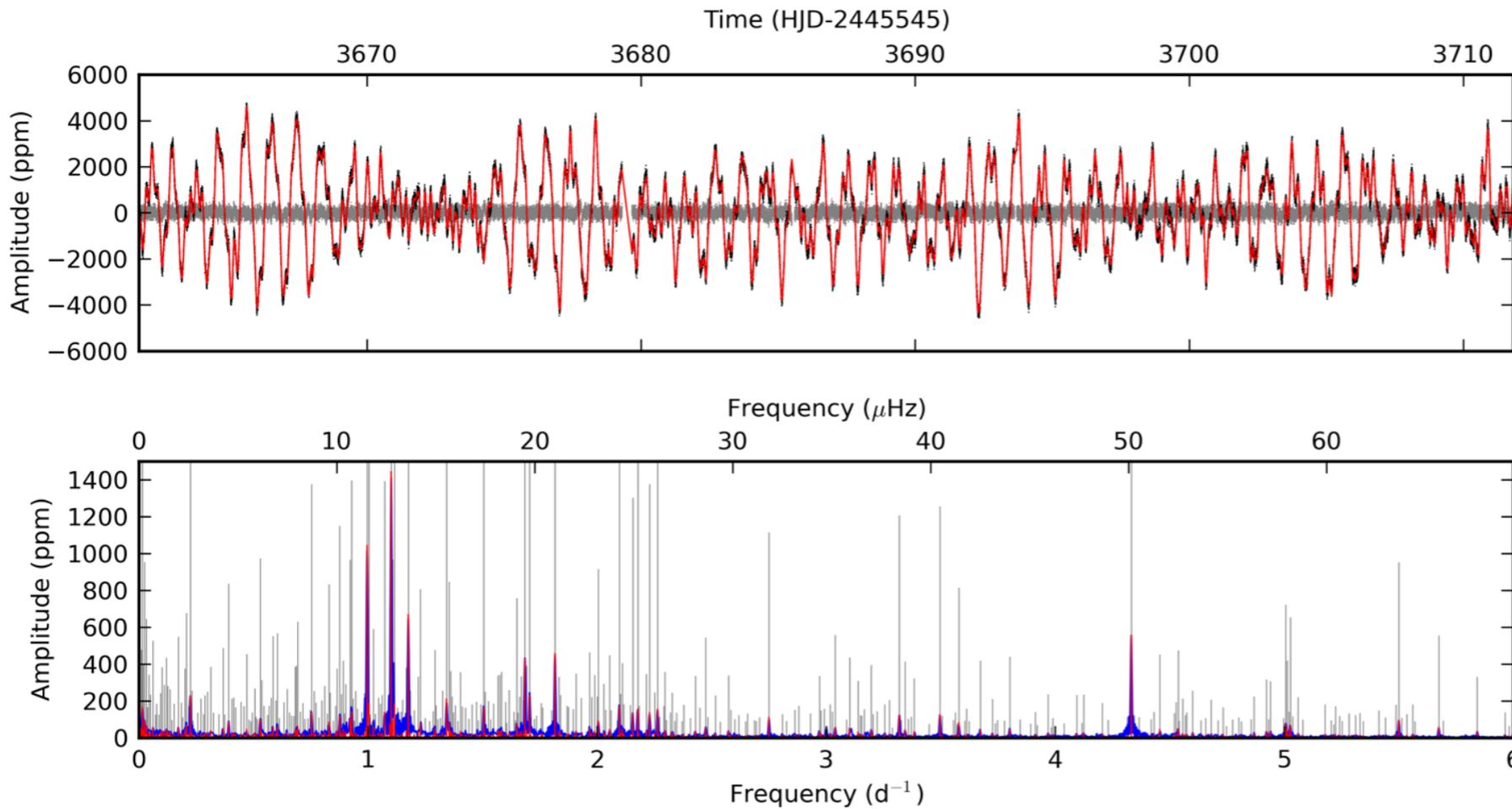# Studies triggered by asteroseismology

Adapted from Aerts (2015, Astron. Nachrichten 336, 477)

Pulsators with faster envelope than core rotation (or even counter-rotation) are piling up by the day…
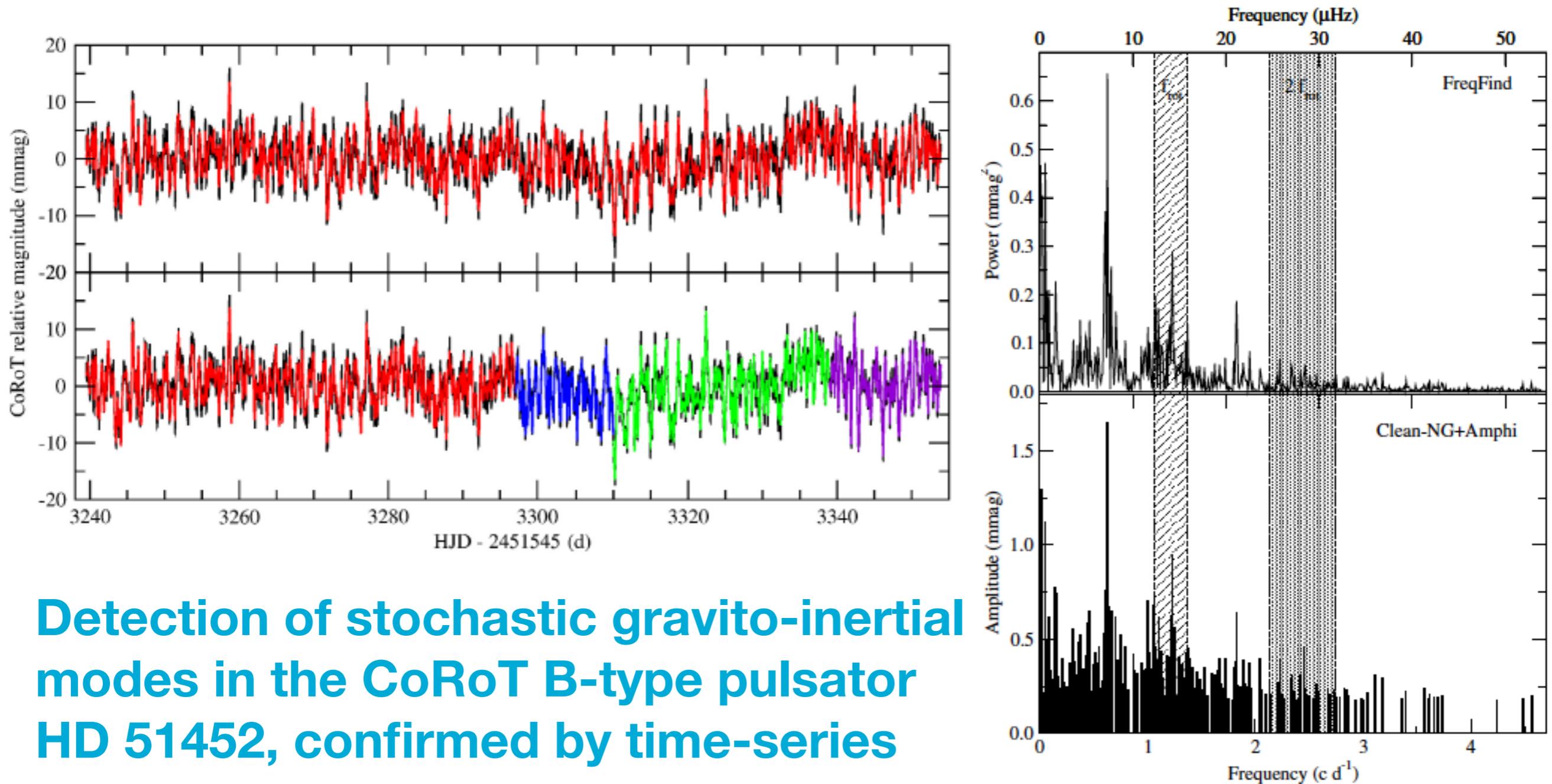
Kurtz et al. (2014)
Triana et al. (2015)
Schmid et al. (2015)

3

# Cases triggered by space photometry

Detection of gravito-inertial & classical resonant high-order g- modes in the magnetic B3V-type CoRoT pulsator HD 43317 (Pápics et al. 2012, Briquet et al. 2013)

Cases triggered by space photometry

Detection of stochastic gravito-inertial modes in the CoRoT B-type pulsator HD 51452, confirmed by time-series spectroscopy (Neiner et al. 2012)
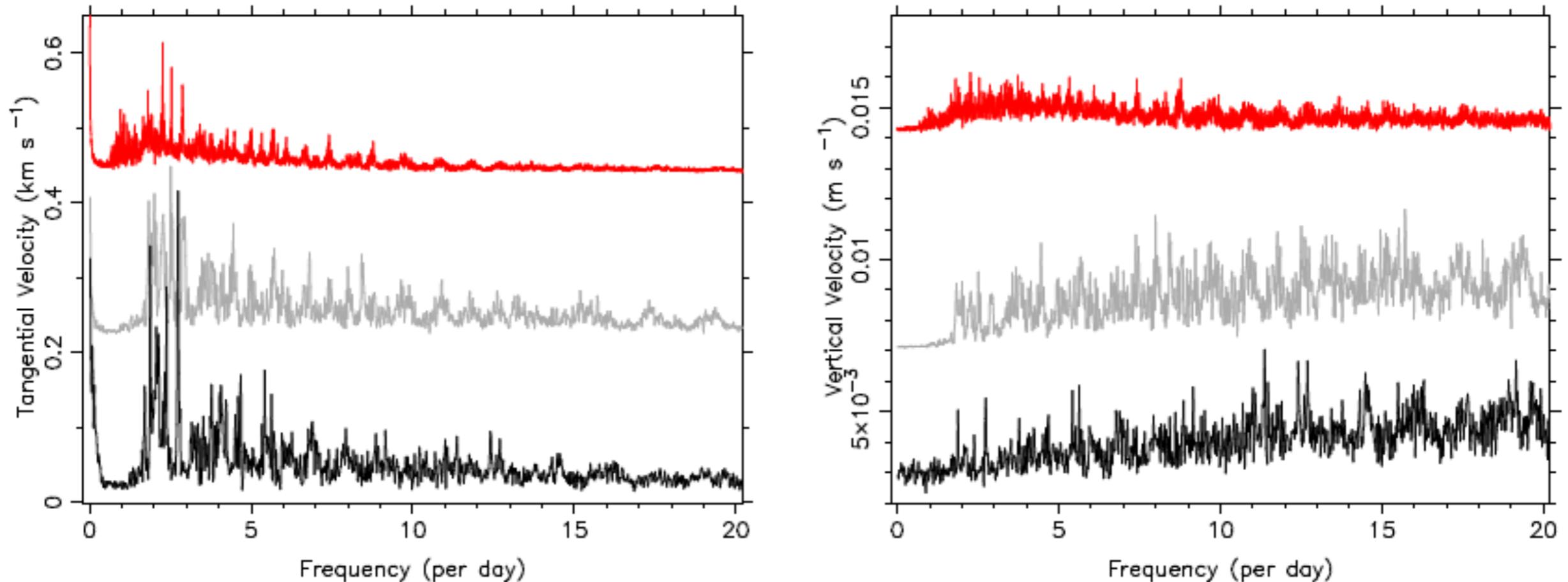
Studies triggered by modern spectroscopy
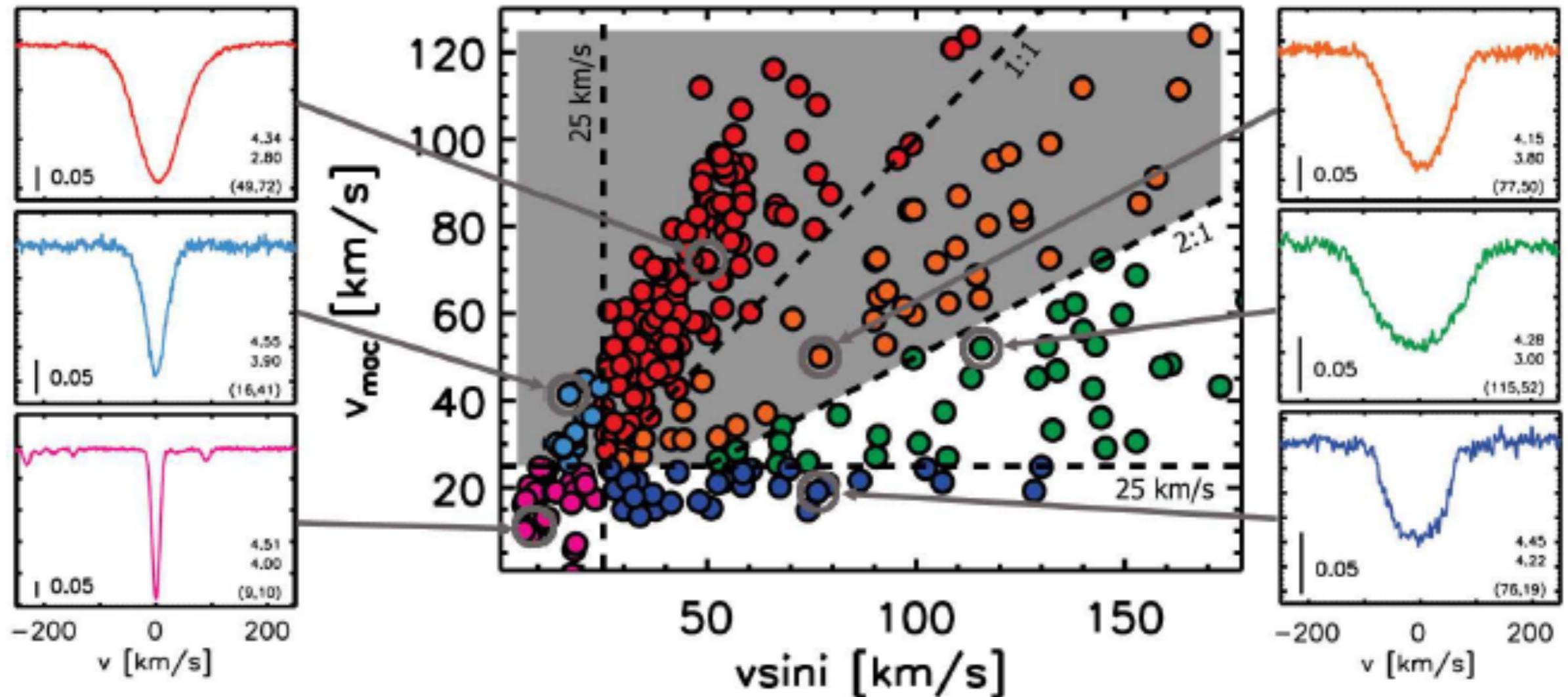
Macroturbulence in 100s of OB-type stars

Simón-Díaz, IAUS 307, 194 (2015) and references therein, cf. IACOB project
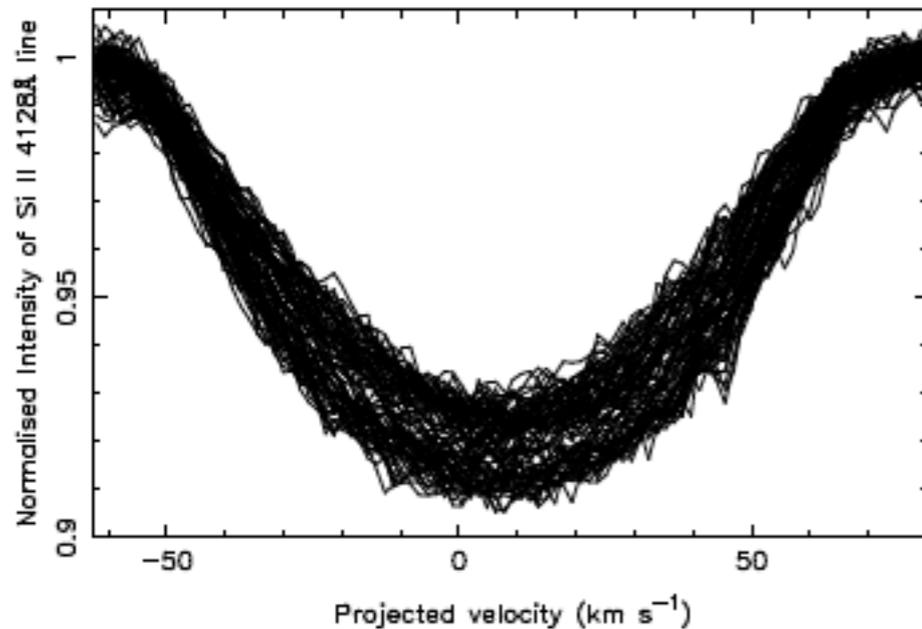
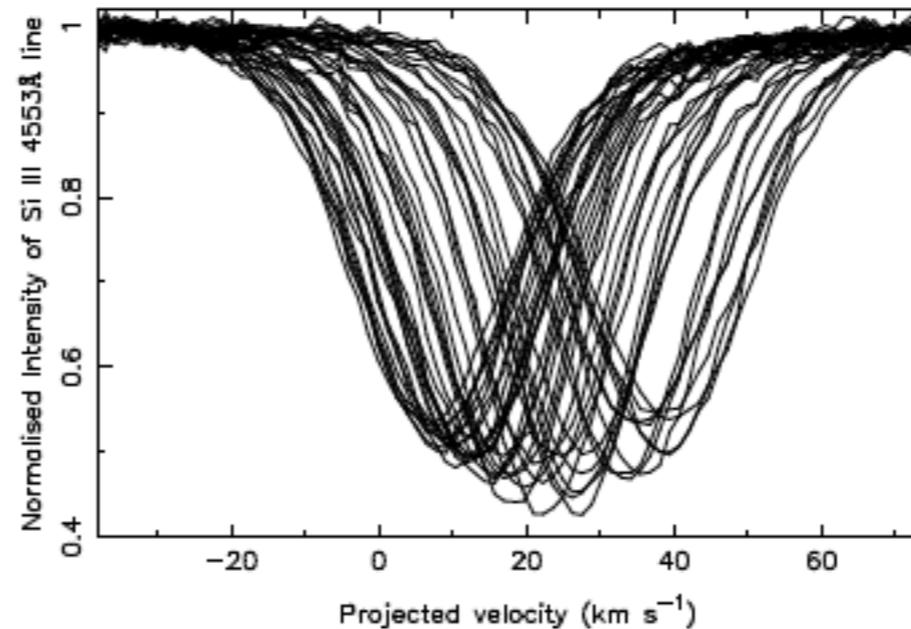# How confront 2D simulations & observations?

Proof-of-Concept study by Aerts & Rogers (2015):
How do velocity spectra predicted from IGW simulations compare with those from time-series space photometry and/or spectroscopy?
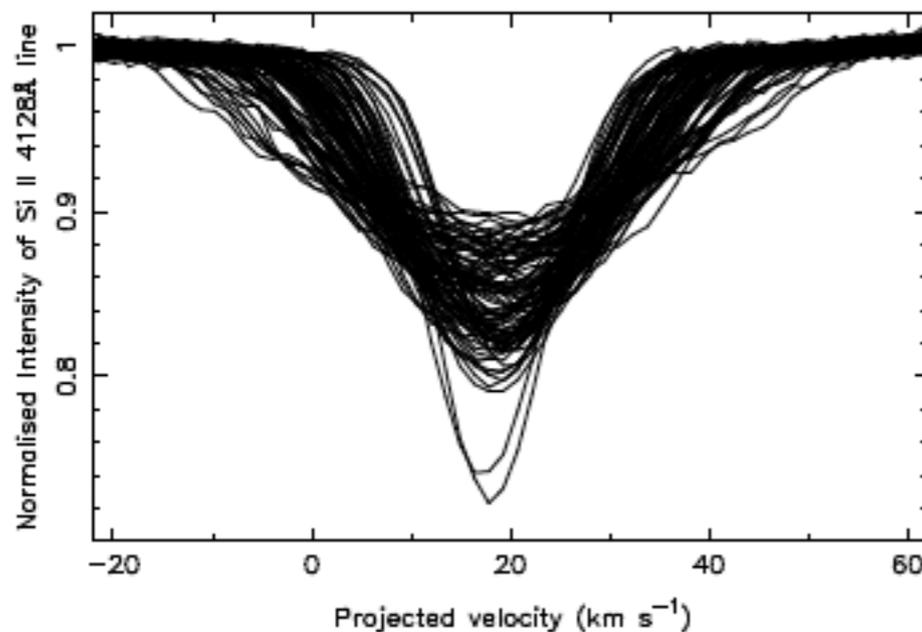
How unravel spots, resonant modes, waves?
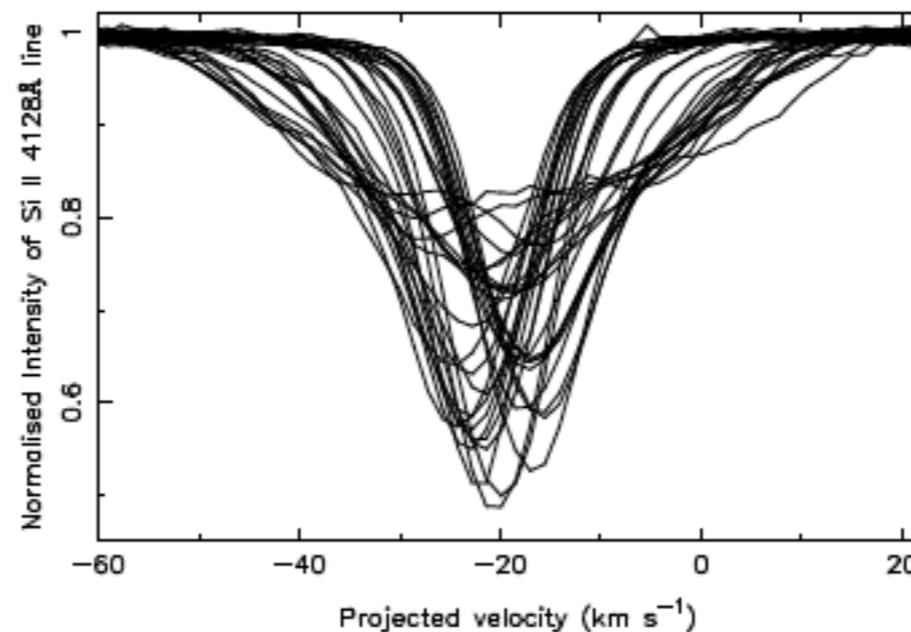

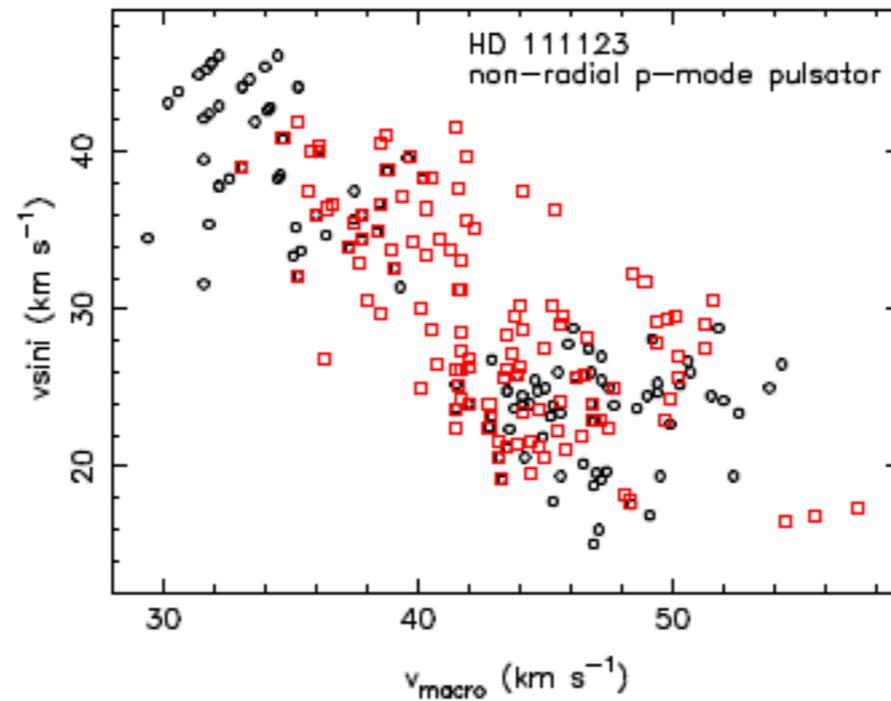HD 131120, spotted line-profile variable star
HD 46328, radial pulsator
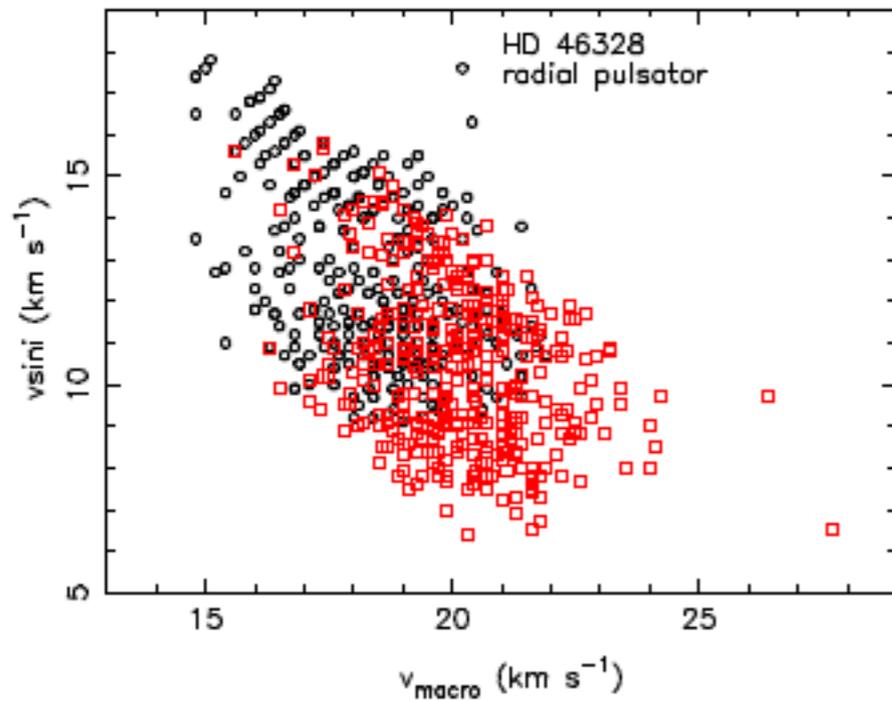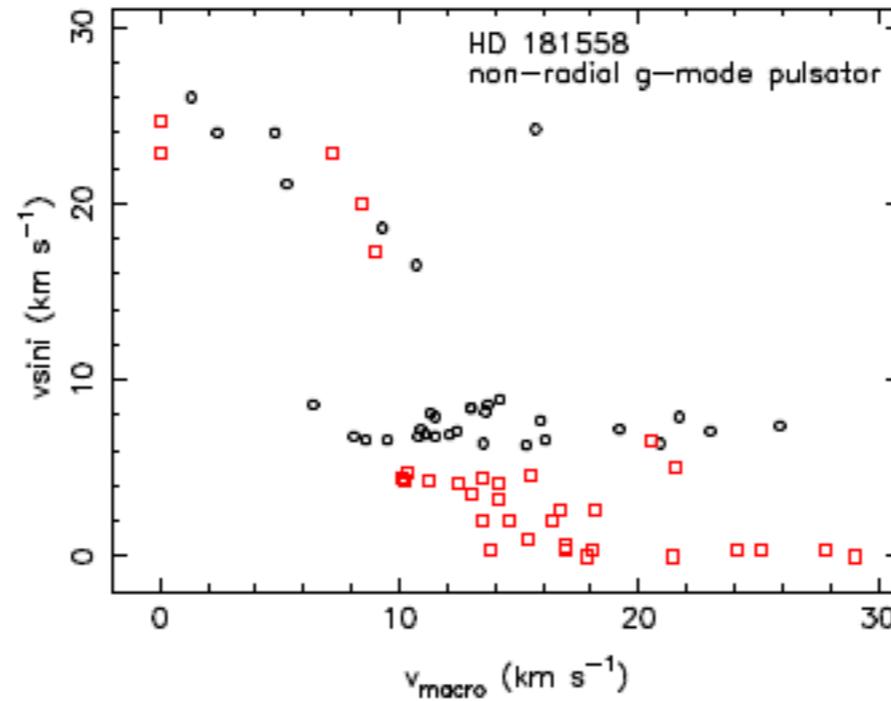HD 74195, non-radial g-mode pulsator
HD 181558, non-radial g-mode pulsator

Existence and derivation of macroturbulence in spotted or pulsating stars far from trivial

Aerts et al. (2014)

How unravel spots, resonant modes, waves?
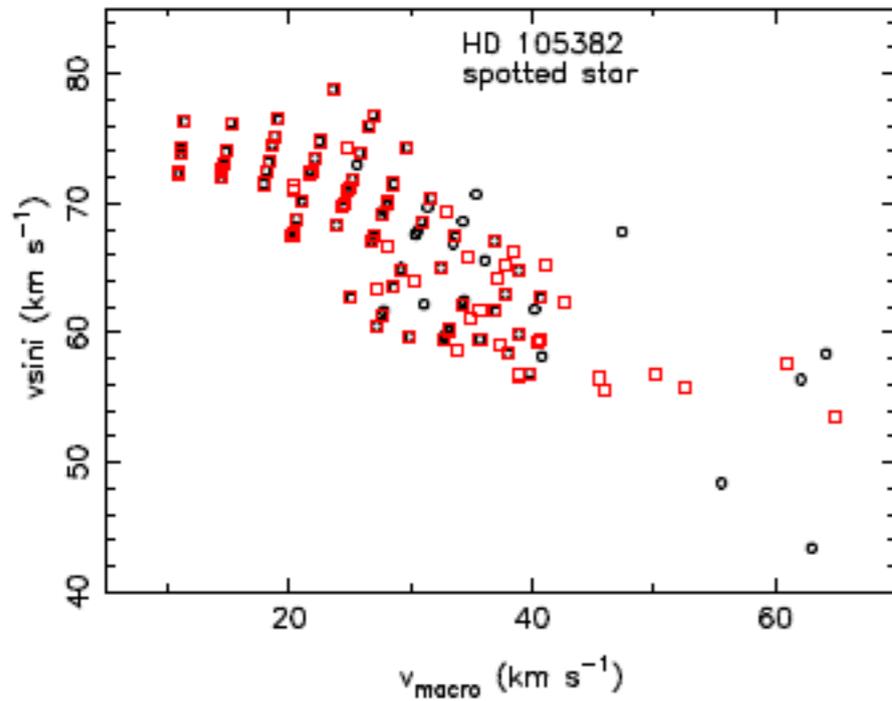
Effects of spots and/or pulsations in spectroscopy misinterpreted as macroturbulence

Aerts et al. (2014)

So how about this case?

Simón-Díaz, IAUS 307, 194 (2015)

Waves or pulsations, that's the question: compute line-profile diagnostics & analyse their frequency spectrum

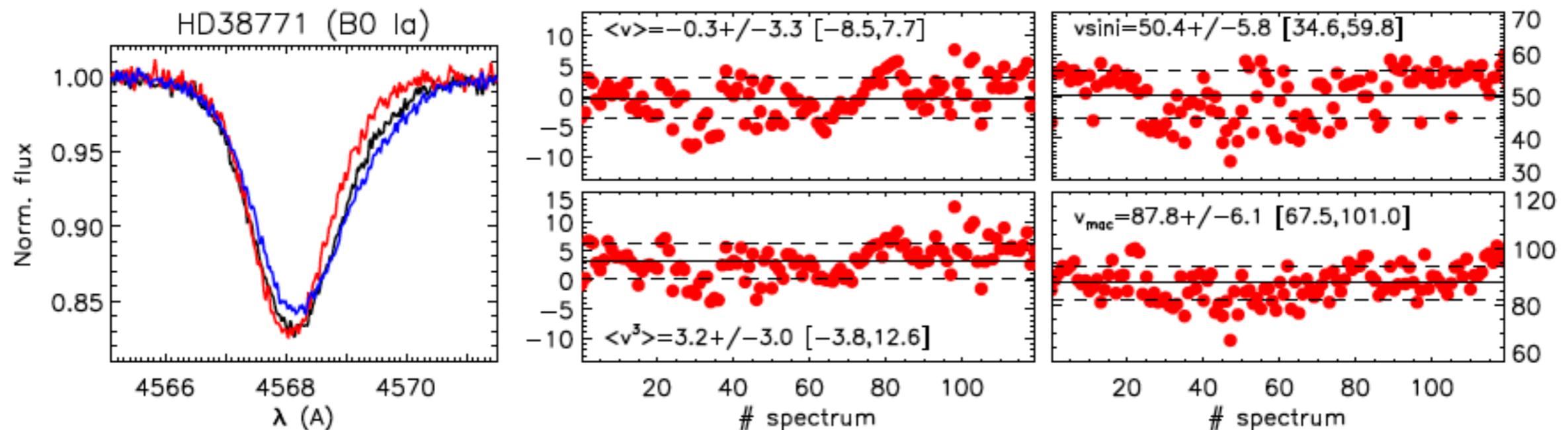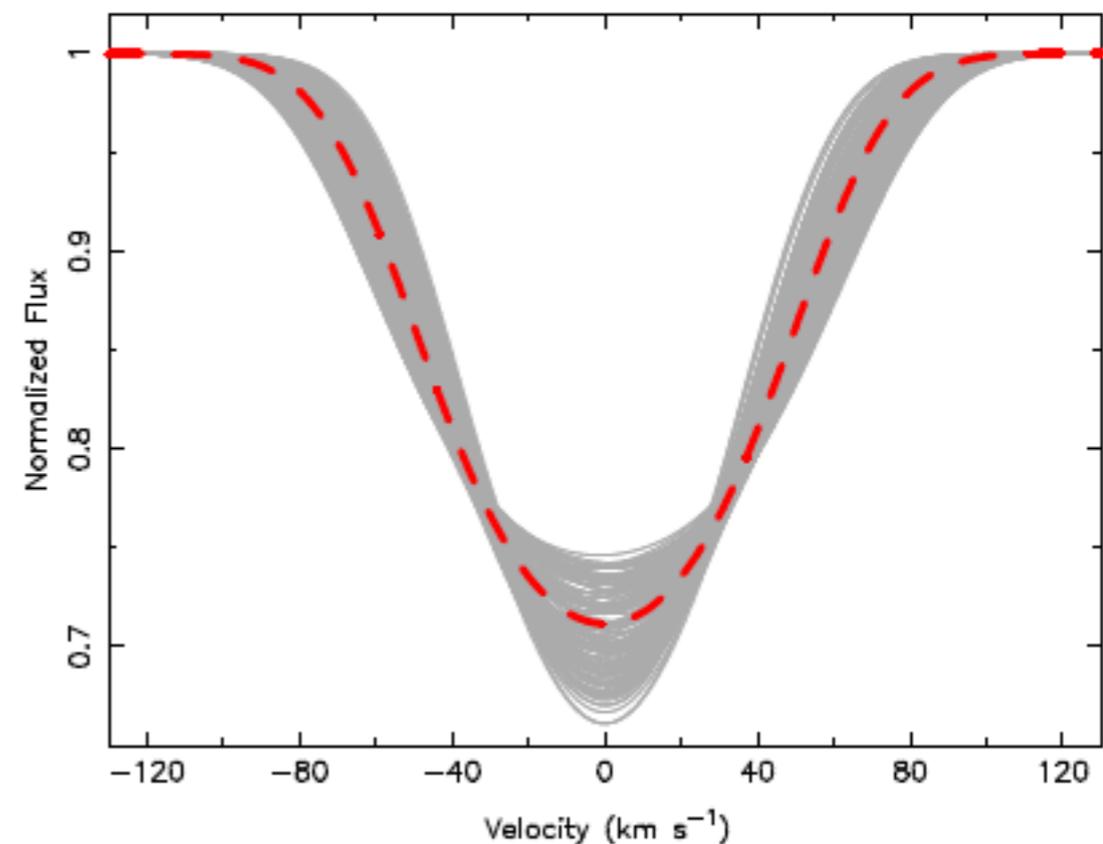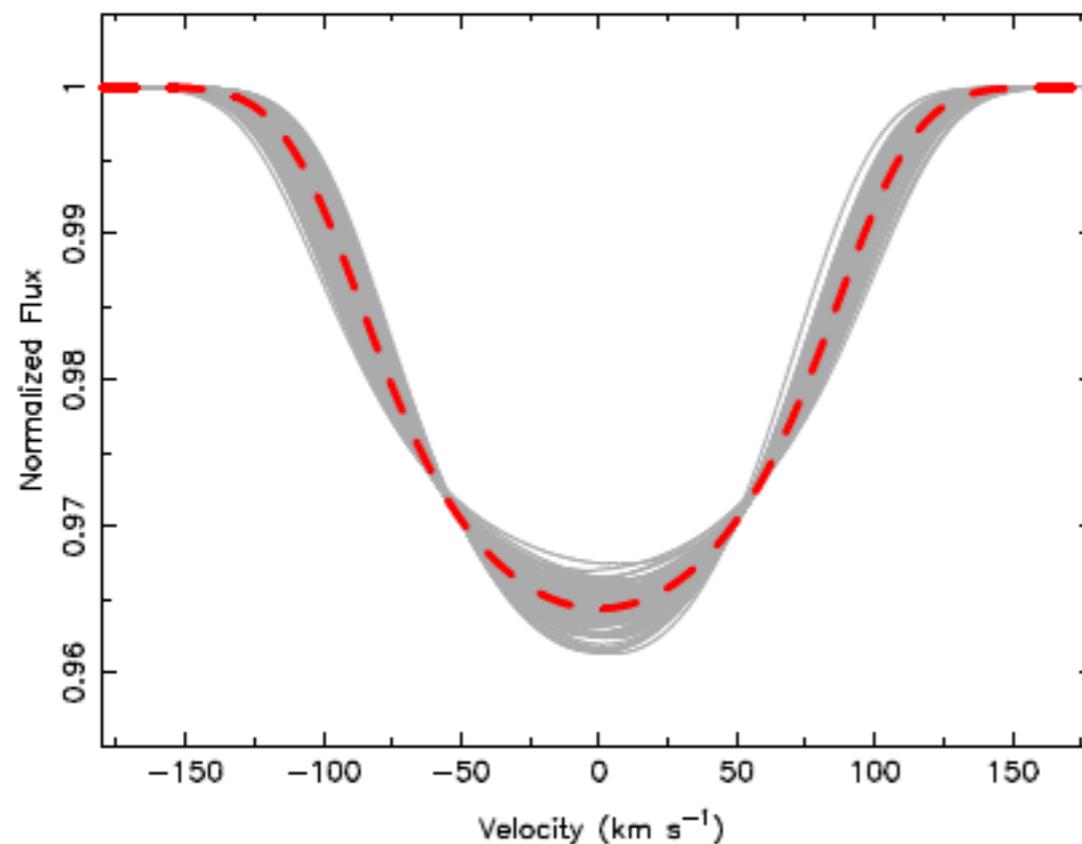# Line-profile simulations from IGW simulations
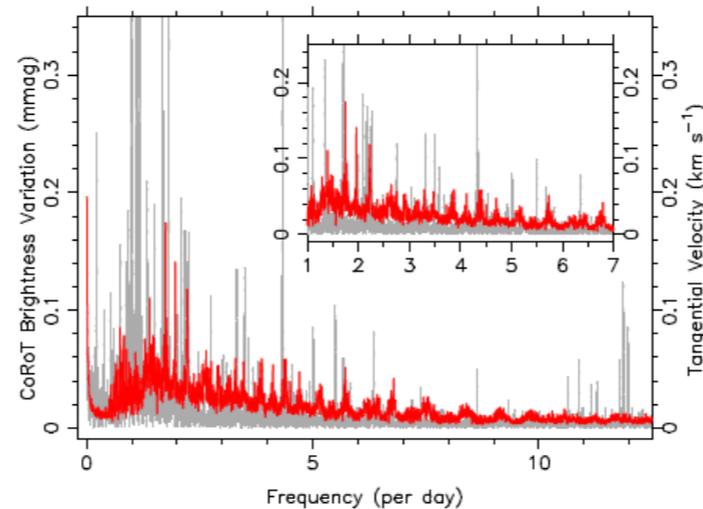
From Aerts & Rogers (2015)

Line-profile predictions for two stars
left: OIII 5922Å line of O-type star HD 46150
right: Mg II 4481Å line of SPB KIC7760680

Photometric variability from IGW simulations
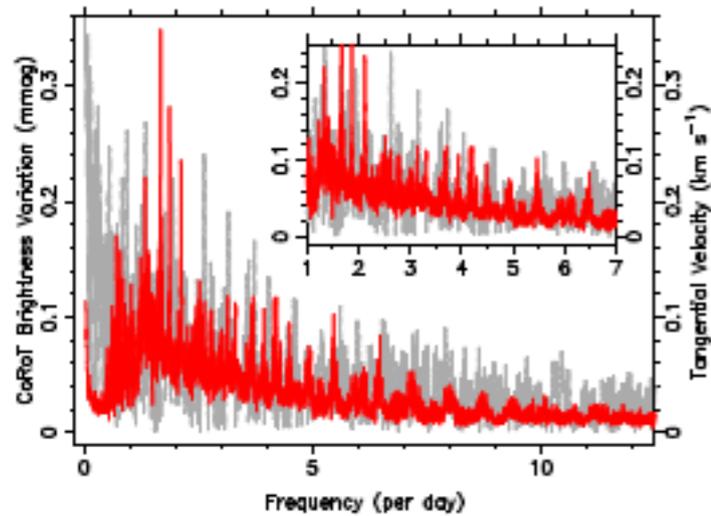
From Aerts & Rogers (2015)
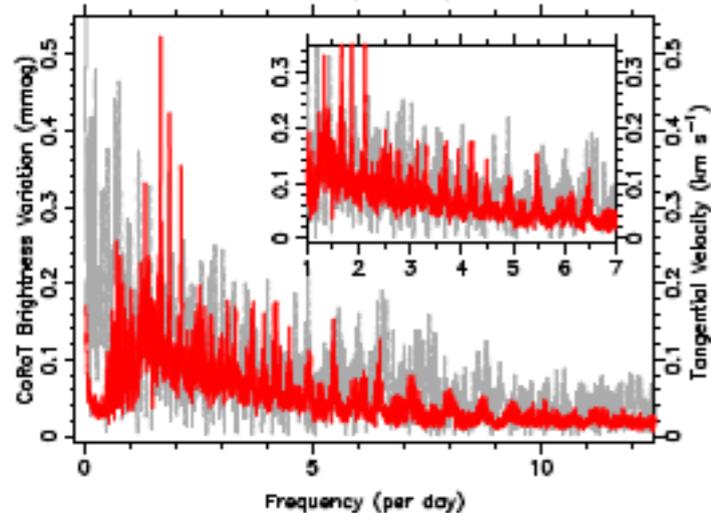
CoRoT photometry (Blomme et al. 2012 & Pápics et al. 2012)

IGW predictions from Rogers et al. (2013)

left: 3 O-type stars HD 46150, HD 46223, HD 46966

top: magnetic SPB HD 43317; much tougher due to numerous dominant resonant g-modes to be prewhitened

12

Near future prospects

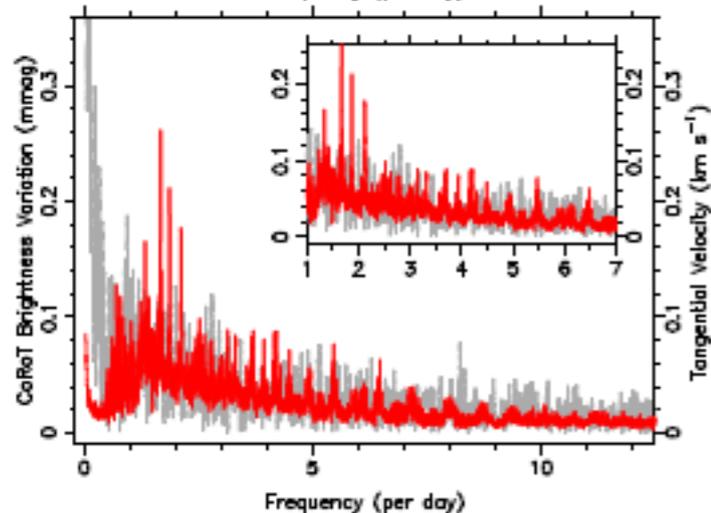- **Consider predictions from IGW spectra for intensity variations, 3D simulations, various levels of non-rigid rotation,… (Tami @ Newcastle)**

- **Exploit all the line-profile variations observed in the framework of the long-term time-resolved database IACOB (Sergio Simón-Díaz @ IAC)**

- **Revisit the CoRoT and Kepler databases of heat-driven g-mode pulsators to search for IGW signatures after careful prewhitening + K2 + TESS and prepare for PLATO-CS (Conny @ Leuven)**

Farther future prospects

Beyond 2024: PLATO's Complementory Science

https://fys.kuleuven.be/ster/Projects/plato-cs

PLATO Guest Observer programme open to all
CS will help prepare GO+provide data products

Credits: DLR (Susanne Pieth)