CENTRO DE ASTROBIOLOGÍA
ASOCIADO AL NASA ASTROBIOLOGY INSTITUTE
CSIC INTA
Laboratorio de Astrofísica Estelar y Exoplanetas

LAEFF

Contributions of asteroseismology to the science with RoPACS

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- Introduction (What is asteroseismology?)
- Tools
- Some examples about what can be done:
  1. Pulsating stars harboring planets
  2. Pulsations in VLM stars and BD
- Conclusions and future work

Introduction

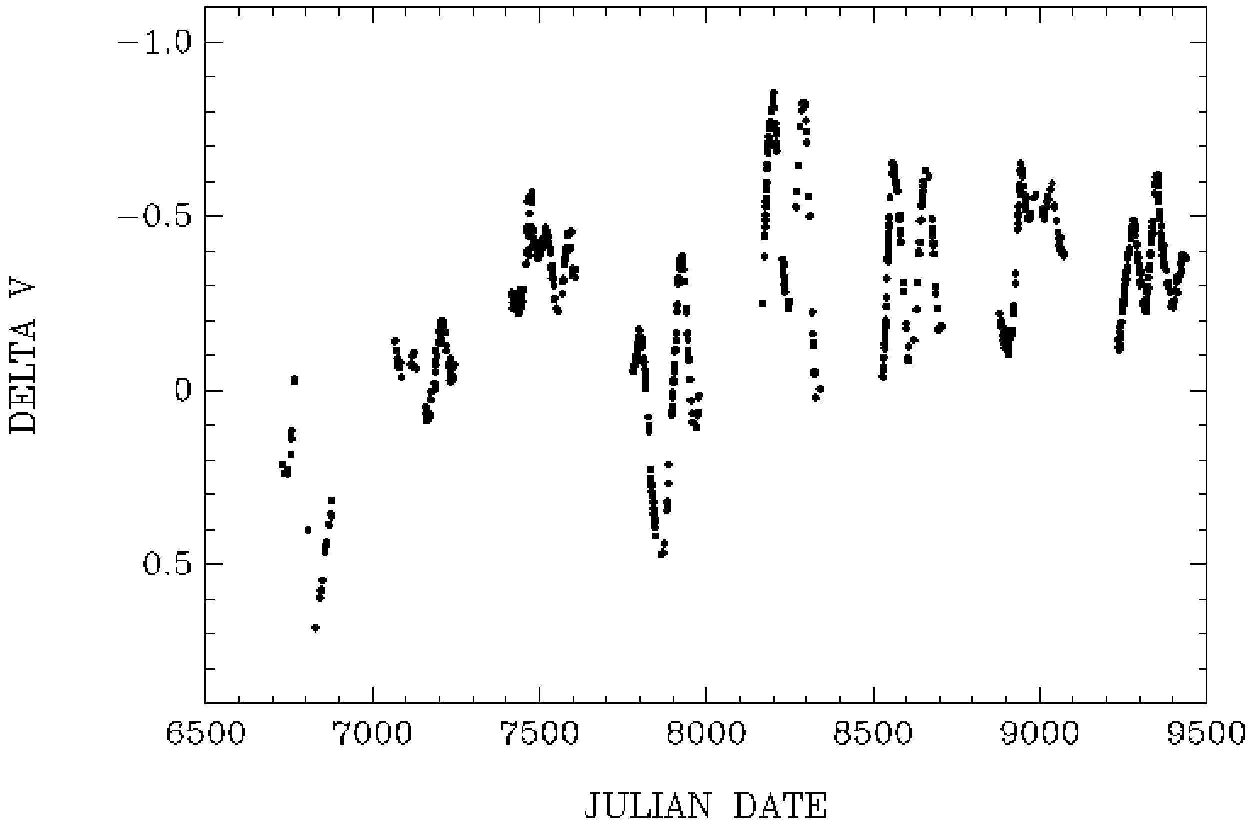
Almost all the known techniques to find exoplanets are based on the observation of the hosting star, as it is the case of RoPACS' data.

Therefore, **we need to know precisely the physical characteristics of the star** to infer the characteristics of the planets.

Asteroseismology is the most precise tool known for this objective.

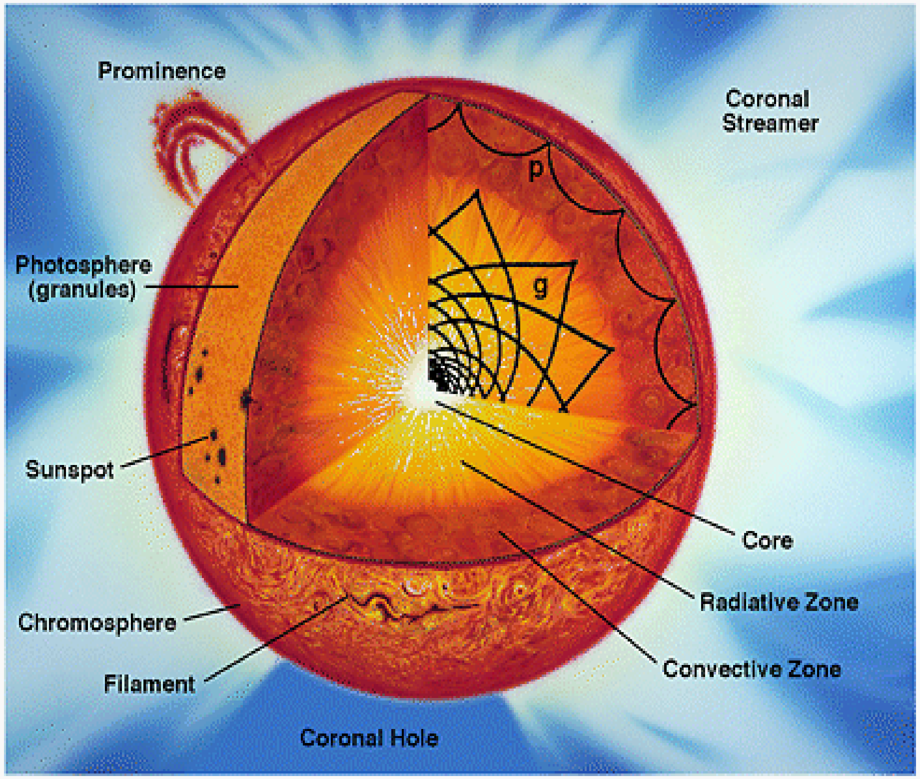
Introduction

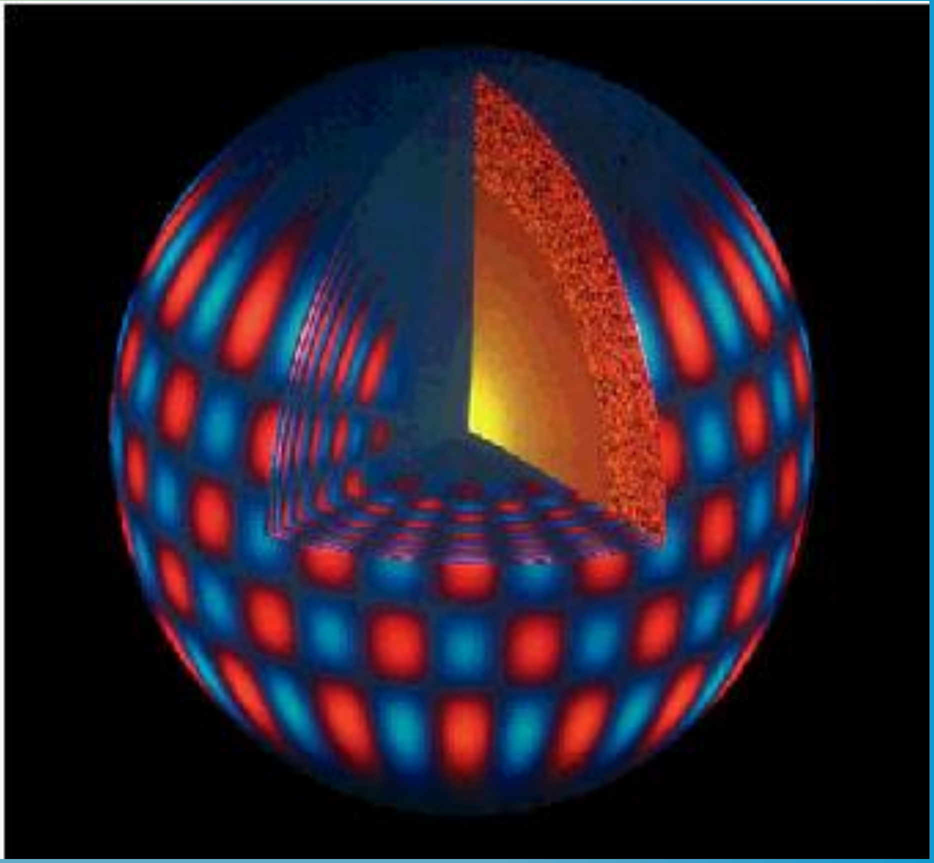
What is asteroseismology?



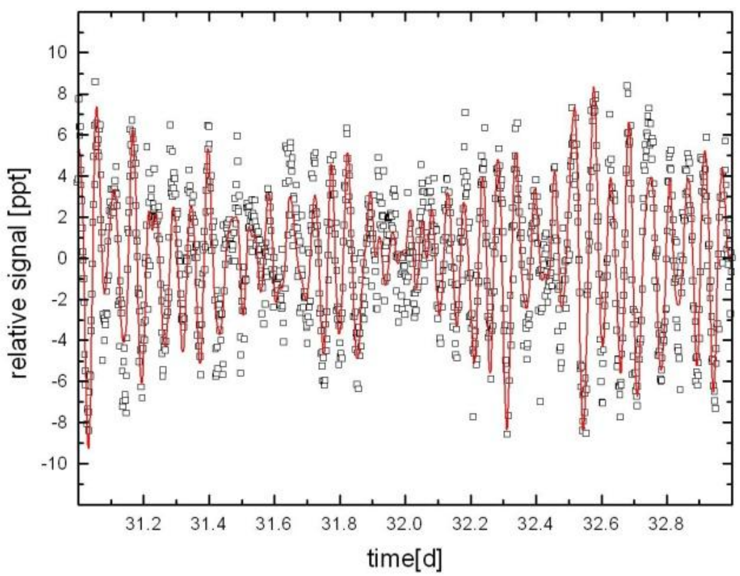
To infer stellar properties (generals and internal) observing and fitting with theoretical models the pulsational modes of the star.

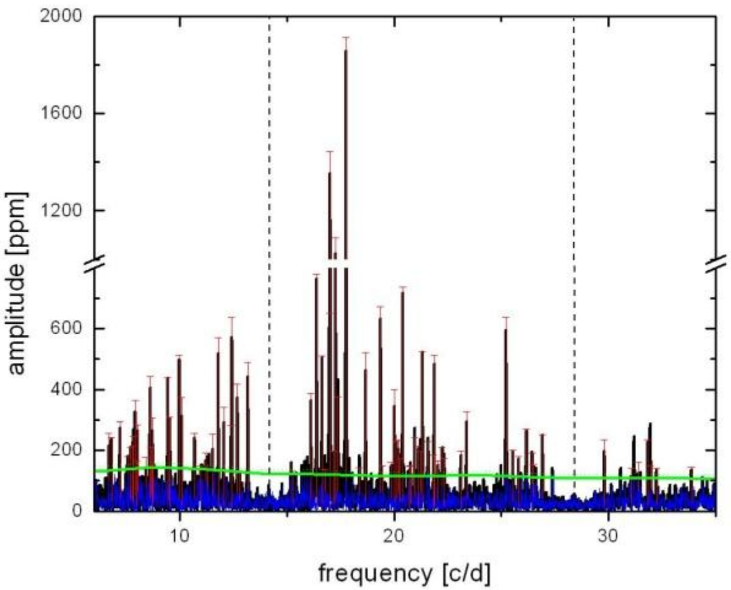
Introduction





Introduction





???

Compute numerical models of the star

Obtain their pulsational modes

Introduction

Observations

Frequencies and non-adiabatic observables

Equilibrium models (Evolutional code CESAM)

Pulsational models (GraCo)

Stellar parameters as radius, mass, age,…

δ Scuti
γ Doradus

Convection

Mixing length (α)
FST
Hydrodinamics

Atmospheric models - Limb darkening

β Cephei
SPB

Chemical composition(Z) , …

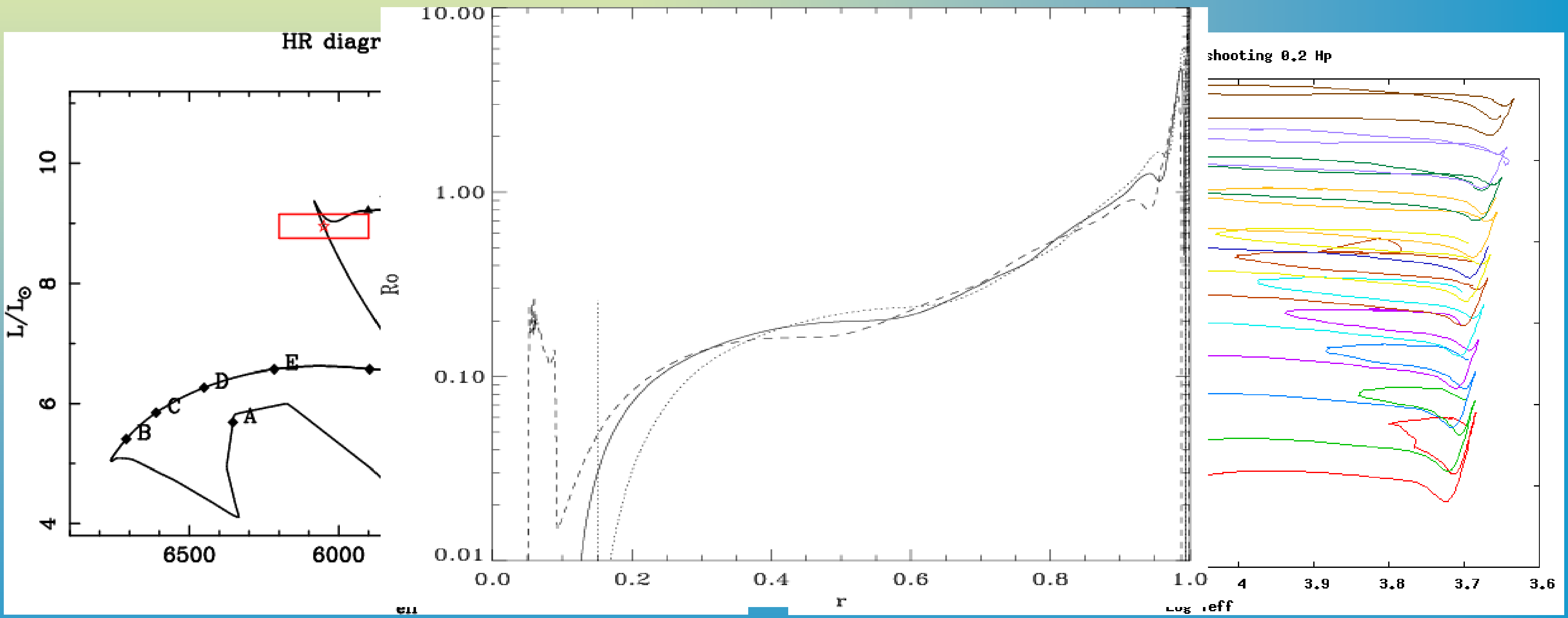
Mode identification

Fitting improvement

Tools

CESAM (*Code d'Évolution Stellaire Adaptatif et Modulaire*), developed by P. Morel

Outputs complete 1D equilibrium stellar models, and evolutionary tracks to compute isochrones,



Tools

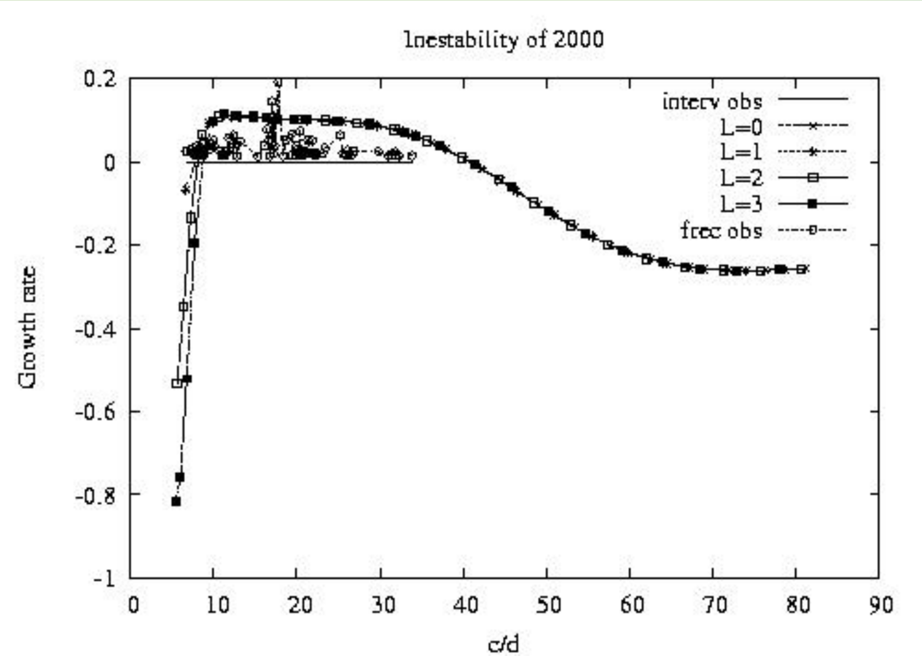
GraCo (Granada oscillation Code) developed by A. Moya

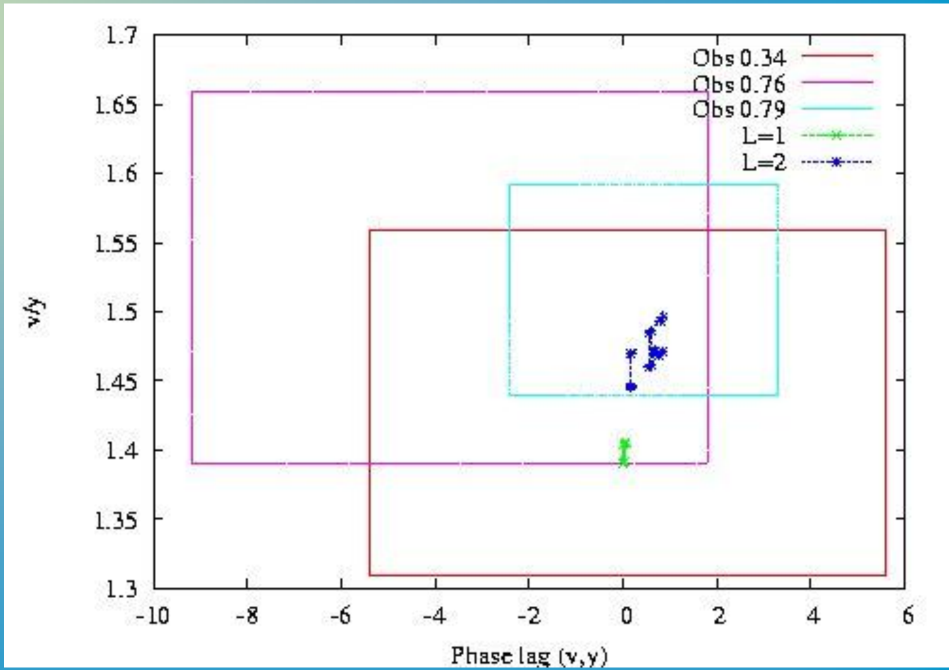
Adiabatic and non-adiabatic pulsational code using as input equilibrium stellar models and some physical elections (interaction pulsation - atmosphere, interaction convection - pulsation through Time Dependent Convection, etc.)

Herramientas

GraCo (Granada oscillation Code) developed by A. Moya

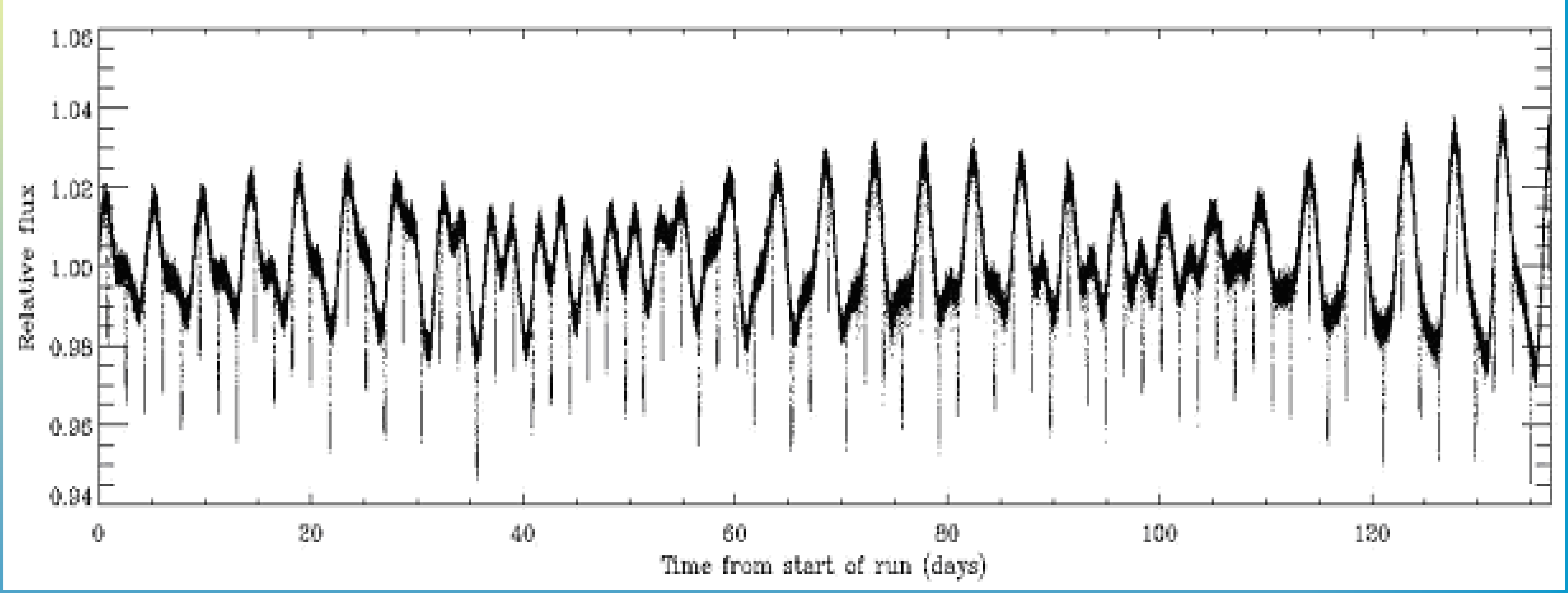
Outputs the stellar eigenfrequencies and eigenfunctions, and any combination of them (non-adiabatic observables, rotational kernels, etc.)



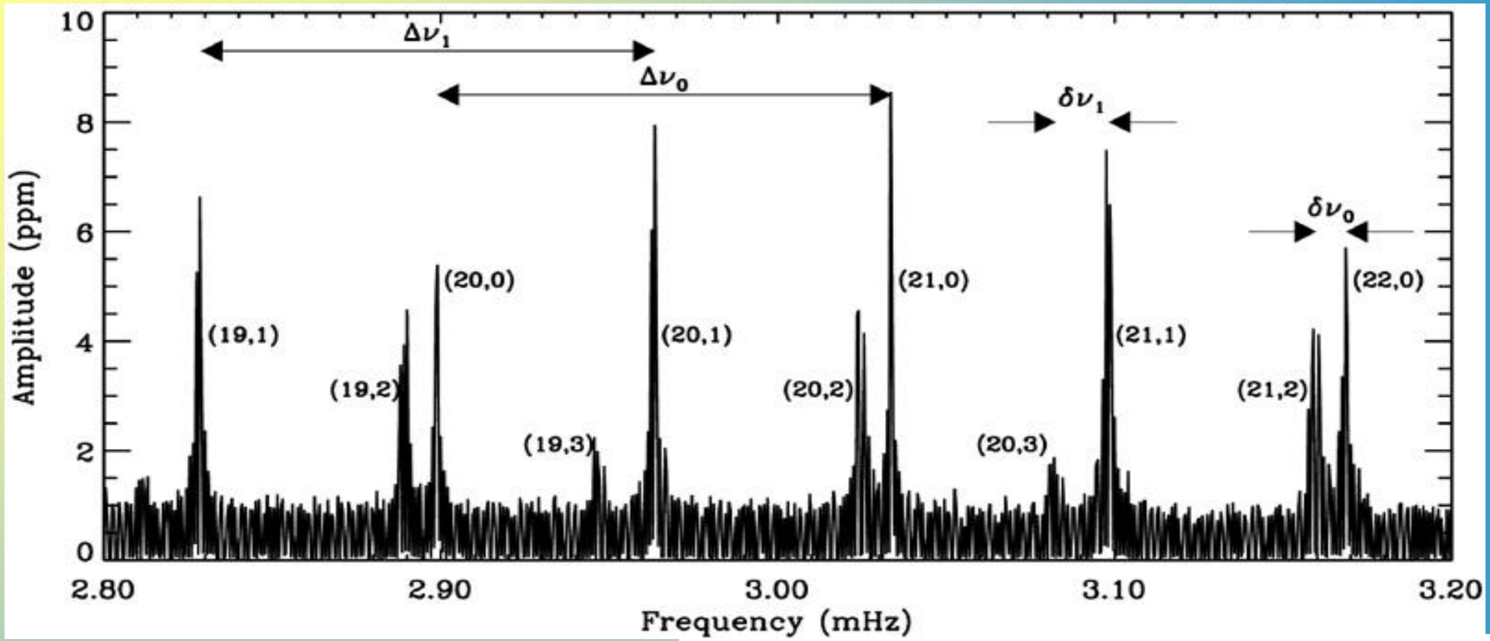


Scientific case: Pulsating star harboring planets

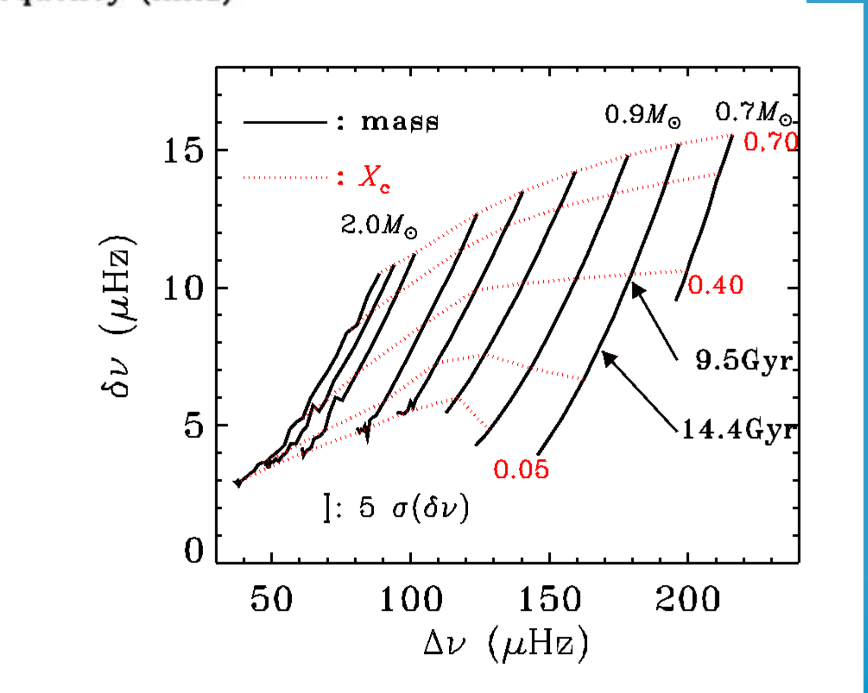
A CoRoT's observation



Scientific case: Pulsating star harboring planets

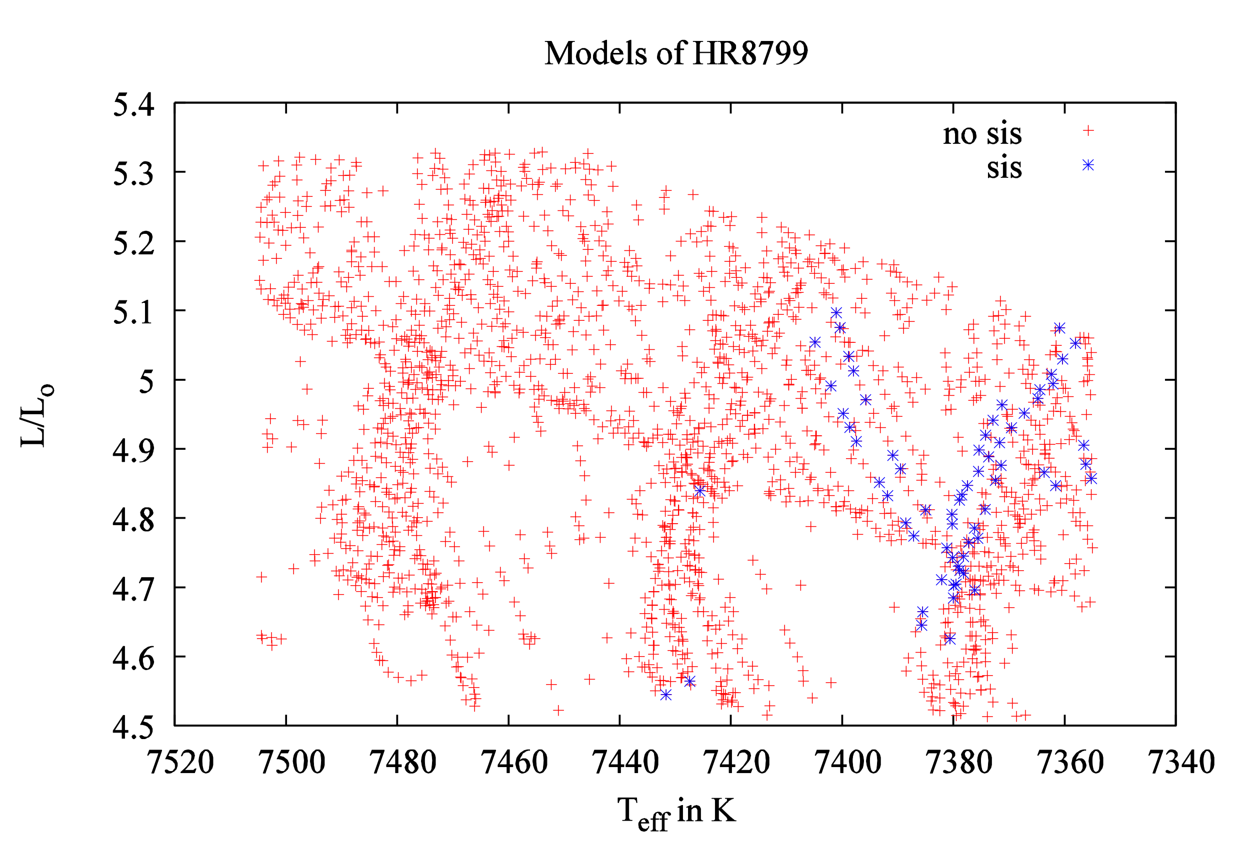


In solar-type stars information is obtained, mainly, from the mode's separations (Stello et al. 2009), giving an improvement in the uncertainty of the radius determination from 40% to 0.4%



Scientific case: Pulsating star harboring planets

The planetary system HR8799 (Marois et al. 2008)

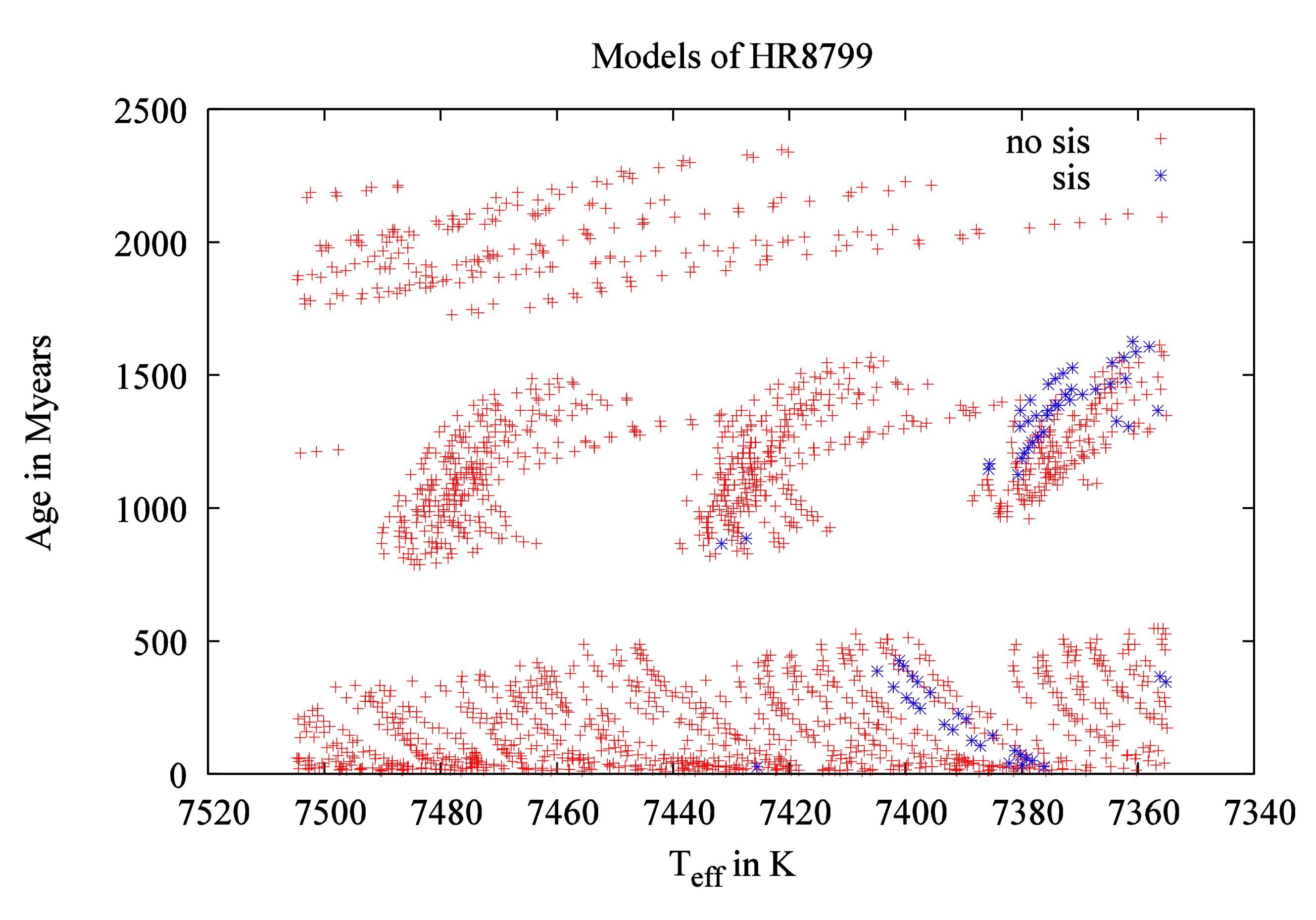


Direct imaging of 3 planets

T_{eff}, log g, luminosity and radius quite well know with spectroscopy. Metallicity unknown (is a λ Bootis)

Scientific case: Pulsating star harboring planets

The planetary system HR8799 (Marois et al. 2008)



Age estimated in [30,160] Myrs

This may not be true.

Large impact in the structure of the planetary system

Scientific case: Pulsating VLM stars and BD

BD are theoretically predicted to pulsate during their initial stages, due to the ε mechanism. Pulsations of a few hours (fundamental radial mode, Palla and Baraffe 2005)

Project: If there are non-radial modes also excited, the detection of the pulsational modes is easier. Is there other instability zones for VLM stars?

Conclusions and future work

1. Asteroseismology is very useful for an accurate determination of the physical characteristics and internal structure of the stars
2. This has an impact in our knowledge about planetary systems and the first stages of objects in the lower part of the HRD as VLM stars and BD

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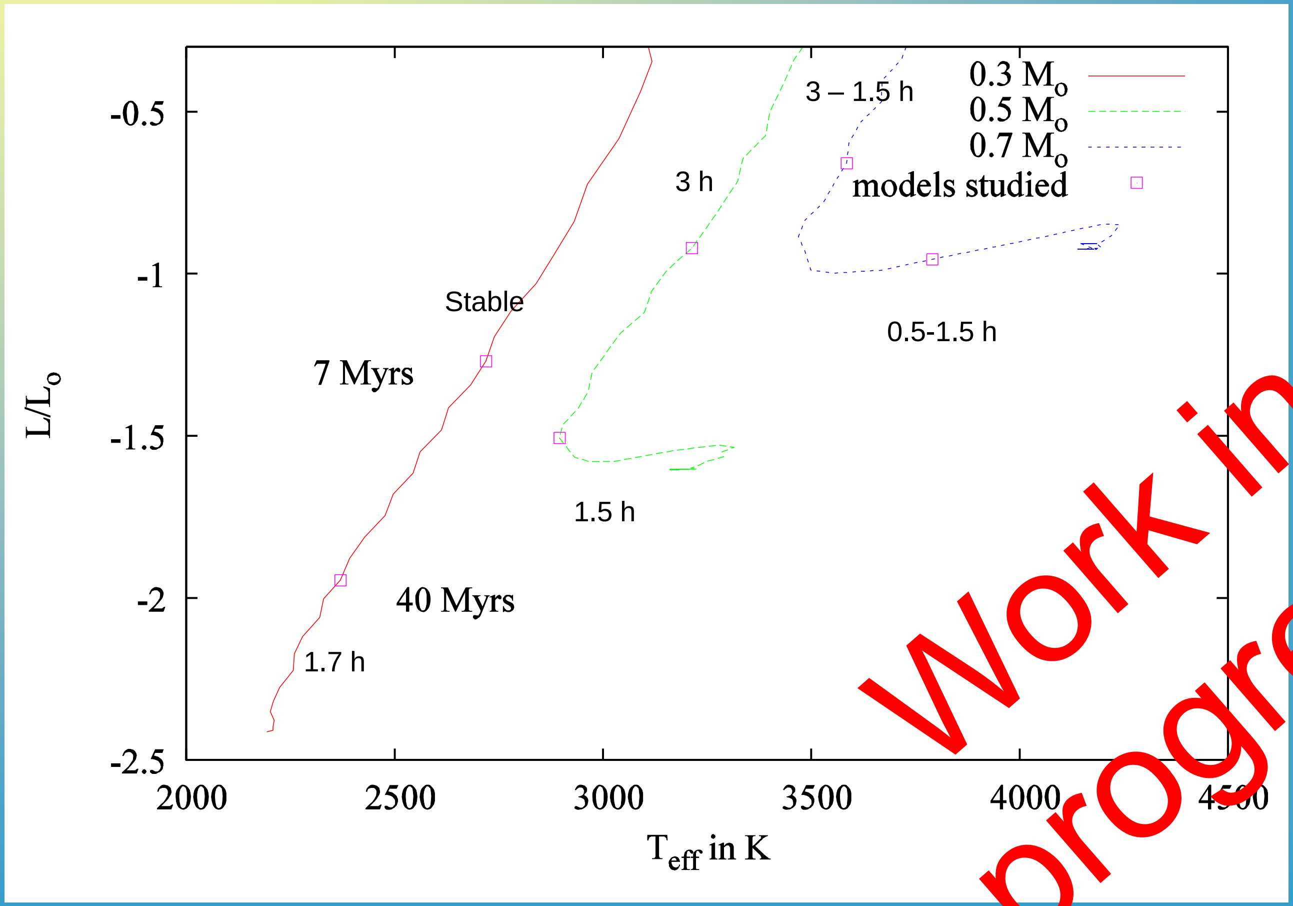
Conclusions and future work

Different research lines:

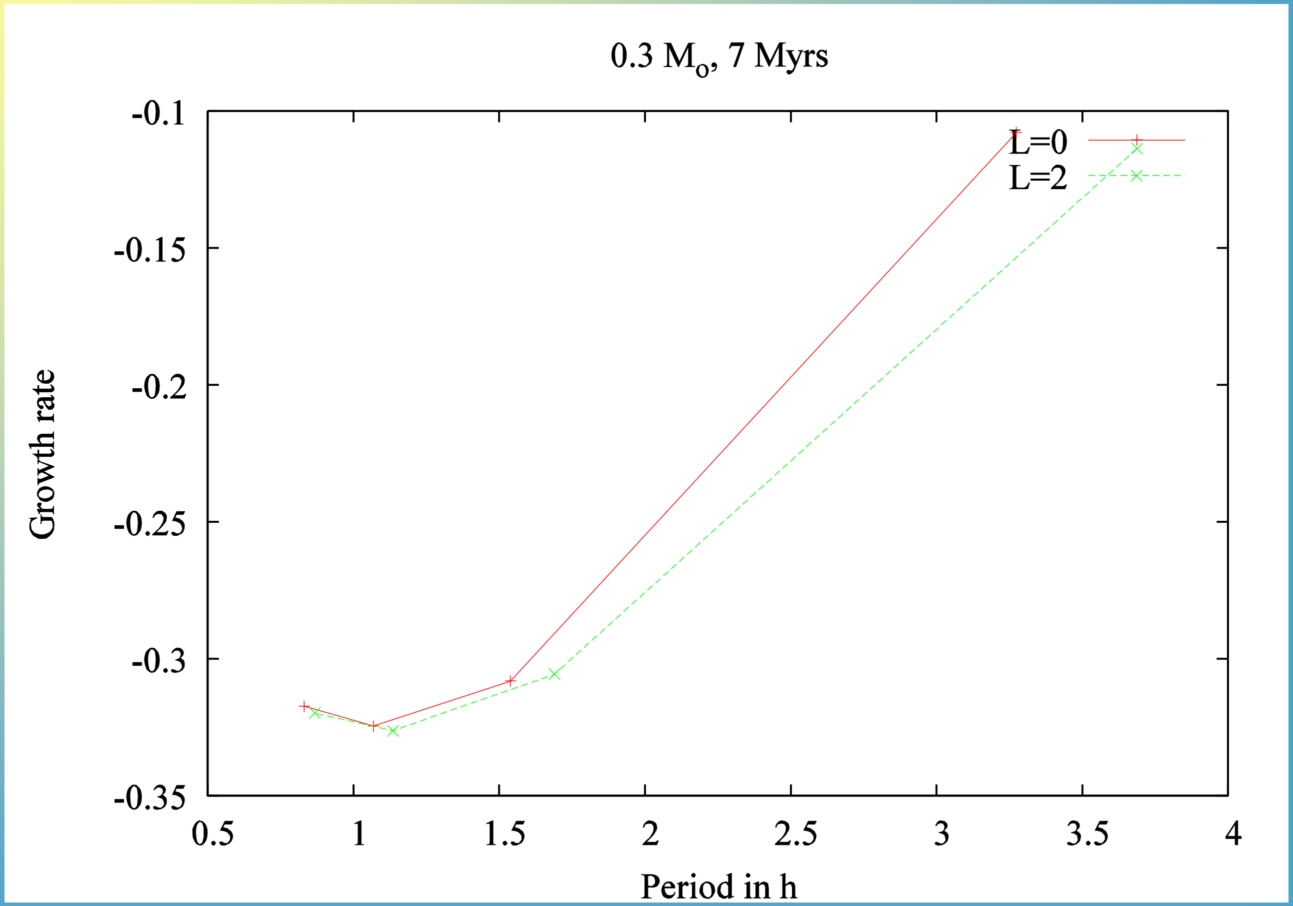
1. Characterization of pulsating stars harboring planets
2. Study of new instability zones of VLM stars
3. Search for non-radial pulsations in BD

Scientific case: Pulsating VLM stars and BD

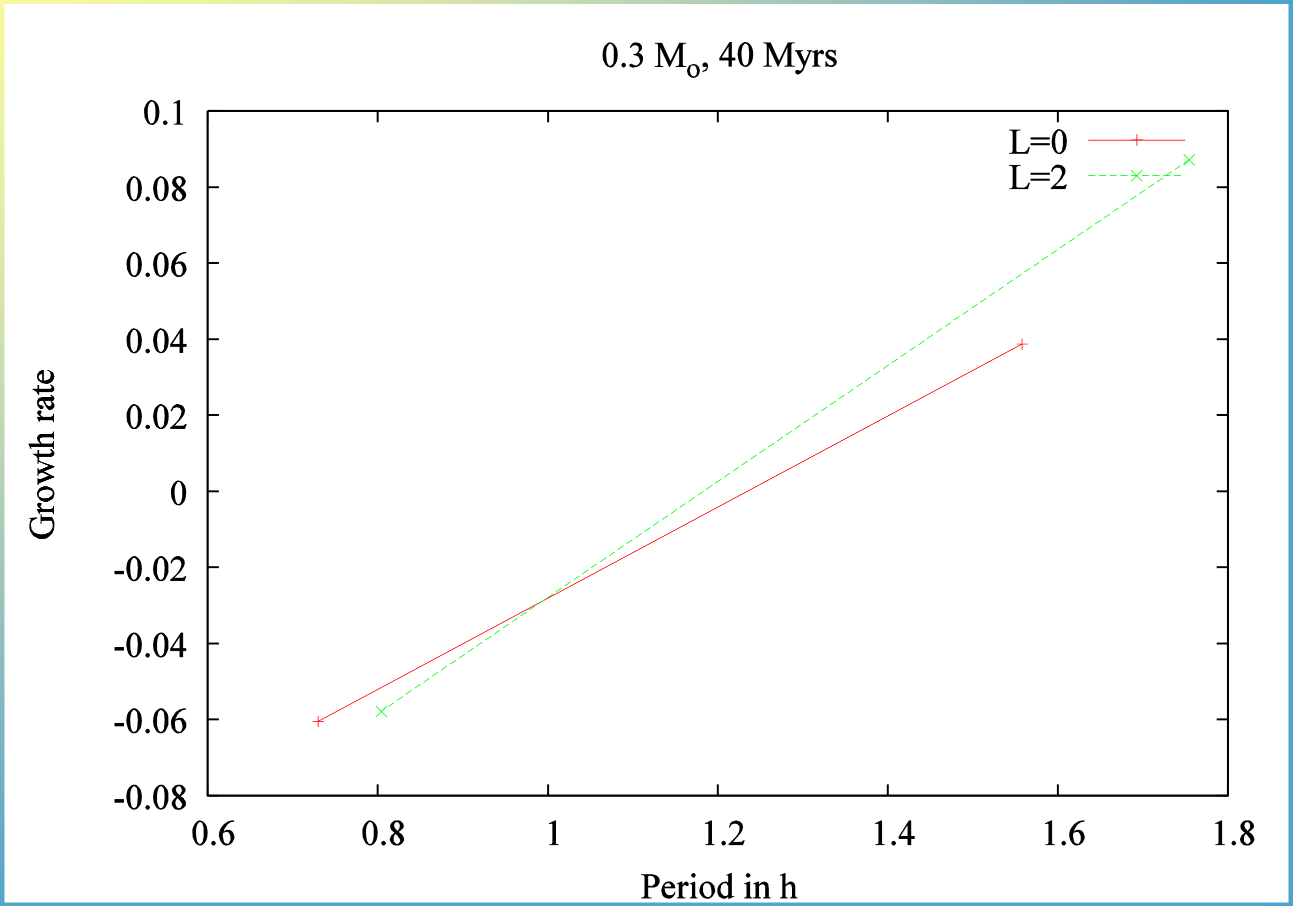
Are there instability zones in the VLM region?



Work in progress

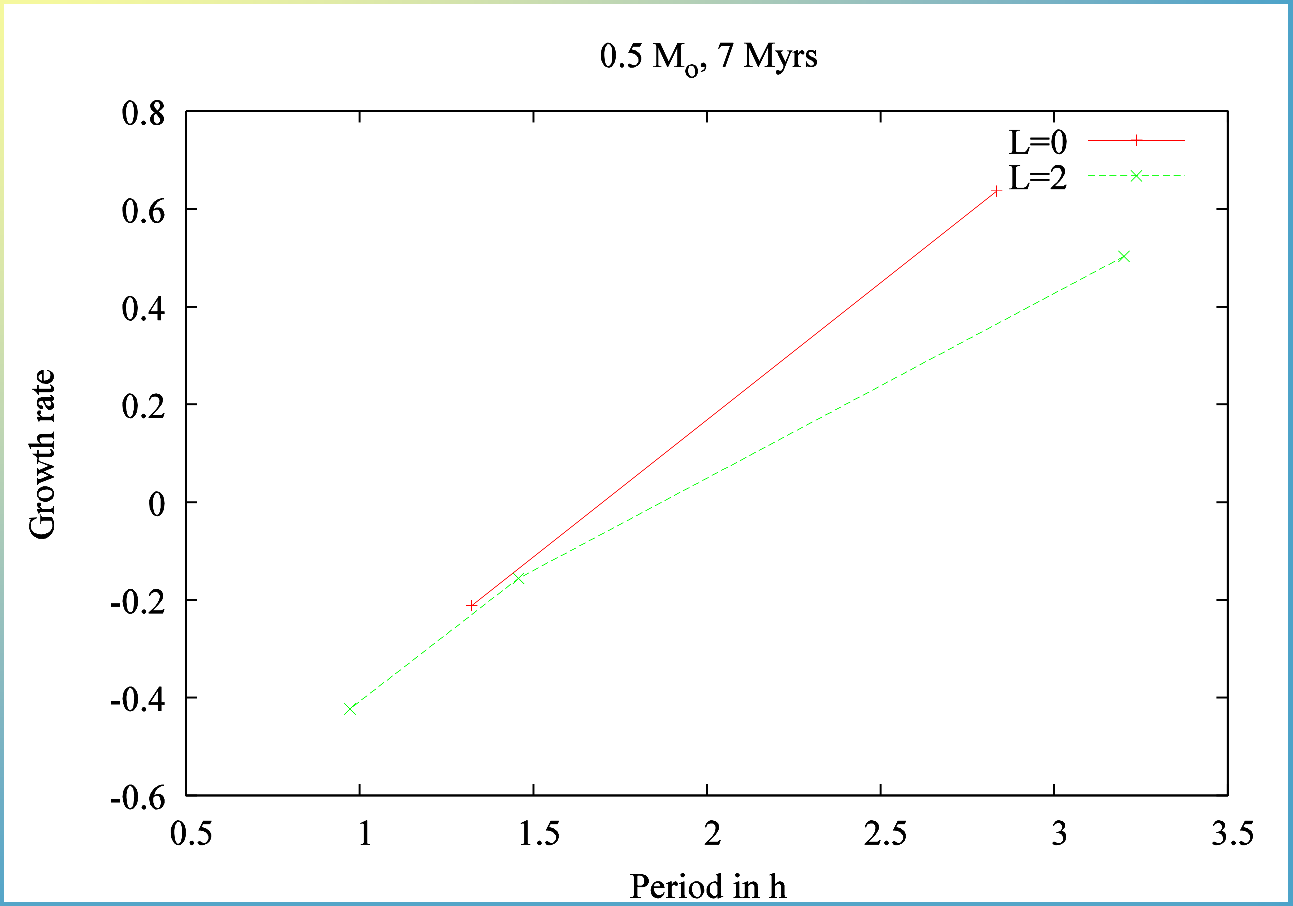

0.3 M$_o$, 7 Myrs
Growth rate
Period in h
L=0
L=2
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
0.5
1
1.5
2
2.5
3
3.5
4

Back

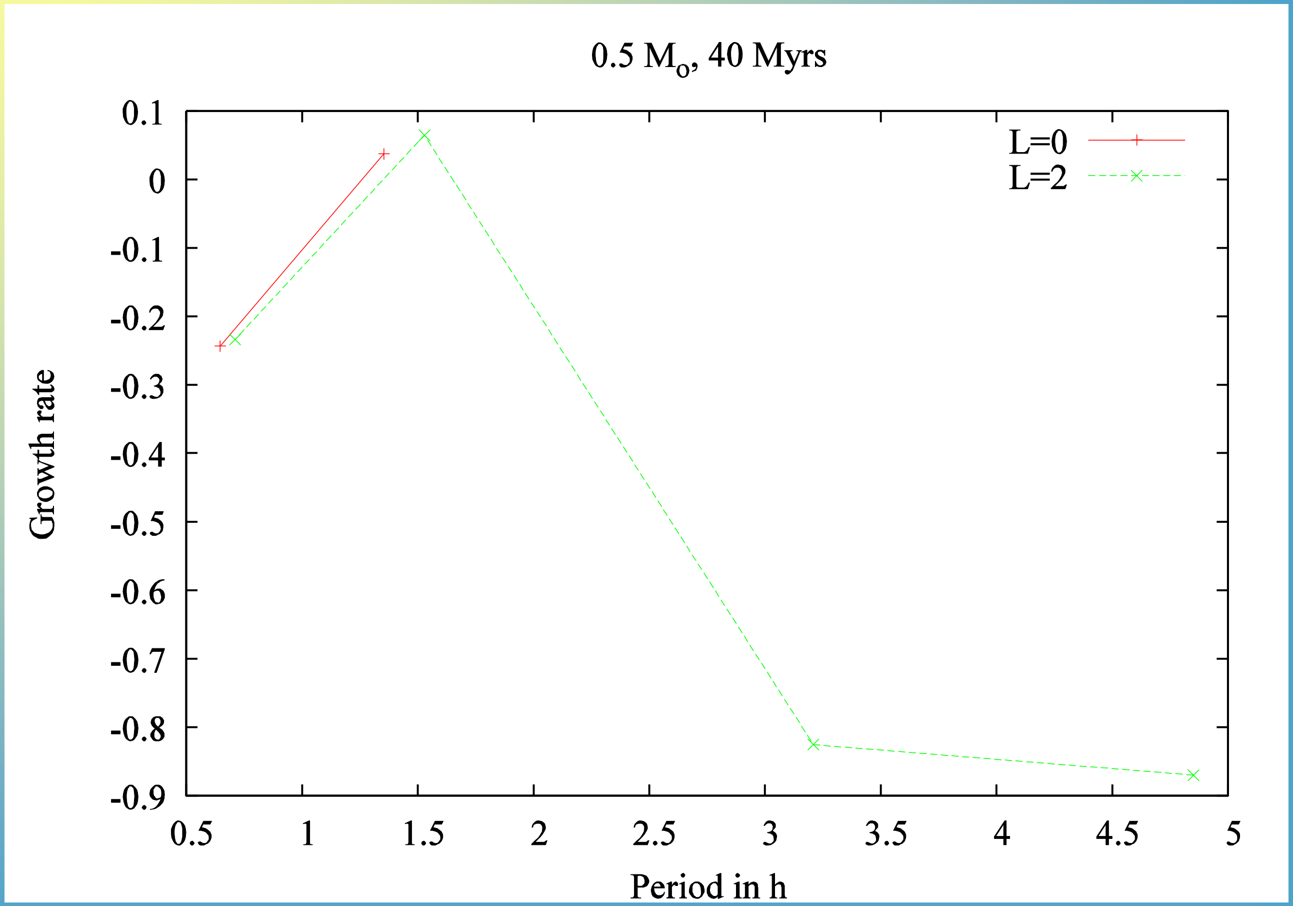


0.3 M$_o$, 40 Myrs
L=0
L=2
Growth rate
Period in h
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
0.6
0.8
1
1.2
1.4
1.6
1.8

Back

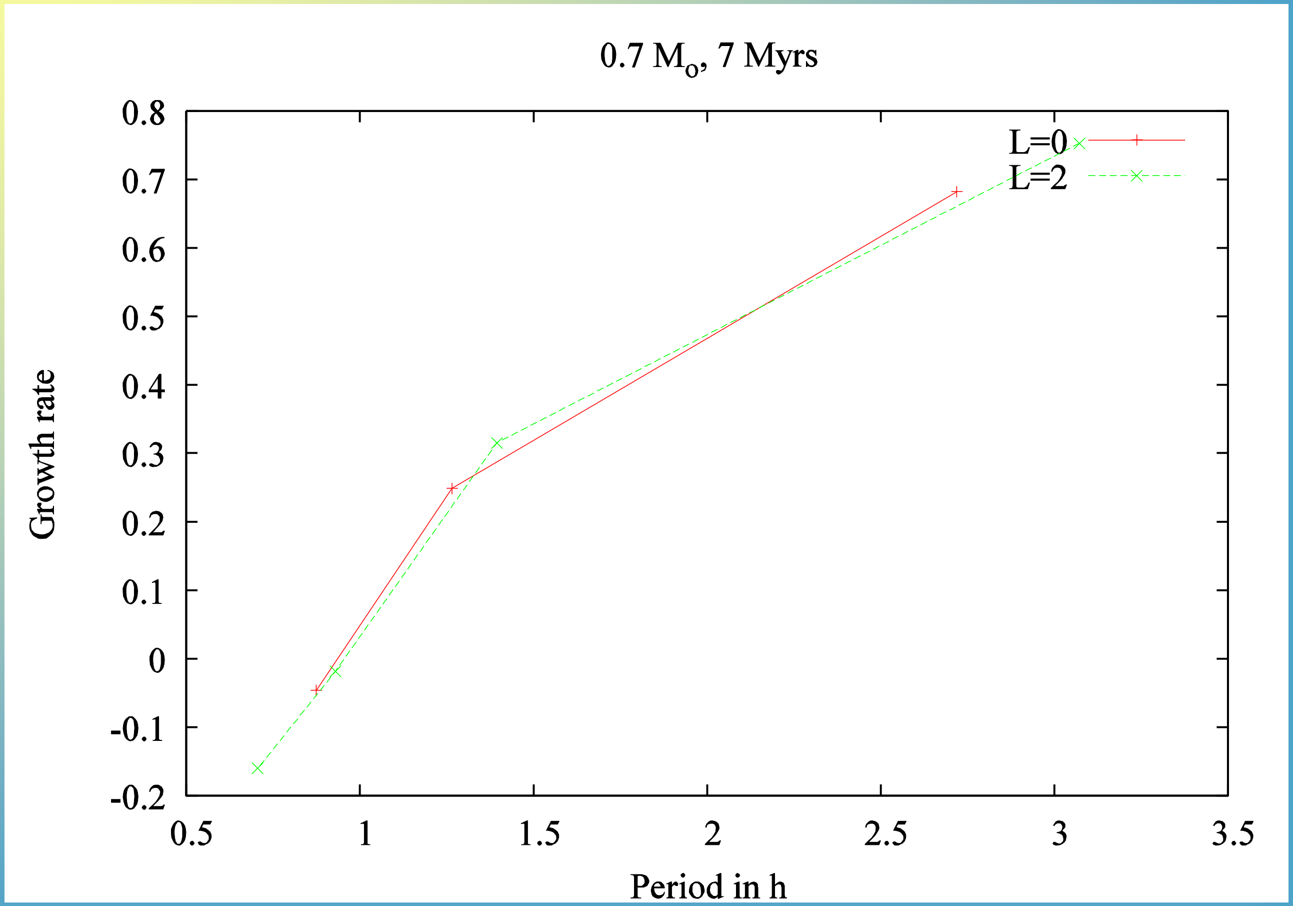

0.5 M$_o$, 7 Myrs
L=0
L=2
Growth rate
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0.5
1
1.5
2
2.5
3
3.5
Period in h

Back

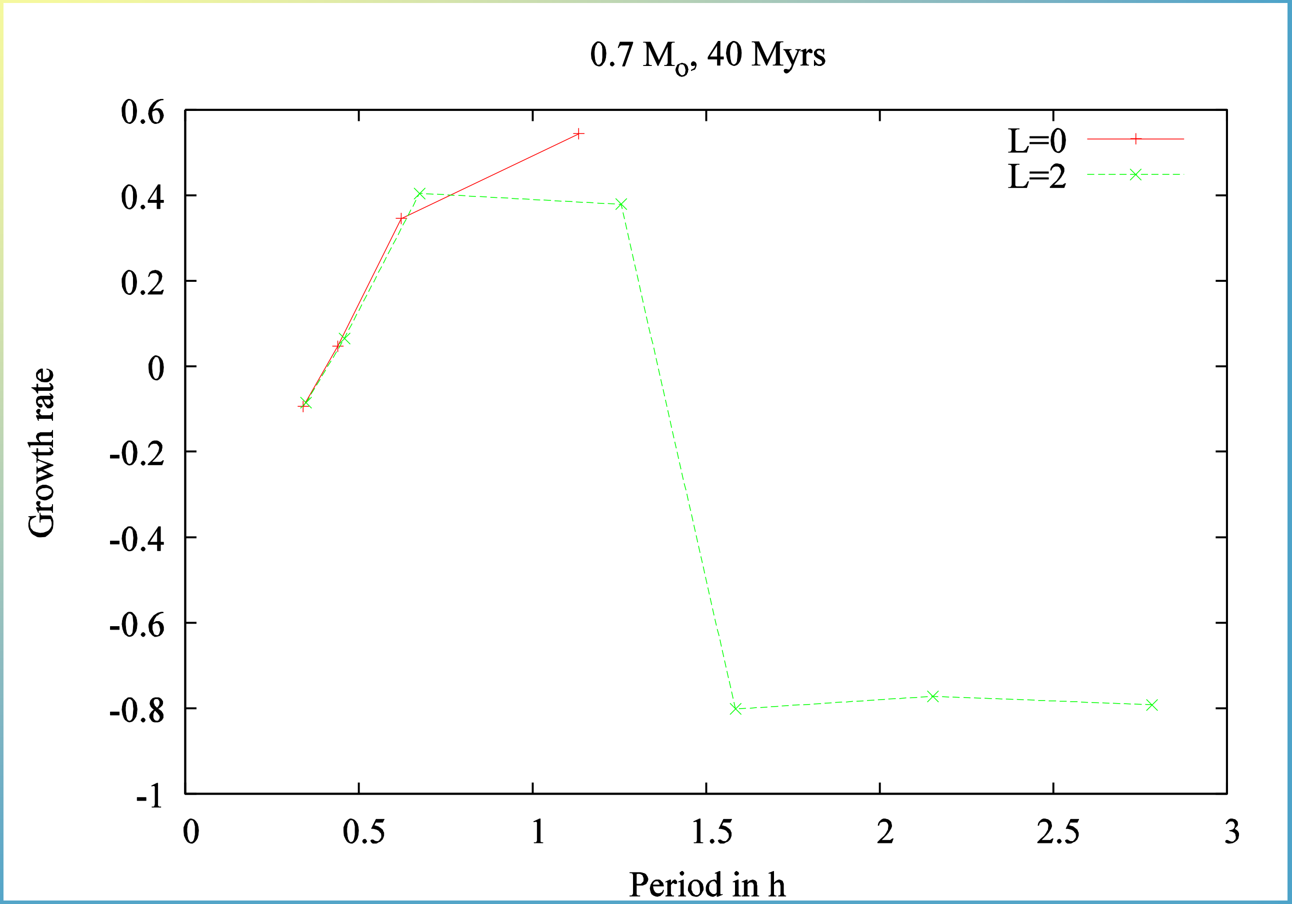


0.5 M_o, 40 Myrs
L=0
L=2
Growth rate
Period in h
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Back


0.7 M$_o$, 7 Myrs
Growth rate
Period in h
L=0
L=2
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0.5
1
1.5
2
2.5
3
3.5

Back



0.7 M_o, 40 Myrs
L=0
L=2
Growth rate
Period in h
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.5
1
1.5
2
2.5
3

Back