Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

Stellar Seismic Indices data base (SSI)

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Outline

I. Seismic Indices

II. Stellar Seismic Indices data base, what we plan to do ?

Some definitions

- Seismic indices give global informations about stars oscillations
- Stellar seismic indices : $\nu_{max}, \Delta\nu, \Delta\Pi, ...$

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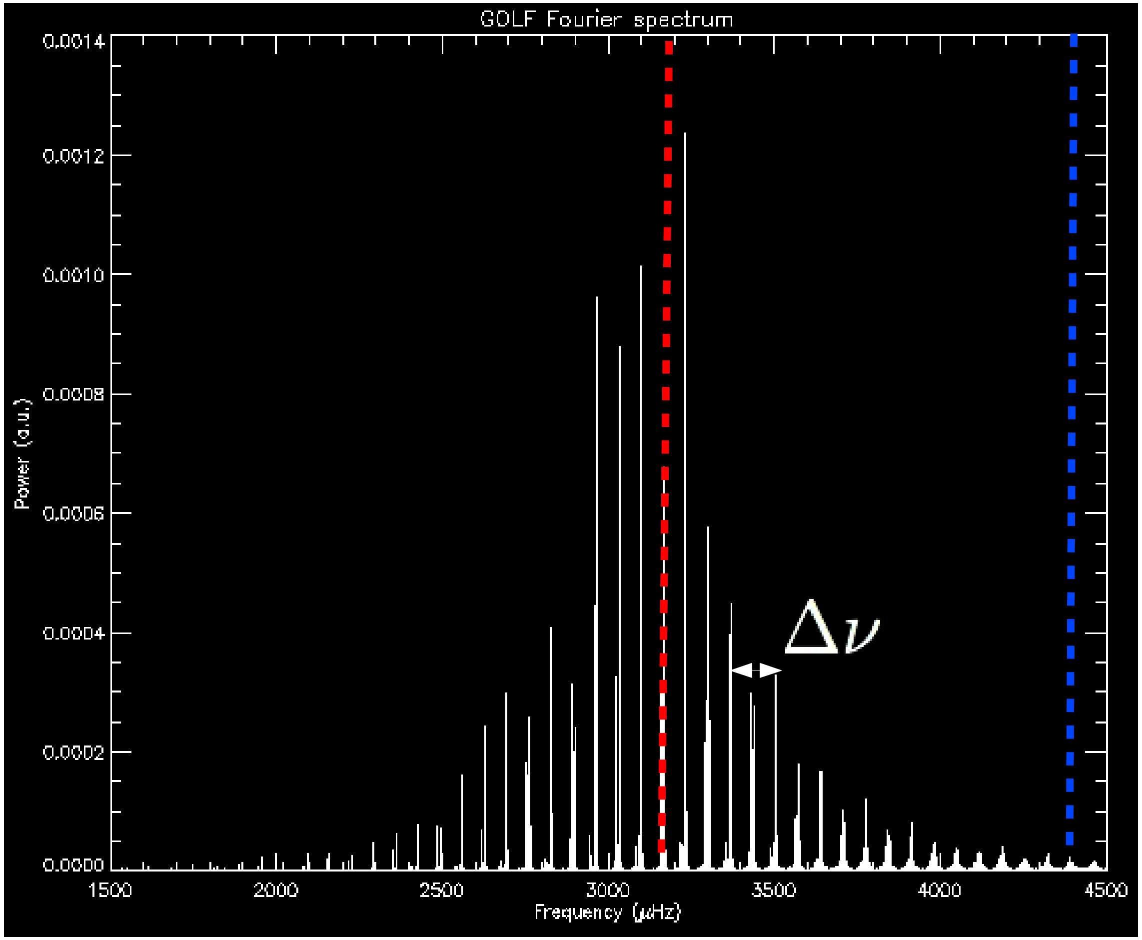

ν_{max} ν_c

ν_{max} Frequency of the maximum height in the power spectrum

ν_c Cut-off frequency

$\Delta\nu$ Mean large separation

$$\Delta\nu = \langle \nu_{l,n+1} - \nu_{l,n} \rangle$$

$\Delta\Pi$ Mean Period spacing

$$\Delta\Pi = \langle p_{l,n+1} - p_{l,n} \rangle$$

Canonical scaling relations

Seismic scaling law : Relation between global seismic parameters and fundamental stellar parameters

$\nu_{max}, \Delta\nu, \Delta\Pi, ...$ ⟺ Mass, Radius, log *g*, ...

Canonical scaling relations

- Frequency of the maximum height (Brown 1991)

$$\nu_{max} \propto \nu_c \propto \frac{c_s}{2\mathrm{H}_p} \propto \frac{g}{\sqrt{T_{eff}}} \propto \frac{M}{R^2\sqrt{T_{eff}}}$$

- Large separation (Ulrich 1986)

$$\Delta\nu \propto \langle\rho\rangle^{1/2} \propto \left(\frac{M}{R^3}\right)^{1/2}$$

- Period spacing

$$\Delta\Pi \propto \langle\rho\rangle_{core}^{-1/2}$$

Canonical scaling relations

$\Delta\nu$, ν_{max} + T_{eff} ⇨ M, R

$$\frac{M}{M_\odot} \simeq \left(\frac{\nu_{max}}{\nu_{max,\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{3/2}$$

$$\frac{R}{R_\odot} \simeq \left(\frac{\nu_{max}}{\nu_{max,\odot}}\right) \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2} \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{1/2}$$

Benefits

- For **stellar community** :
  - e.g. constraint on stellar evolution
- For **exoplanets community** :
  - e.g. better estimates of radii and masses
- For **galactic community** :
  - e.g. masses and radii for a large sample of stars (e.g. Miglio et al. 2009)

Outline

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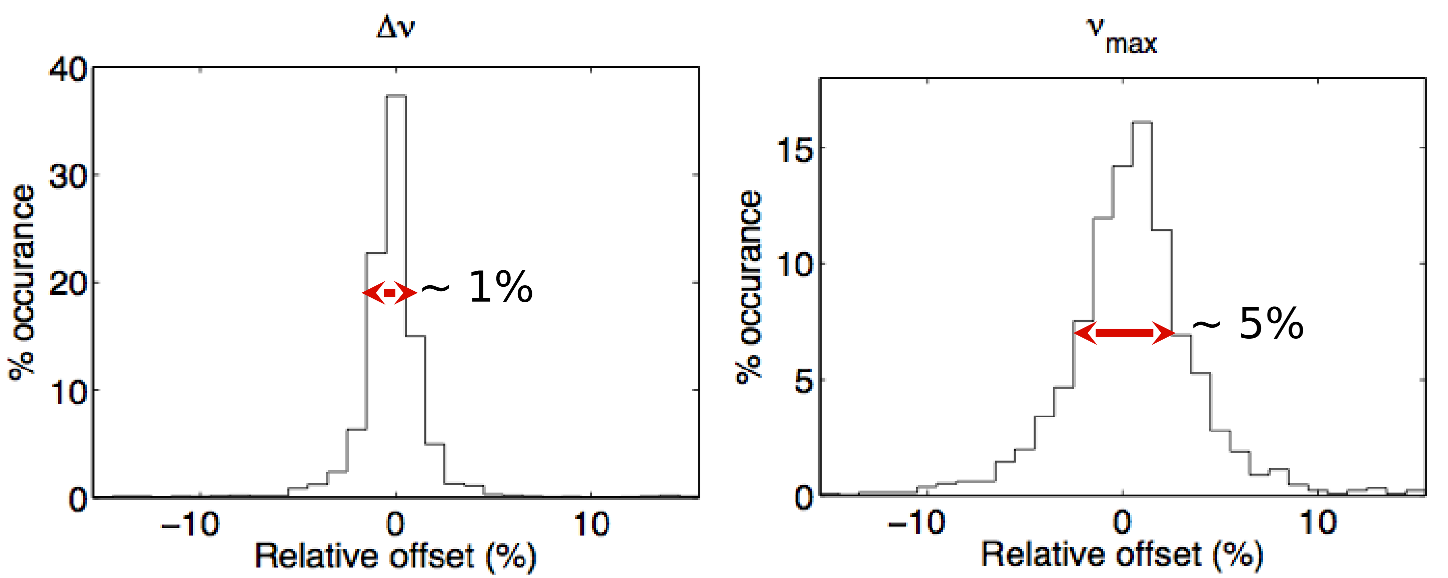
II. Stellar Seismic Indices data base, what we plan to do ?

Are seismic masses and radii accurate ?

Scaling relations give us precise determination of M, R
but...

Are seismic masses and radii accurate ?

- ✔ Typical precision :
  15 methods of analysis applied by 6 teams on simulated power spectrum (Verner et al. 2011)

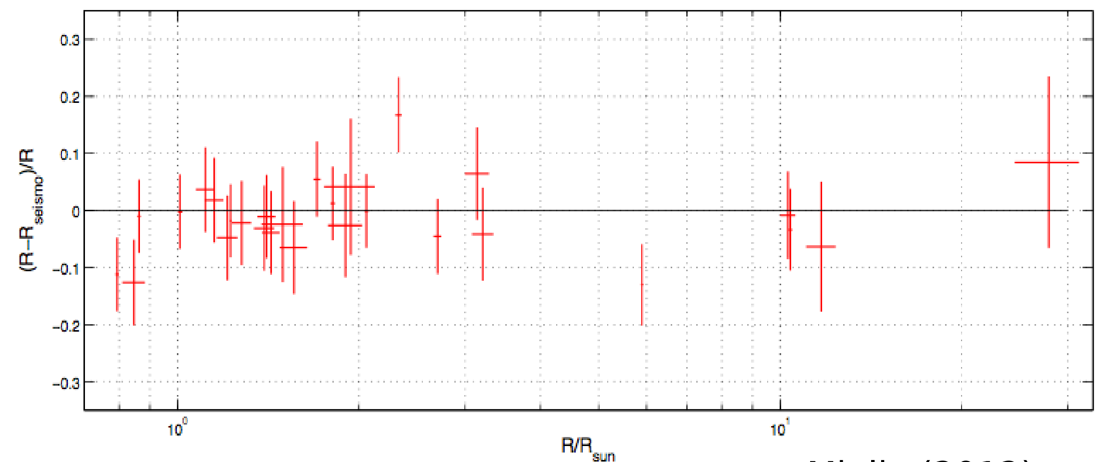


$$\left.\begin{array}{rcl} \nu_{max} & \sim & 5\,\% \\ \Delta\nu & \sim & 1\,\% \\ \Delta T_{eff} & \sim & 100\mathrm{K} \end{array}\right\} \Rightarrow \begin{array}{l} \dfrac{\Delta M}{M} \sim 20\,\% \\ \dfrac{\Delta R}{R} \sim 8\,\% \end{array}$$

- R and M are rather insensitive to uncertainties on ΔT_{eff}
- The precision on ν_{max} the limiting factor

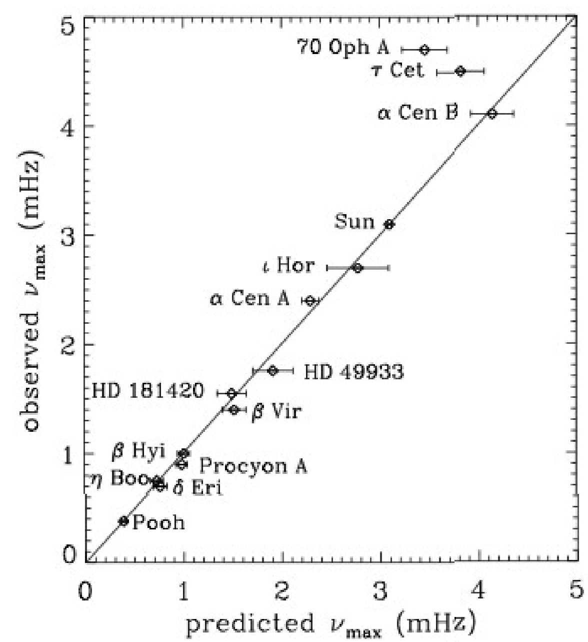
Are seismic masses and radii accurate ?

- ✔ There are some uncertainties related to the definitions of the seismic parameters



Miglio (2012)

- ✔ Can scaling relations be considered as exact relations? (e.g. Belkacem SF2A 2012)



Bedding 2011

What do we propose ?

- **Stellar Seismic Indices (SSI) data base**
  - ν_{max}, $\Delta\nu$, $\Delta\Pi$…
- « The Seismic plus » portal
  - M, R, ...

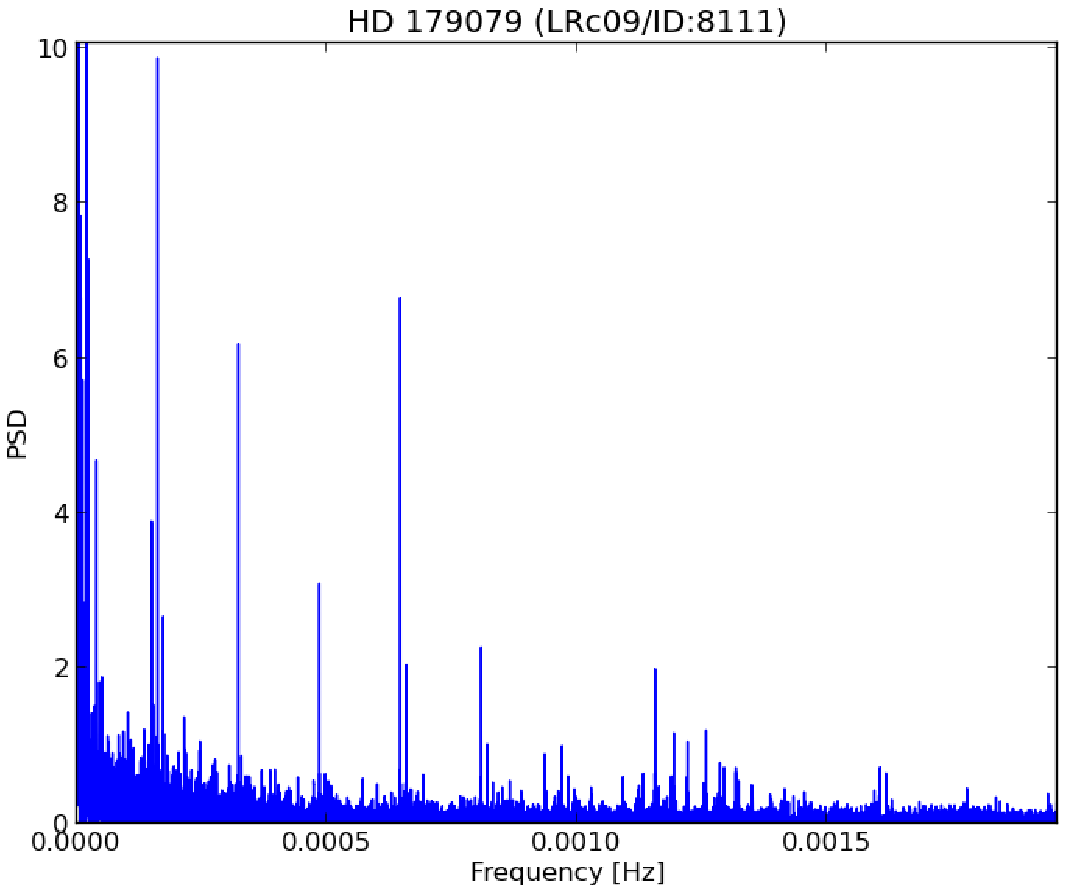
http://spaceinn.eu/

What do we need to do ?

- We propose to **test** and **choose** one standard method for each seismic parameter
- The « standard » method : a trade off between :
  - Automatic
  - Robust and fast
  - Well documented about algorithm precision and accuracy

What do we need to do ?

- Example : **Autocorrelation method** (Roxburgh & Vorontsov 2006 ; Mosser & Appourchaux 2009)
  HD179079 (LRc09/ID:8111) studied by exoplanet team



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- Example : **Autocorrelation method** (Roxburgh & Vorontsov 2006 ; Mosser & Appourchaux 2009)
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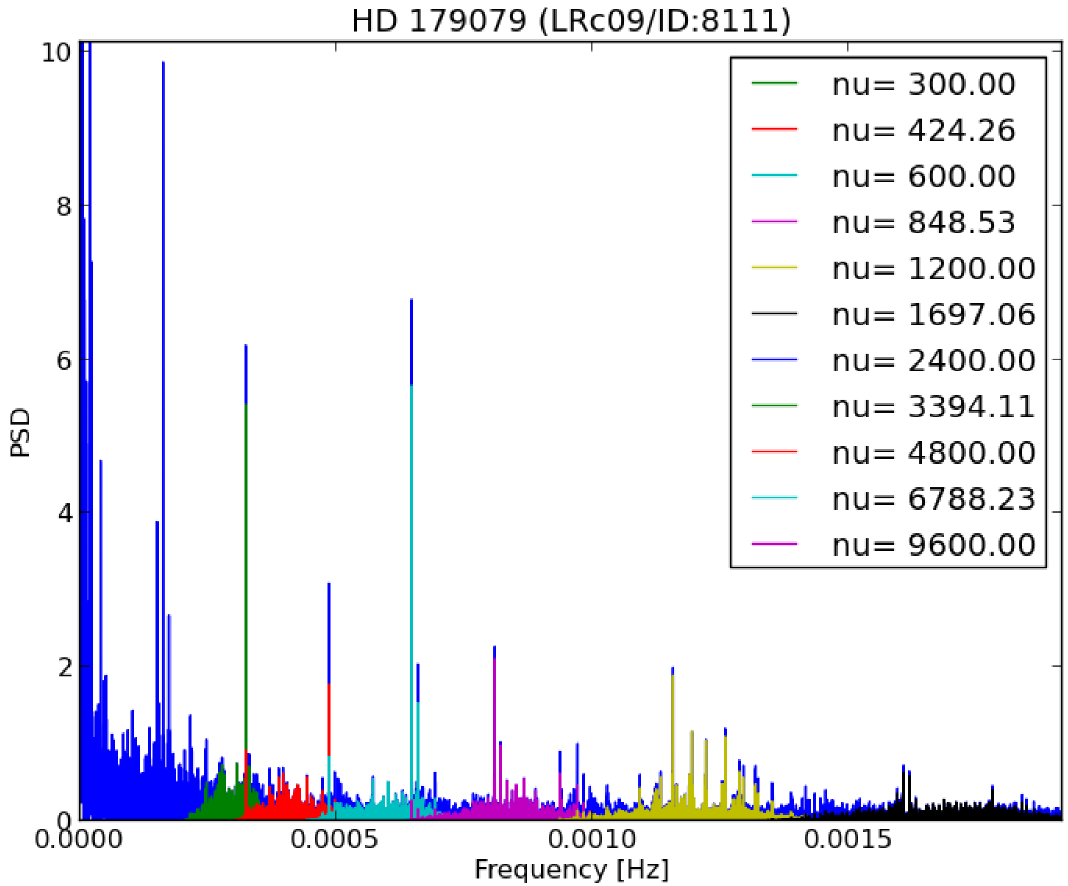
- Fourier transform of the filtered power spectrum → autocorrelation of the light curve



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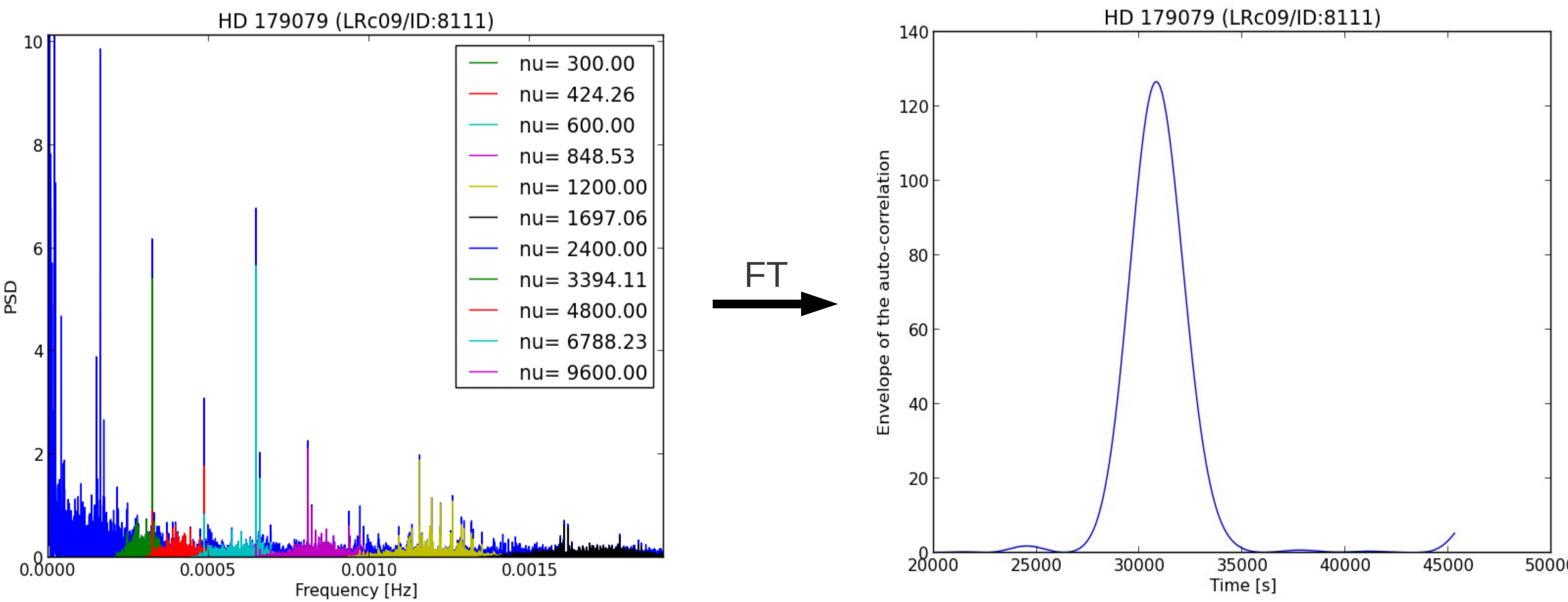

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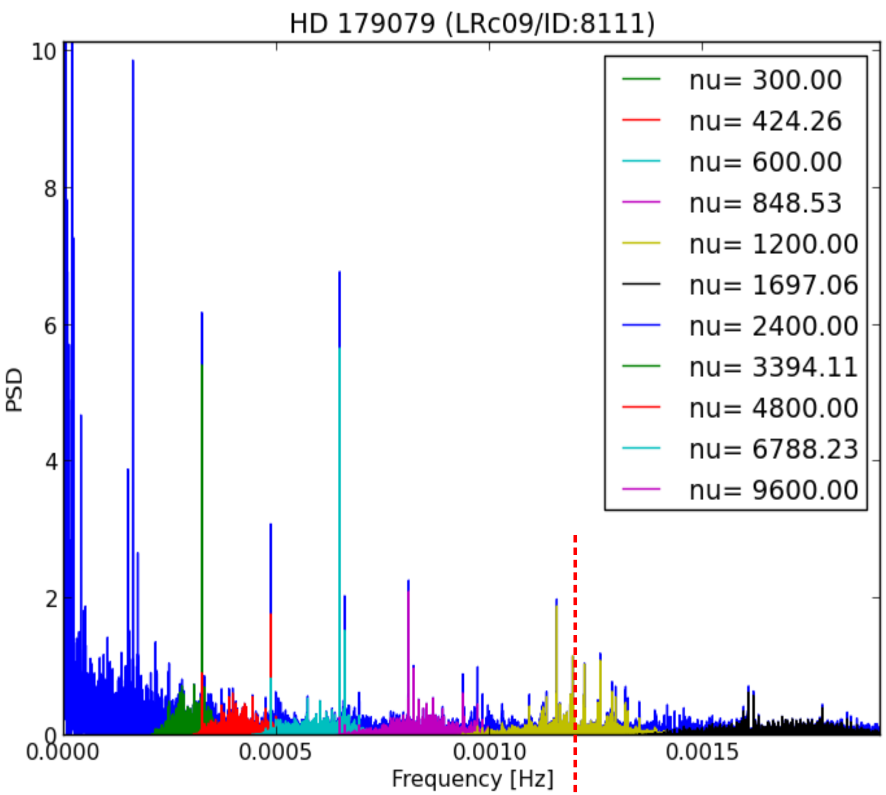
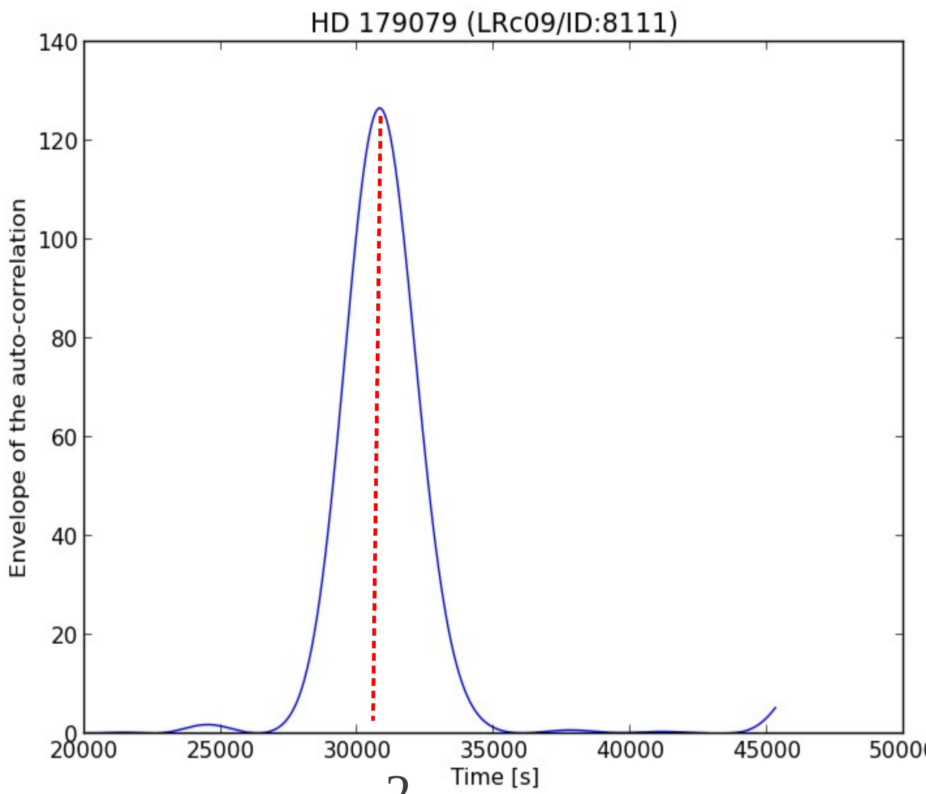


ν_{max}

FT



$$\tau = \frac{2}{\Delta\nu}$$

What do we need to do ?

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HD179079 (LRc09/ID:8111) studied by exoplanet team
- Results :

Seismic parameters

$\Delta\nu$ = 64.95 ± 0.01 µHz

ν_{max} = 1226.6 ± 32.4 µHz

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- Results :

Seismic parameters

$\Delta\nu$ = 64.95 ± 0.01 μHz

ν_{max} = 1226.6 ± 32.4 μHz

T_{eff} = 5684 ± 100 K (Valenti et al. 2009)

Hence :

$\mathbf{M_{☼} = 1.13 \pm 0.05\ M_{\odot}}$

$\mathbf{R_{☼} = 1.71 \pm 0.09\ R_{\odot}}$

What do we need to do ?

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- Results :

Our values	Valenti et al. 2009
$\mathbf{M_{☼} = 1.13 \pm 0.05\ M_{\odot}}$	$\mathbf{M_{☼} = 1.15 \pm 0.03\ M_{\odot}}$
$\mathbf{R_{☼} = 1.71 \pm 0.09\ R_{\odot}}$	$\mathbf{R_{☼} = 1.60 \pm 0.09\ R_{\odot}}$

What do we need to do ?

- **Refine** scaling relations :
  - Theoretical work to understand (and reduce) the dispersion of the scaling relations (e.g. White et al. 2011 ; Belkacem 2012 ; ...)

    e.g. Study of metallicity influences

What do we need to do ?

- **Refine** scaling relations :
  - Theoretical work to understand (and reduce) the dispersion of the scaling relations (e.g. White et al. 2011 ; Belkacem 2012 ; ...)

    e.g. Study of metallicity influences

- **Test** and **Calibrate** the scaling relations :
  - Comparing seismic masses and radii with independent measurements (interferometry and astrometry)

Set of data

- **CoRoT :**
  - Red Giants + Sub-Giants ~ 20,000
  - Main Sequence ~ 10
- **Kepler :**
  - Red Giants + Sub-Giants ~ 20,000
  - Main Sequence ~ 500
- **OGLE** (optical gravitational lensing experiment) **:**
  - Red Giants ~ 20,000

Future set of data

- 2 missions projects which might provide seismics indices :
  - **PLATO** : its objective is to characterize exoplanets and their host stars in the solar neighbourhood
  - **SINDICS** (Seismic INDICes Survey) : propose the 1st seismic all sky survey of our galactic environnement (idea, submited to CNES prospective).


Thank you