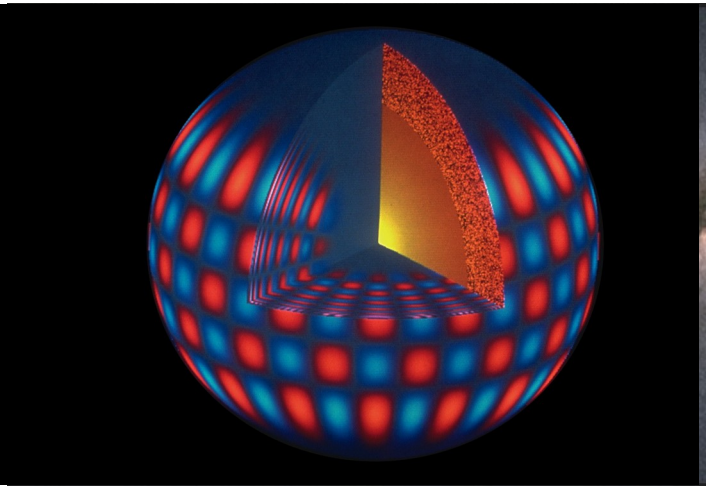
Deriving Stellar Parameters with Asteroseismology



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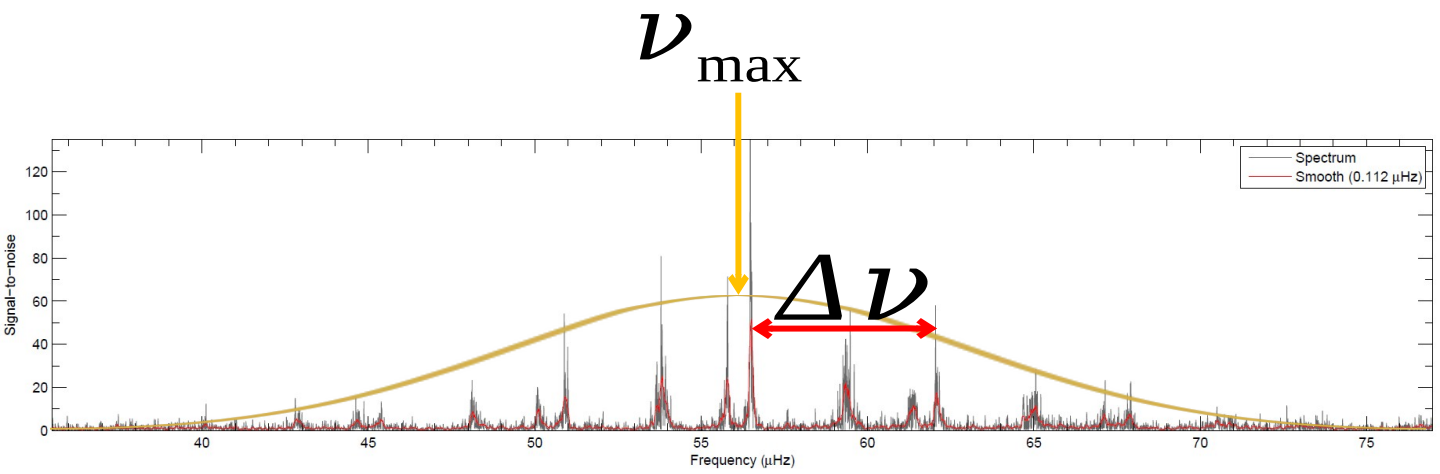
UNIVERSITÀ DEGLI STUDI DI PADOVA

How accurate is our measures of global stellar properties when we use seismic constrains?

Seismic Parameters



$\Delta\nu$: large separation

ν_{max}: frequency of the maximum oscillation power

Scaling Relations

$$\Delta\nu = \Delta\nu_{\odot}\sqrt{\frac{M}{R^3}}$$

$$\nu_{\max} = \nu_{\max,\odot}\frac{M}{R^2\sqrt{T_{\mathrm{eff}}}}$$

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DIRECT METHOD

Inverting the scaling relations

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

$$\frac{R}{\mathrm{R}_{\odot}} = \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)\left(\frac{\Delta\nu}{\Delta\nu_{\odot}}\right)^{-2}\left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{1/2}$$

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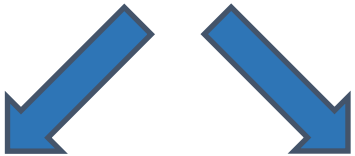

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STATISTICAL METHOD

It takes into account stellar theory predictions

“Grid-based” or “Bayesian” Method

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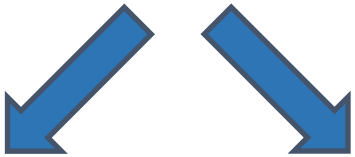

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PARAM

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PARAM code is a **Bayesian** tool to **estimate stellar properties** by comparing observational data with a grid of stellar models.

$$\mathrm{INPUT} = \left([\mathrm{M/H}], T_{\mathrm{eff}}, \Delta\nu, \nu_{\mathrm{max}} \right)$$

STELLAR MODELS

$$\mathrm{OUTPUT} = \left(M, R, \mathrm{age}, \log g, M_{\lambda}, \ldots \right)$$

Rodrigues et al. 2014

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two asteroseismic observables

STELLAR MODELS

$\Delta\nu$ and ν_{max} from scaling relations

$$\mathrm{OUTPUT} = \left(M, R, \mathrm{age}, \log g, M_{\lambda}, \ldots \right)$$

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Beyond Scaling Relations

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Scaling relations do not consider that:

- Stars in general are **not homologous to the Sun**. Hence the sound speed in their interior does not simply scale with mass and radius only.
- The oscillation modes detected in stars do **not obey to the asymptotic approximation** to the same degree as in the Sun.

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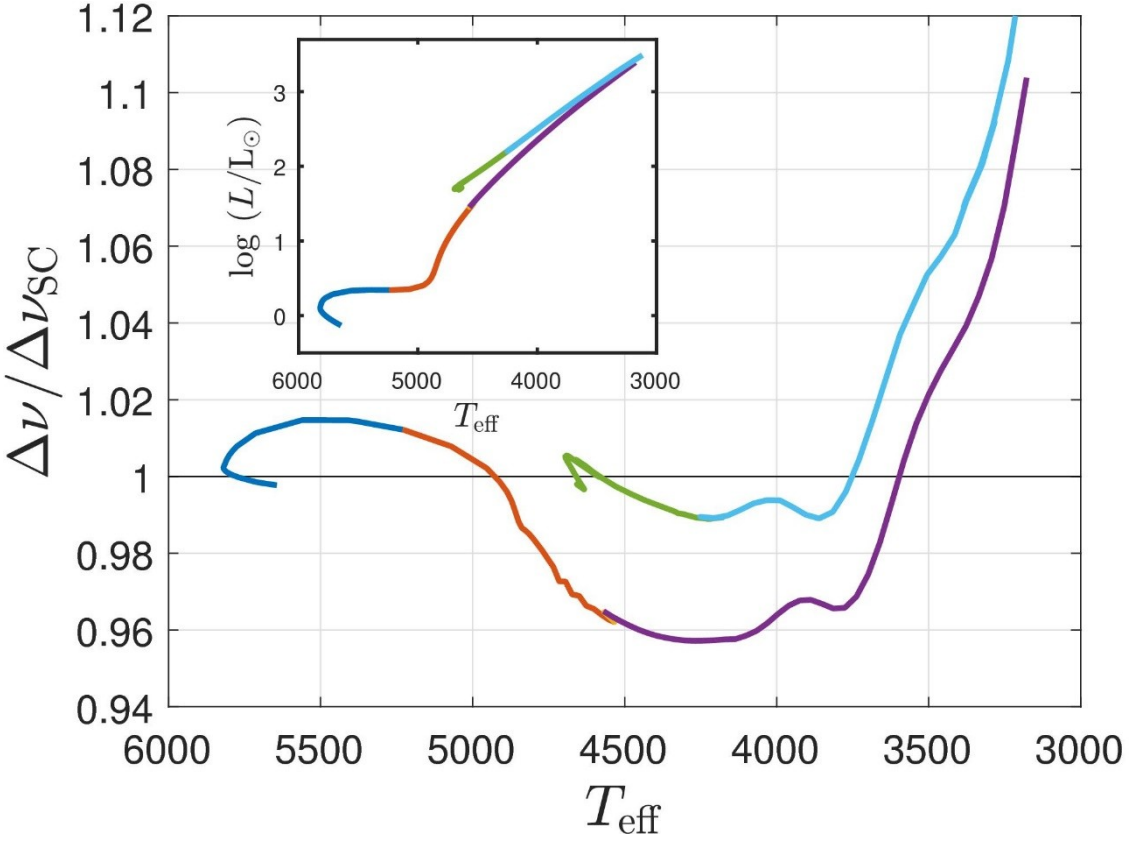
→ deviation from the scaling relations

White et al. 2011; Miglio 2012; Miglio et al. 2013; Brogaard et al. 2016; Miglio et al. 2016; Guggenberger et al. 2016; Sharma et al. 2016; Handberg et al. 2017

Deviation of Scaling Relations



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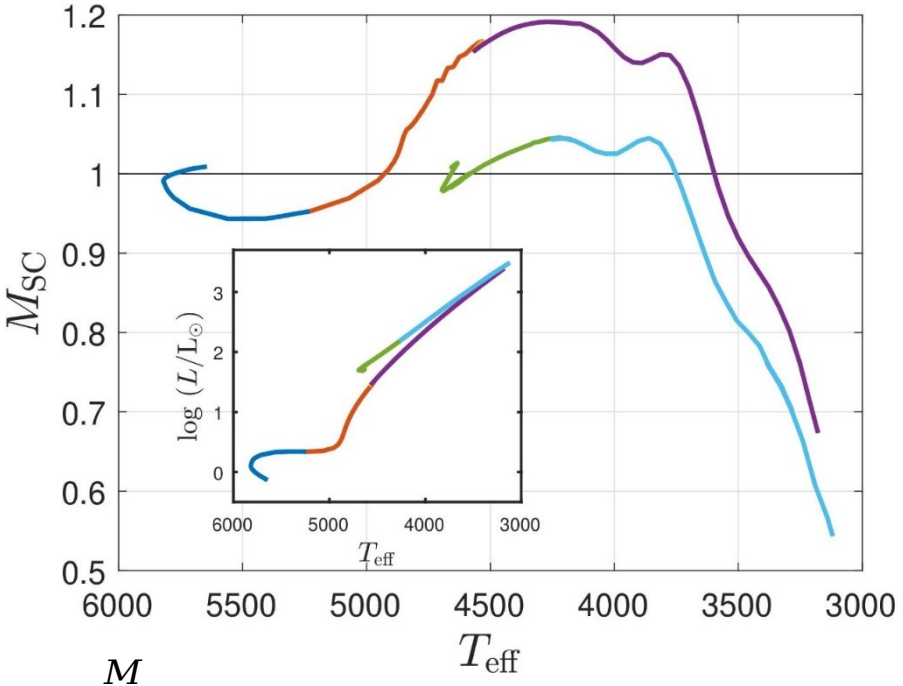
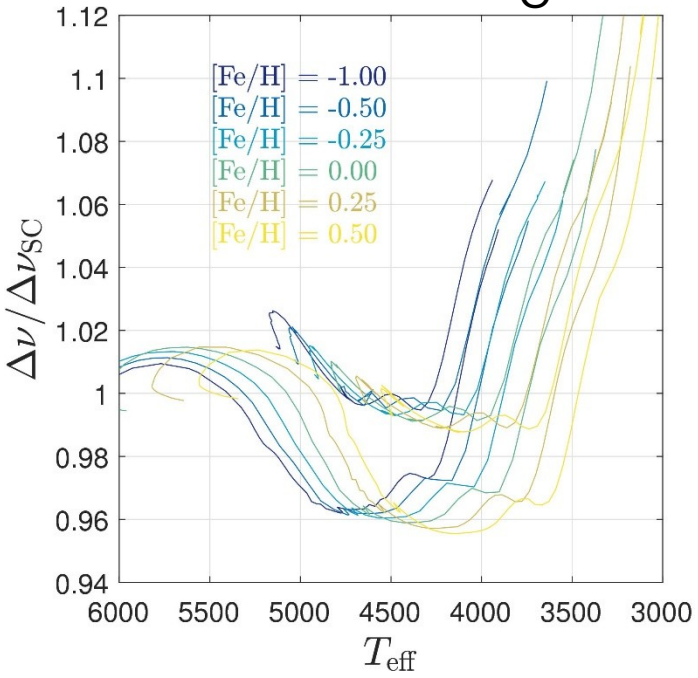


$$\nu_{max} = \nu_{max,\odot} \frac{M}{R^2 \sqrt{T_{eff}}}$$

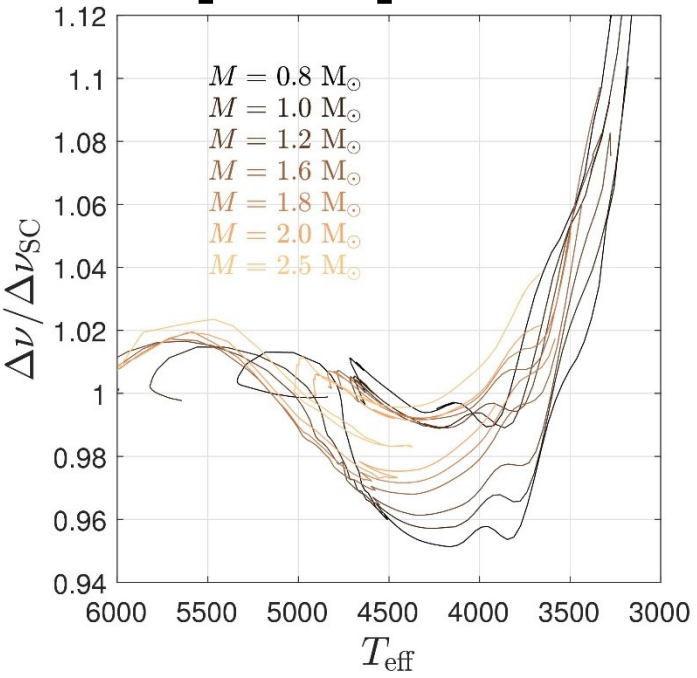
$$\frac{M}{M_\odot} = \left(\frac{\nu_{max}}{\nu_{max,\odot}}\right)^3 \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{3/2}$$

Deviation of Scaling Relations

M=1.0 $M_\odot$



[Fe/H]=0.00



PARAM 1.4

$$\mathrm{INPUT} = \left([\mathrm{M/H}], T_{\mathrm{eff}}, \Delta\nu, \nu_{\mathrm{max}}, \Delta\Pi \right)$$

Three asteroseismic observables

STELLAR MODELS

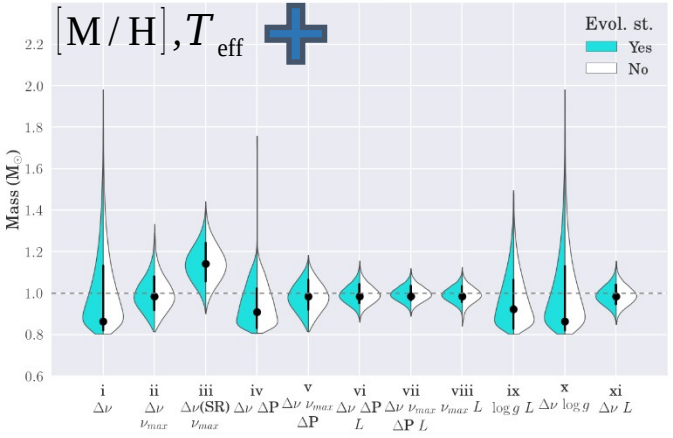
- ν_{max} from scaling relations
- $\Delta\nu$ from individual frequency
- Asymptotic $\Delta\Pi$
- Physical inputs in accordance with Bossini et al. 2015

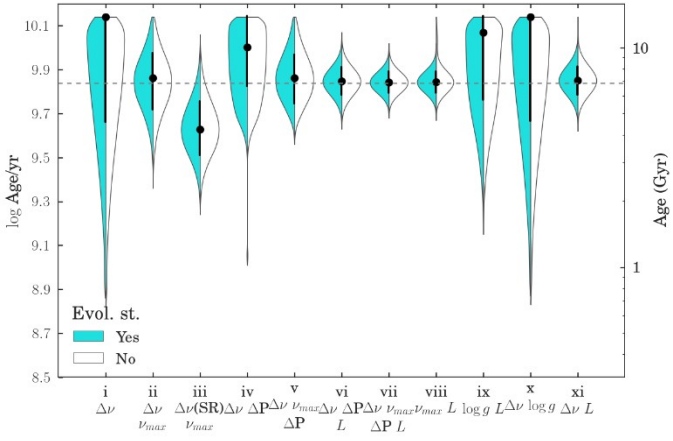
$$\mathrm{OUTPUT} = \left(M, R, \mathrm{age}, \log g, M_{\lambda}, \ldots \right)$$

Rodrigues et al. **2017**

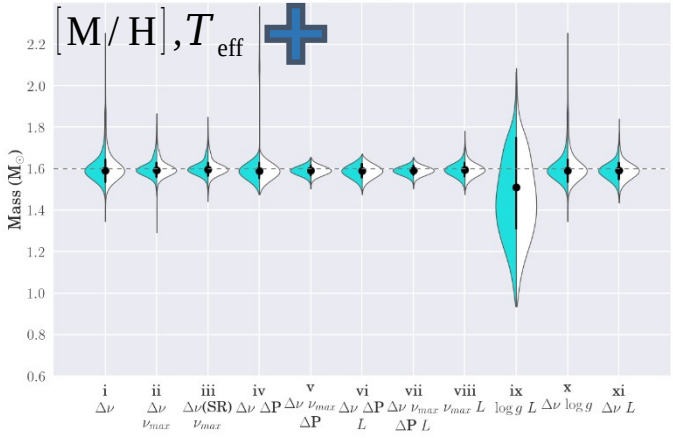
Testing: Artificial Stars

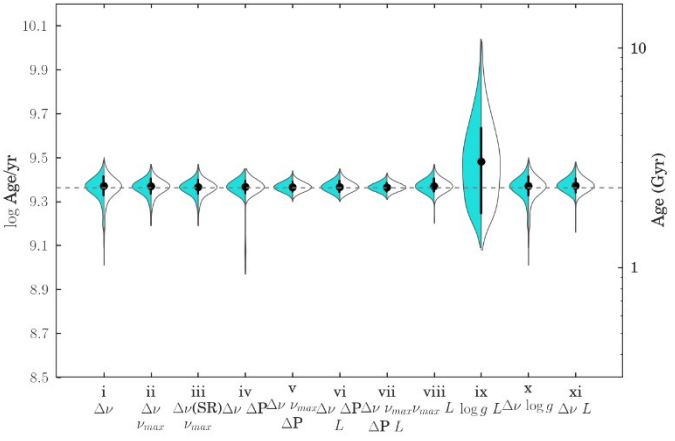
RGB





RC





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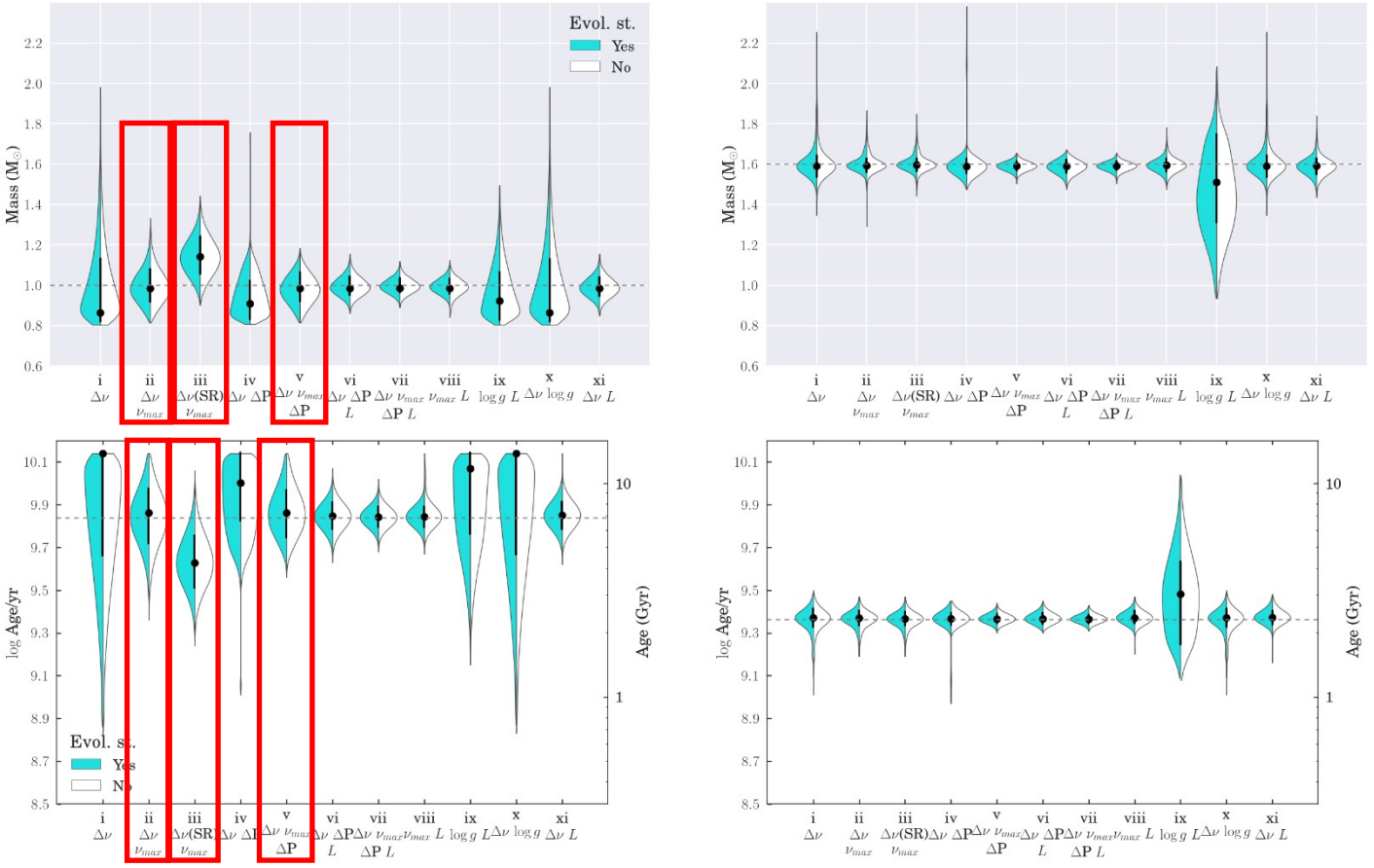

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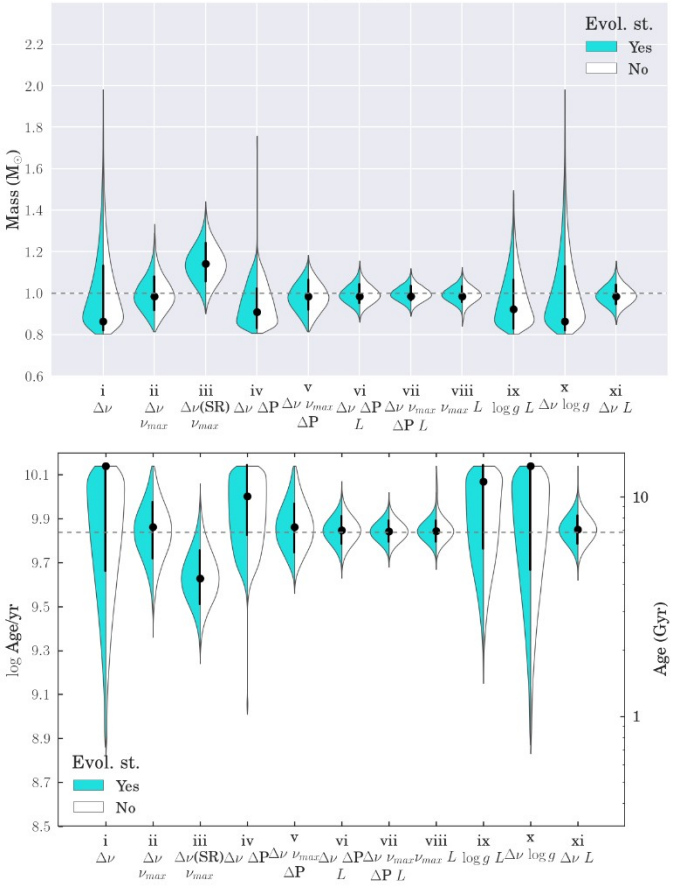

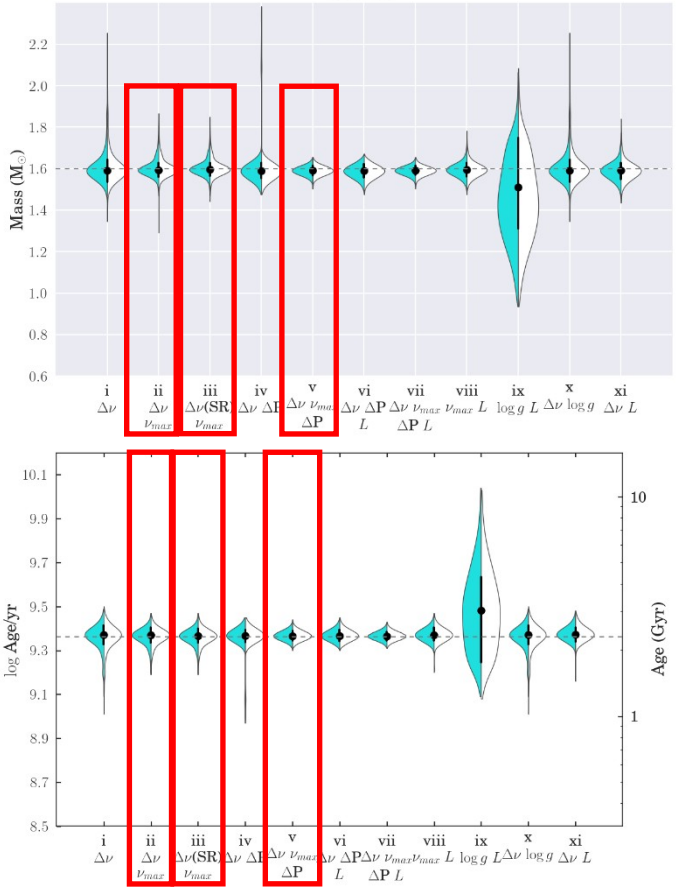

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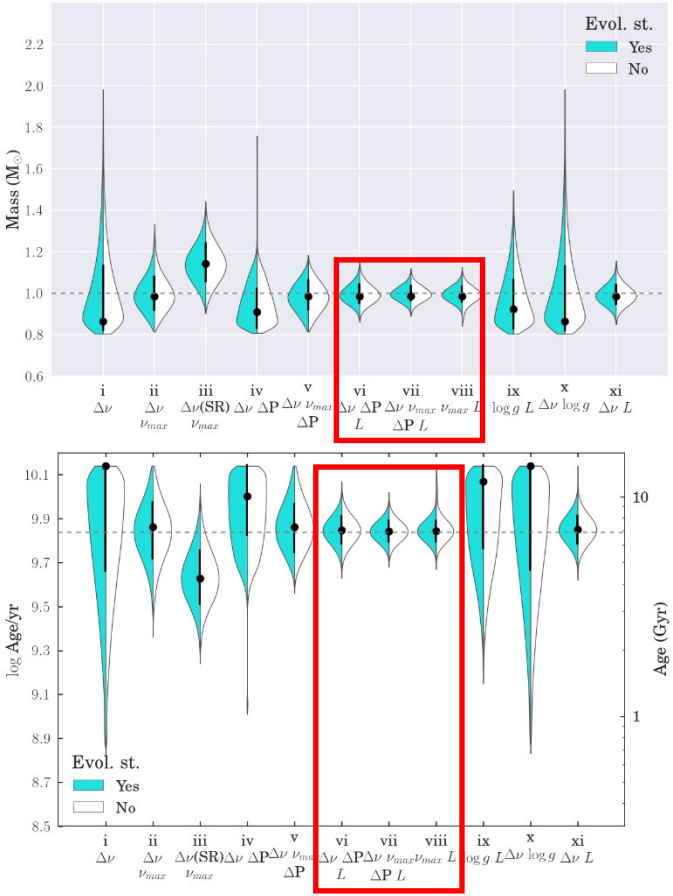

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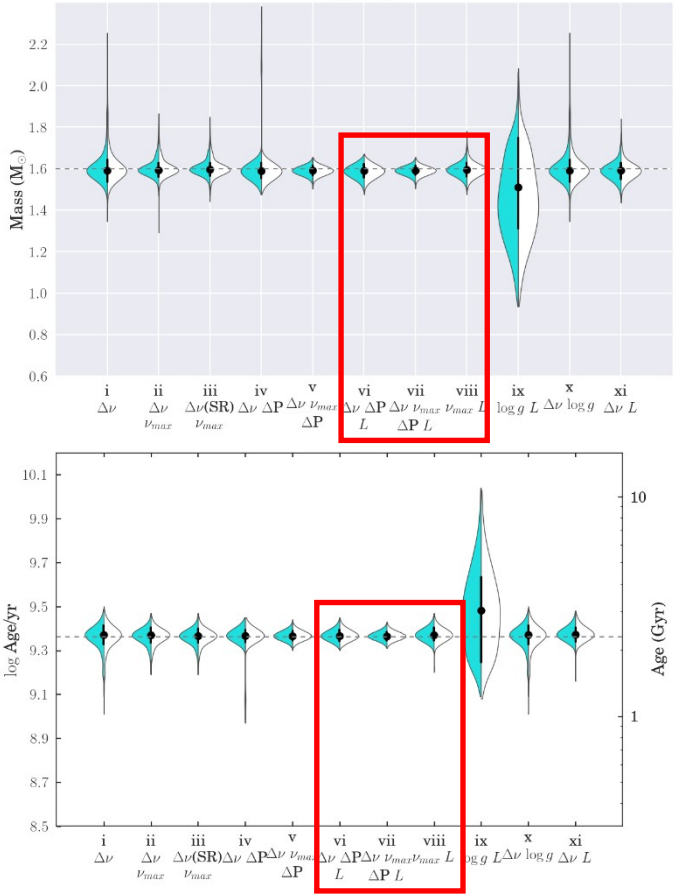

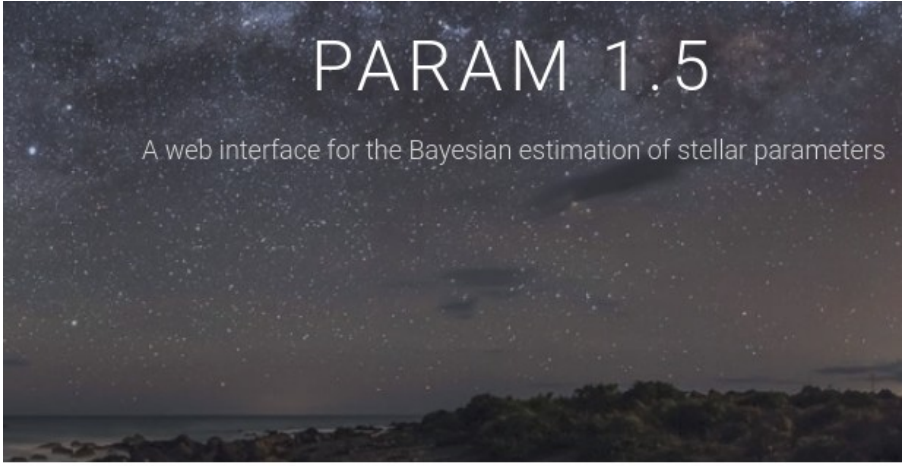

LET'S START

Fill in the parameter list with your data

☆ STELLAR OBSERVABLES

Enter with stellar observed parameters together with their 1σ errors (here assumed to be Gaussian):

Name: 5024405

Effective temperature: T_{eff} = 4775.0 ± 70.0 K

Metallicity: [Fe/H] = 0.02 ± 0.10 dex

Logarithm of surface gravity: *logg* = -99.9 ± -99.9 dex

Luminosity: L = -99.9 ± -99.9 $L_\odot$

Parallax[1]: ϖ = -99.9 ± -99.9 mas

http://stev.oapd.inaf.it/param