Asteroseismology of alpha Centauri

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- The α Cen binary stellar system
- Calibration of α Cen
- Asteroseismology of α Cen A & B
- Conclusion

Reference: Morel P., Provost J., Lebreton Y., Thévenin F., Berthomieu G., Calibrations of α Cen A & B, A&A 2000, in press

α Cen binary stellar system

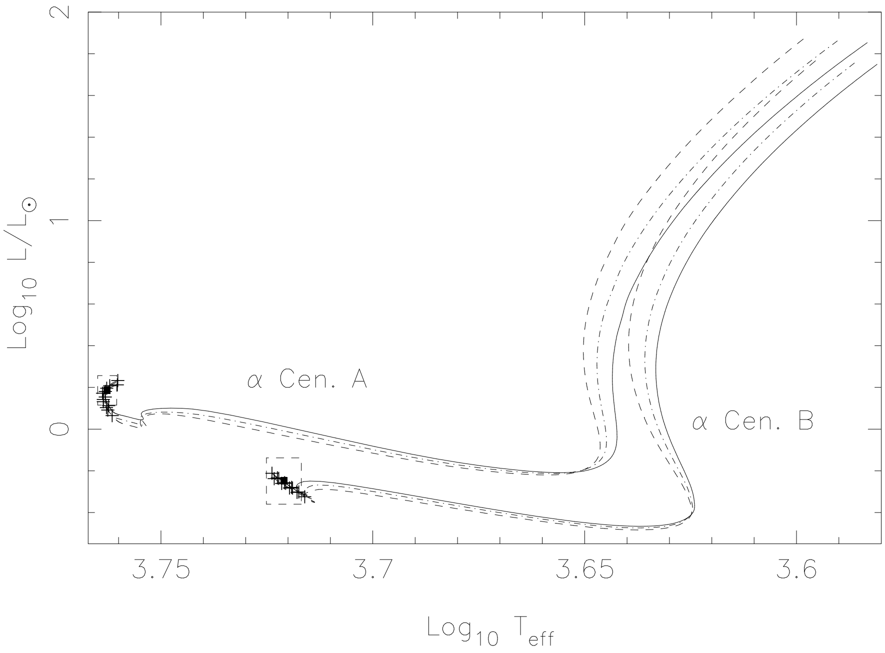
Very well known visual binary system α Cen A& B

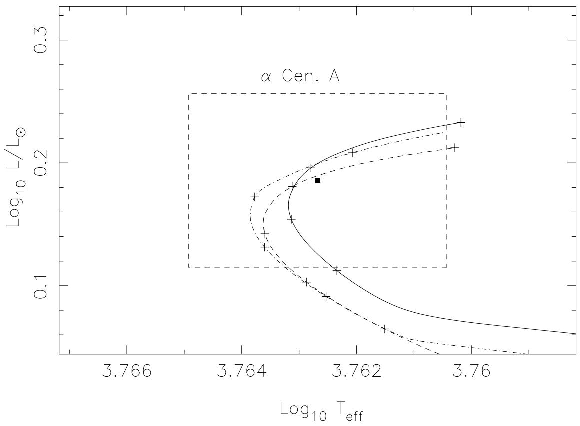
- Spectral types G2V & K1V
- Orbital distance (Pourbaix et al.) measurements larger by 1.5% from revised Hipparcos (Söderhjelm)
- Revised masses from Pourbaix et al. (1) larger by 5.5% compared to (2)

Observational data to be reached by the calibration

	α Cen A	α Cen B	
$M/M_\odot$	1.16 ± 0.031	0.97 ± 0.032	(1)
	1.1015 ± 0.008	0.9159 ± 0.007	(2)
$T_{\rm eff}$	$5790 \pm 30\,{\rm K}$	$5260 \pm 50\,{\rm K}$	
$L/L_\odot$	1.534 ± 0.103	0.564 ± 0.064	
$[\frac{\rm Fe}{\rm H}]_{\rm surf}$	0.20 ± 0.02	0.23 ± 0.03	

α Cen A & B calibration





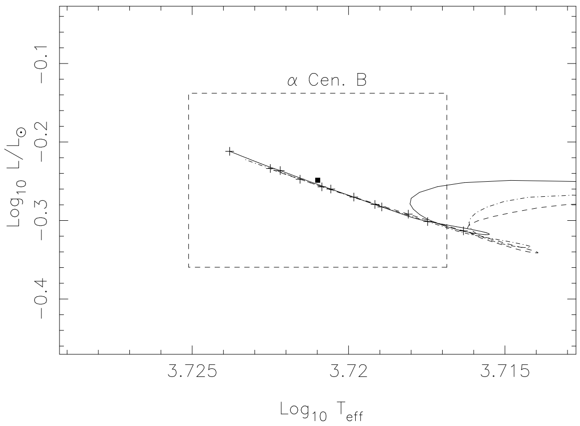


Figure 1: Evolutionary tracks in the H-R diagram of α Cen A & B models (full: A_{BV}, B_{BV}; dashed: A_{CM}, B_{CM}; dot-dash-dot: A_{ov}, B_{ov}). More details on the models in Morel et al. 2000 (A&A 363, 675).

α Cen calibration results

Age ($t_{\alpha\,\mathrm{Cen}}$), initial chemical composition (Y_i and $(\frac{Z}{X})_\mathrm{i}$) and convection parameters (α_A & α_B) for the binary system obtained by fitting the observed data for α Cen A & B.

	$\mathrm{A_{BV}(B_{BV})}$ (1)	$\mathrm{A_{ov}(B_{ov})}$ (1)	$\mathrm{A_{GD}(B_{GD})}$ (2)	$\mathrm{A_{CM}(B_{CM})}$ (1)
$t_{\alpha\,\mathrm{Cen}}$(Myr)	2710	3530	5640	4086
Y_i	0.284	0.279	0.300	0.271
$(\frac{Z}{X})_\mathrm{i}$	0.0443	0.0450	0.0480	0.0450
α_A (α_B)	1.53 (1.57)	1.64 (1.66)	1.86 (1.97)	0.96 (0.99)

(1) new larger masses (2) previous smaller masses

- 5% increase in masses decreases the age of the system by factor 2

Oscillations: large spacing $\Delta\nu_{n,\ell}$

$$\Delta\nu_{n,\ell} = \nu_{n,\ell} - \nu_{n-1,\ell}$$

$\overline{\Delta\nu_{n,\ell}} \Longrightarrow$ mean stellar density

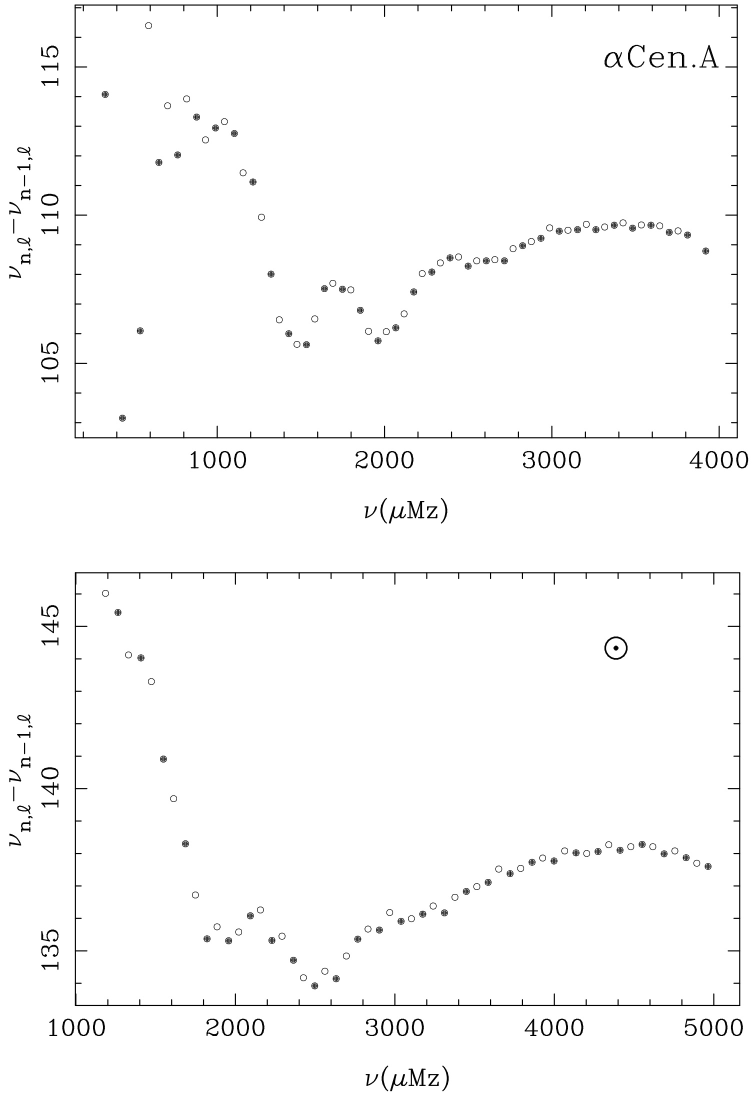


Figure 2: Variations of the large frequency spacing between modes of consecutive radial order $\Delta\nu_{n,\ell} = \nu_{n,\ell} - \nu_{n-1,\ell}$ for p-modes of degree $\ell = 0$ (full point) and $\ell = 1$ (open point), for α Cen A (larger mass (1)) and for the Sun

Oscillations: small spacing

$\delta\nu_{0\ 2} = \overline{\nu_{n,\ell=0} - \nu_{n-1,\ell=2}}$ ($\Longrightarrow$ core structure & age)

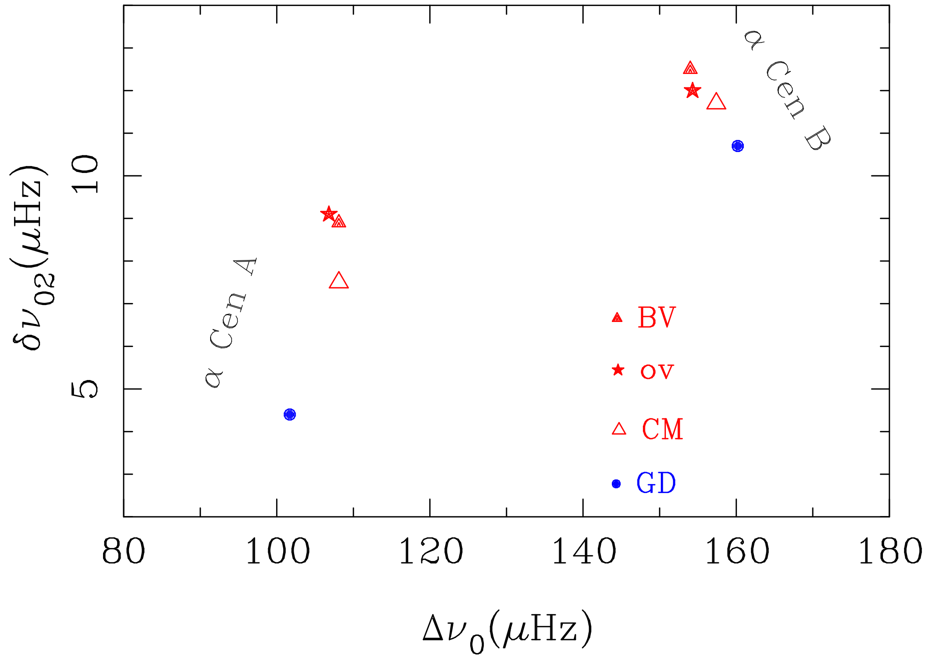


Figure 3: Asteroseismic HR diagram. Variations of the mean small spacing $\delta\nu_{02}$ as a function of the mean large spacing $\Delta\nu_0$ for all the calibrated models of α Cen A & B. Red symbols for recently revised larger masses (1).

- Revised mass of α Cen A larger by 5.5%

  $\Longrightarrow$ Mean large spacing $\Delta\nu_0$ larger by 7 μHz

  Mean small spacing $\delta\nu_{02}$ larger by factor 2

Conclusion

- Calibrations of α Cen binary system using recent mass determinations
  $\Longrightarrow$ age notably smaller than previously due to mass differences

- Seismological analysis
  $\Longrightarrow$ mean small frequency spacing very sensitive to the mass
  $\delta\nu_{02} = 8.9\mu$Hz larger mass
  4.4 μHz smaller mass

- Asteroseismology of α Centauri A would help to better "measure" masses and age of the binary system