Mem. S.A.It. Vol. 77, 451

Memorie della

Asteroseismology of solar-type stars with Coralie and Harps

II: Observations and modelling of binary stars

P. Eggenberger and F. Carrier

Observatoire de Genève, 51 chemin des Maillettes, 1290 Sauverny, Suisse
e-mail: Patrick.Eggenberger@obs.unige.ch

Abstract. We present here the detection and characterization of solar-like oscillations in visual binary stars such as α Centauri, Procyon and 70 Ophiuchi obtained with the Coralie and Harps spectrographs at the ESO La Silla Observatory. The strong additional constraints resulting from the binary nature of the systems (same age and initial chemical composition) allow us to accurately determine their global parameters and to test the physics of the models.

Key words. Techniques: radial velocities – Stars: fundamental parameters – Stars: oscillations – Stars: evolution

1. α Centauri

Thirteen nights of observation with the Coralie spectrograph in 2001 revealed the presence of solar–like oscillations in α Cen A (Bouchy & Carrier 2002). Twenty–eight oscillation frequencies have been identified in the power spectrum between 1.8 and 2.9 mHz with a mean large and small separation of 105.5 μHz and 5.6 μHz, respectively. The amplitudes of the modes are in the range 12 to 44 cm s^{-1} The B component was observed with Coralie in April 2003 during thirteen nights (Carrier & Bourban 2003). Twelve oscillation modes have been identified in the power spectrum between 3 and 4.6 mHz with amplitudes in the range 8.7 to 13.7 cm s^{-1} and a large separation of 161.1 μHz.

Based on these seismological data, detailed models of the α Centauri system have been computed using the Geneva evolution code (Eggenberger et al. 2004b). Taking into account the numerous observational constraints available for the α Cen system, we determine a stellar model which is in good agreement with the astrometric, photometric, spectroscopic and asteroseismic data. The global parameters of the α Cen system are now firmly constrained to an age of $t = 6.52 \pm 0.30$ Gyr, an initial helium mass fraction $Y_{\rm i} = 0.275 \pm 0.010$ and an initial metallicity $(Z/X)_{\rm i} = 0.0434 \pm 0.0020$. We also confirm that the mixing–length parameter α of the B component is larger than the one of the A component ($\alpha_{\rm B}$ is about 8 % larger than $\alpha_{\rm A}$).

Send offprint requests to: P. Eggenberger

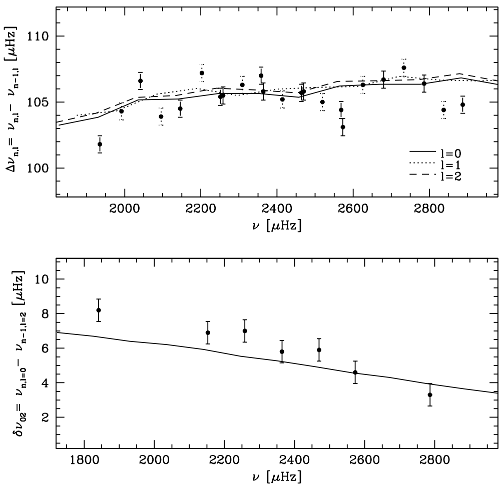

Fig. 1. Large and small separations versus frequency for the model of α Cen A. Dots indicate the observed values of the large and small separations.

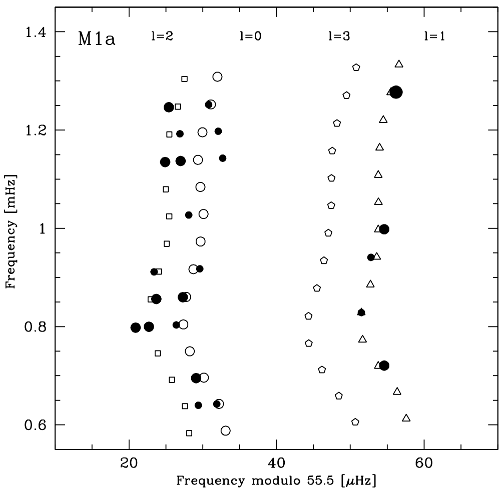

Fig. 2. Echelle diagram of Procyon A. Open symbols refer to theoretical frequencies, while the filled circles correspond to the observed frequencies.

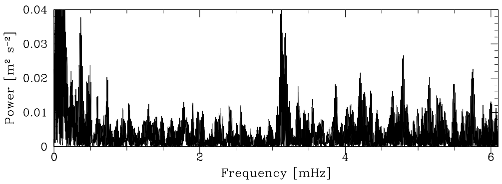

Fig. 3. Power spectrum for 70 Ophiuchi A.

2. Procyon

The F5 subgiant star Procyon A was observed with the CORALIE spectrograph in February 1999. The resulting 908 high–accuracy radial velocities show a significant excess in the power spectrum between 0.6-1.6 mHz with 0.60 $m\,s^{-1}$ peak amplitude. An average large separation of 55.5 μHz has been determined and twenty-three individual frequencies identified (Eggenberger et al. 2004a).

Models of Procyon A have been computed using the Geneva evolution code including shellular rotation (Eggenberger et al. 2005). By combining all non–asteroseismic observables with the seismological data, we find that the observed mean large spacing of $55.5 \pm 0.5\,\mu$Hz favours a mass of 1.497 $M_\odot$ for Procyon A. We also determine the following global parameters of Procyon A: an age of $t = 1.72 \pm 0.30$ Gyr, an initial helium mass fraction $Y_i = 0.290 \pm 0.010$, and a nearly solar initial metallicity $(Z/X)_i = 0.0234 \pm 0.0015$ and mixing–length parameter $\alpha = 1.75 \pm 0.40$.

3. 70 Ophiuchi

The K0 dwarf star 70 Ophiuchi A was recently observed with the HARPS spectrograph. The preliminary analysis of the resulting 1738 high–accuracy radial velocities shows an excess in the power spectrum near 4.2 mHz with peak amplitudes of about 13 $cm\,s^{-1}$.

Acknowledgements. We thank J. Christensen-Dalsgaard for providing us with the Aarhus adiabatic pulsation package.

References

Bouchy, F., & Carrier, F. 2002, A&A, 390, 205
Carrier, F., & Bourban, G. 2003, A&A, 406, L23
Eggenberger, P., Carrier, F., Bouchy, F., & Blecha, A. 2004a, A&A, 422, 247
Eggenberger, P., Charbonnel, C., Talon, S., et al. 2004b, A&A, 417, 235
Eggenberger, P., Carrier, F., & Bouchy, F. 2005, New Astron., 10, 195