Radial and Nonradial Pulsations as Probes of Stellar Physics
ASP Conference Series, Vol. 259, 2002
C. Aerts, T.R. Bedding, & J. Christensen-Dalsgaard, eds.

Future Doppler Ground-Based Search for Solar-Like Oscillations with HARPS

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1. Introduction

Observations of solar-like oscillation frequencies allow us to constrain the theory of structure and evolution of stars with an outer convective zone. Recent improvements in radial velocity measurements have led to p-mode detection on Procyon (Martic et al., 1999) and β Hydri (Bedding et al., 2001; Carrier et al., 2001a). Very recently, characterization of the p-modes of α Cen A has been made with the spectrograph CORALIE mounted on the 1.2-m Swiss telescope at the ESO La Silla Observatory (Bouchy & Carrier, 2001, Carrier et al., these proceedings). The power of the radial velocity technique promises the development of ground-based search for solar-like oscillations on a large sample of stars especially with the future spectrograph HARPS.

2. Asteroseismology with HARPS

The future spectrograph HARPS (High Accuracy Radial velocity Planetary Search) (Pepe et al., 2000) will be installed on the 3.6-m ESO telescope at La Silla Observatory at the end of 2002. Dedicated to the search for extra-solar planets, HARPS is an instrument optimized to high precision radial velocity measurements and is expected to reach the precision level of 1 $\mathrm{m\,s^{-1}}$ with the simultaneous thorium technique.

A complete photon noise study for this instrument has been made by Bouchy et al. (2001). Fig. 1 shows the photon noise uncertainty versus the spectral type and the rotational broadening and versus the stellar magnitude in the best stellar case (T_{eff} =4500 K, $v \sin i = 0\,\mathrm{km\,s^{-1}}$) for various exposure times. This quantity is less than 1 $\mathrm{m\,s^{-1}}$ for an exposure time of 1 minute on stars with magnitude lower than 8. Typically, HARPS is expected to observe stars with magnitude 5 dimmer than CORALIE and with a better radial velocity precision.

A first selection of solar-like targets, limited to $m_V = 5.0$, gives 45 solar-like stars (27 F, 13 G and 5 K). In some cases (low $v \sin i$), stars up to $m_V = 8$ can be added to this selection. We estimate that HARPS will be fully adapted to the search and characterization of p-mode oscillations on a sample of more than 100 solar-like stars.

3. Discussion

With a single-site ground-based campaign of asteroseismology, the identification of oscillation modes could be complicated by the window of observation limited

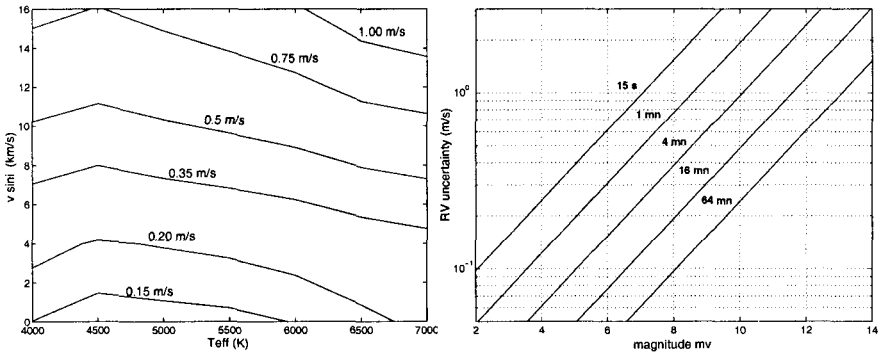

Figure 1. Radial velocity uncertainty predictions for HARPS for a flux given by $t_{exp}\,(s) = 2.512^{mV}$ (left) and versus magnitude in the best stellar case (right).

by the diurnal cycle and meteorological conditions. In order to improve the spectral window, it is necessary to develop a ground-based network of 4-m class telescopes with, for example, existing spectrograph like UCLES on the 3.9-m AAT, an updated version of UES on the 4.2-m WHT and future spectrographs like HARPS on the 3.6-m ESO and ESPADONS on the 3.6-m CFHT.

Of course, such a ground-based program is far from the expected accuracy and the objectives of the future photometric space missions like MOST, MONS, COROT and EDDINGTON. However, it is useful to conduct in the nearest years a preliminary study on solar-like stars. Furthermore, a complementary seismological Doppler study on these stars is necessary from the ground for the following reasons : 1) mode observation with higher angular degree l, 2) characterization of the Doppler amplitude of modes, 3) low sensitivity to the stellar granulation effect.

References

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