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SONG: Stellar Oscillations Network Group

A global network of small telescopes for asteroseismology and planet searches.

F. Grundahl[1], H. Kjeldsen[1,2], S. Frandsen[1], M. Andersen[2], T. Bedding[3], T. Arentoft[1], and J. Christensen-Dalsgaard[1]

[1] Department of Physics and Astronomy – University of Aarhus, Ny Munkegade, 8000 Århus C, Denmark. e-mail: `fgj@phys.au.dk`
[2] Astrophysikalisches Institut Potsdam An der Sternwarte 16 D-14482 Potsdam Germany
[3] School of Physics A28 University of Sydney 2006 Australia

Abstract. One of the limiting factors in current asteroseismic investigations of solar type stars is the limited time coverage of single-site observations. To remedy this problem we are studying the design of a global network based on 16–24 inch telescopes equipped with fibre fed high–efficiency and high–resolution spectrographs and iodine cells. These will measure precise radial velocity time-series for stars in order to carry out asteroseismic analyses and search for low-mass planets in short period orbits around our targets.

1. Science

In recent years the study of solar-like oscillations using radial-velocity time-series observations has progressed very much by the high precision now obtained by the most sophisticated instrumentation (Butler et al. 2004; Santos et al. 2004)).

We have initiated a project, SONG (Stellar Oscillations Network Group) which aims at constructing a new network which can provide long-term and continuous coverage of interesting solar-like targets for asteroseismic observations. The main scientific goal is to study solar-like oscillations using radial velocity time series. Since this will yield precise velocities it will also be possible to search for planets around the target stars.

Send offprint requests to: F. Grundahl

2. Instrumentation

In order to ensure a high duty cycle for both northern and southern targets a total of eight network nodes is required. A possible location of these is shown in Fig. 1. At each node the instrumentation will consist of a single high-resolution ($R \sim 100000$) spectrograph equipped with an iodine cell. Light from 3-4 telescopes – each with an aperture of 50cm – will feed the spectrograph via optical fibres, one from each telescope. The spectrograph will be optimized for iodine work only and thus it only need to cover the wavelength range between 4800Å and 6200Å making it possible to simplify its design. The optical coatings will be optimized for this wavelength region as well.

An important point about the use of a network and several telescopes per site is that the near continous coverage of objects allow us

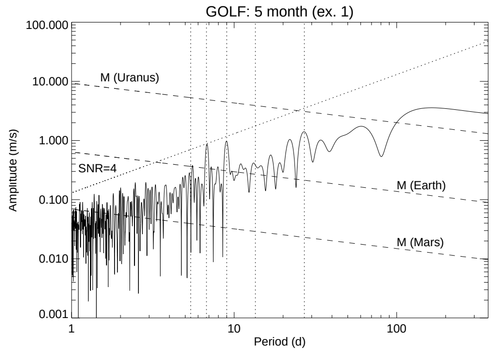

Fig. 2. Example of detectability of low mass planets with SONG.

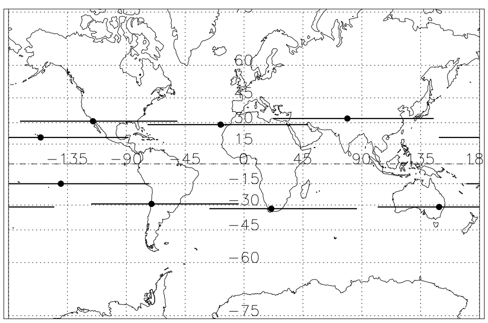

Fig. 1. Illustration of possible network node locations. Each node is shown as a small black circle. The horizontal bars extending from each node show the observability for an equatorial object with a zenith distance less than 70 degrees.

to monitor the velocity stability of the instruments such that zeropoint drifts can be kept very low. This is crucial for detecting low-mass planets.

By scaling the results of Kjeldsen et al. (2005) for α Cen B obtained with UVES on the VLT using an iodine cell we estimate the following measurement precision per observing minute: 0.5m/s at $V = 0$ and 5.0m/s at $V = 5$. For this it has been assumed that the network spectrographs have a total efficiency which is 3 times higher than UVES – this is possible mainly because UVES has a slitwidth of only $0\farcs3$ in order to achieve its highest resolution. A small telescope allows the use of a fibre diameter significantly larger, thereby reducing slit-loss.

3. Capabilities of SONG

Based on the velocity precision estimates we have carried out simulations of long time-series observations to estimate the network performance. For this the GOLF time-series from SoHO was used with noise added acording to that for a star of given magnitude. Fig. 2 show the amplitude spectrum obtained from a 5 month long time-series observation of a star brighter than $V = 6$. For stars brigher than this limit the limiting factor for planet detection is noise from granulation. We see that it will be possible to detect a planet with the mass of the Earth in a 4 day period orbit with s signal–to–noise ratio of 4. For the study of solar-like oscillations the amplitude spectra will be granulation noise limited for stars brighter than $V = 3.5$, and since we are measuring in velocity it is possible to detect $l = 3$ modes, which cannot be done with photometric measurements.

More information about SONG can be found at: `http://astro.phys.au.dk/SONG`

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