EPSC Abstracts
Vol. 6, EPSC-DPS2011-240, 2011
EPSC-DPS Joint Meeting 2011

The *SOPHIE* search for northern extrasolar planets

F. Bouchy (1,2), G. Hébrard (1,2), X. Delfosse (3), S. Udry (4), A.M. Lagrange (3), L. Arnold (2), I. Boisse (5), X. Bonfils (3), K. DeBondt (3), R. Diaz (1,2), A. Eggenberger (3), D. Ehrenreich (3), T. Forveille (3), C. Lovis (4), C. Moutou (6), F. Pepe (4), C. Perrier (3), D. Queloz (4), A. Santerne (6), N. Santos (5), D. Ségransan (4)
(1) Institut d'Astrophysique de Paris, UMR7095 CNRS, Université Pierre & Marie Curie, 98bis Bd Arago, 75014 Paris, France
(2) Observatoire de Haute-Provence, CNRS/OAMP, 04870 St Michel l'Observatoire, France
(3) Institut de Planétologie et d'Astrophysique de Grenoble, Université J. Fourier, CNRS, 38041 Grenoble cedex 9, France
(4) Observatoire de Genève, Université de Genève, 51 Ch. des Maillettes, 1290 Sauverny, Switzerland
(5) Centro de Astrofísica, Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
(6) Laboratoire d'Astrophysique de Marseille, 38 rue Frédéric Joliot-Curie, 13388 Marseille cedex 13, France

Abstract

The *SOPHIE* consortium conducts since end of 2006 a large and key program of search for exoplanets by radial velocities using the spectrograph *SOPHIE* installed on the 1.93-m telescope of Observatoire de Haute Provence (France). Characteristics and performances of the spectrograph are presented, including the last improvement provided by the installation of octagonal optical fibers. The different subprograms led by the consortium and devoted to study and characterization of exoplanets are presented and illustrated by several results obtained these last semesters and recently.

1. Introduction

The vast majority of 550 known exoplanets have been found thanks to radial velocity measurements. Far from beeing an old-fashioned technique, Doppler measurements have illustrated these past years their capabilities extending the exoplanet search around a wide variety of stars. The sensitivity of this technique continuously increases, opening the possibility of exploring the domain of low-mass planets down to a few Earth masses, to discover and characterize multiple planetary systems, to perform long-term surveys to find true Jupiter-like planets, to establish the planetary nature and to characterize the transiting candidates of photometric surveys. Doppler surveys for exoplanet require high-precision spectrographs and a significant amount of telescope time over a long duration.

2. The *SOPHIE* Spectrograph

The *SOPHIE* spectrograph [1][2] has been in operation since October 2006 at the OHP 1.93-m telescope. To benefit from experience acquired on *HARPS* [3] and take the limitations of the *ELODIE* spectrograph into account [4], *SOPHIE* was designed to obtain precise radial velocities with much higher throughput than its predecessor.
SOPHIE is a cross-dispersed, environmentally stabilized echelle spectrograph dedicated to high-precision radial velocity measurements. Its CCD detector records 39 spectral orders covering the wavelength domain from 3872 to 6943 Å. The spectrograph is fed through a pair of 3"-wide optical fibers for the high-resolution mode (R = 75000), and another pair for the high-efficiency mode (R = 40000, allowing one magnitude gain). For each fiber pair, one aperture is used for starlight, whereas the other one, 2' away from the first one, can be used either on a Thorium-Argon lamp for tracking spectrograph drift, or on the sky to estimate background pollution, especially in case of strong moonlight. Apart from thermal precautions, the key point for stability is the encapsulation of the dispersive components in a constant pressure tank. This solution stabilizes the air refractive index sensitive to atmospheric pressure variations. With such a concept, typical intrinsic drift of the spectrograph is less than 3 $\mathrm{m\,s^{-1}}$ per hour.

The radial velocity precision obtained on stable stars is about 4-5 $\mathrm{m\,s^{-1}}$ over several semesters. This limitation is mainly caused by guiding and centering effects on the fiber entrance at the telescope focal plan and the insufficient scrambling provided by the fiber and the double scrambler. The installation of new octagonal fibers, which have the properties to perfectly scramble the beam, will be installed and tested during summer 2011. First results of the scientific validation phase of this upgrade will be presented at the meeting.

3. The *SOPHIE* exoplanet program

The *SOPHIE* consortium program is devoted exclusively to study and characterizing exoplanets, in continuation of a planet-search program initiated 17 years ago with the *ELODIE* spectrograph and to complement the *HARPS* program performed in the southern hemisphere. We started a key program on October 2006 with the aim of covering a large part of the exoplanetary science and constraining on the formation and evolution processes of planetary systems using about 60 nights per semester with *SOPHIE* at the 1.93-m telescope. Our observing strategies and target samples are optimized to achieve a variety of science goals and to solve several important issues: 1) mass function of planets below the mass of Saturn, 2) planetary statistical properties to constrain the formation and evolution models, 3) relationships between planets and the physical and chemical properties of their stars, 4) detection of exoplanets around nearby stars, allowing space and ground-based follow-up, 5) deep characterization of known transiting exoplanets including long term follow-up and spectroscopic transit analysis.

All these aspects are treated through the five complementary subprograms:
- High precision search for super-Earths,
- Giant planets survey on a volume-limited sample,
- Search for exoplanets around M-dwarfs,
- Search for exoplanets around early-type main sequence stars,
- Long-term follow-up of *ELODIE* long period candidates.

A review of results obtained from these five subprograms will be presented at the meeting as well as the strategy for the next coming years.

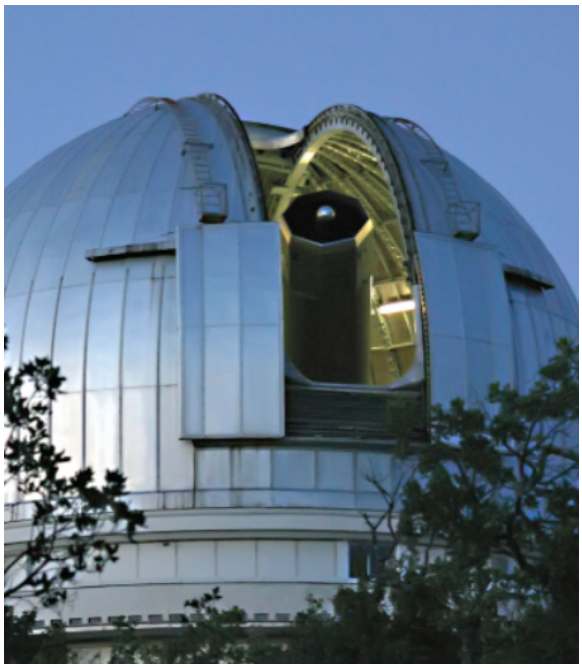

Figure 1: 1.93-m telescope of Observatoire de Haute Provence

References

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