The asteroseismic ground-based observational counterpart of CoRoT

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Abstract. We present different aspects of the ground-based observational counterpart of the CoRoT satellite mission. We give an overview of the selected asteroseismic targets, the numerous instruments and observatories involved, and the first scientific results.

Keywords: asteroseismology, high-resolution spectroscopy, multi-colour photometry, spectropolarimetry, variable stars
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COROT'S SIMULTANEOUS GROUND-BASED OBSERVATIONS

The CoRoT/SWG Ground-Based Observations Working Group is undertaking huge efforts to complement the CoRoT space data (e.g. [1]) with simultaneous ground-based data[1] to guarantee an optimal scientific outcome of the asteroseismic part of the CoRoT mission. Activities are strongly focused on selected targets in the seismo core program, but include also the characterisation of stars in the exoplanet fields.

The ground-based counterpart of CoRoT's seismo core programme

Several CoRoT asteroseismic targets are selected for a simultaneous follow-up from the ground. Table 1 gives an overview of the δ Sct, γ Dor, β Cep, Be, Ap, and solar-like stars, eclipsing binaries (EB) and double-lined spectroscopic binaries (SB2) that were observed between December 2006 and June 2009 (i.e. time of writing) using several high-resolution spectrographs, multi-colour photometers and/or spectropolarimeters. To ensure an unraveling of the beat frequencies multi-site campaigns have been set up, including several Large Programs. The instruments involved are listed in Table 2. The complementary character of each project with respect to the CoRoT space data can be summarised as follows:

- High-resolution spectroscopy (Panel A of Table 2): From time-series of high-resolution spectra valuable information on the mode parameters (ℓ, m) can be extracted. Figure 1 illustrates the number of spec-

[1] Observations are performed at the following observatories: European Southern Observatory (ESO), La Silla and Paranal, Chile; Observatoire de Haute Provence (OHP), France; Calar Alto Astronomical Observatory (CAHA), Spain; Mount John University Observatory (MJUO), New Zealand; Observatorio Roque de los Muchachos (ORM), La Palma, Spain; Konkoly Observatory (KO), Hungary; Observatorio de Sierra Nevada (OSN), Spain; Observatorio San Pedro Mártir (OSPM), Mexico; Observatoire du Pic du Midi (OPM), France.

tra obtained so far.

- Multi-colour photometry (Panel B of Table 2): Time-series of multi-colour observations provide additional information on the degree ℓ of the modes, that cannot be derived from the CoRoT 'white' lightcurve.
- Spectropolarimetry (Panel C of Table 2): By means of spectropolarimetric measurements, signatures of magnetic fields are detected and studied.

Characterisation of asteroseismic and binary targets in CoRoT's exoplanet fields

The CoRoT exoplanet fields reveal a goldmine of new variable stars. However, the CoRoT lightcurves are not sufficient to characterize them. Therefore the following observing programs have been set up (Panel D of Table 2):

- Multi-Object spectrography: Spectra are obtained for many exoplanet field stars simultaneously, which are used to identify the pulsator type and to determine fundamental stellar parameters.
- Wide Field Camera: The complete exoplanet fields are observed in the Strömgren $uvby-\beta$ filters. The colours provide information on the physical parameters and reddening of the targets.
- Multi-colour photometry: Johnson BVRI colours are observed for selected newly discovered δ Sct and RR Lyrae variables in the exoplanet fields, to characterize the stars and to provide additional information on the degree ℓ of the modes.

FIRST SCIENTIFIC RESULTS BASED ON THE OBSERVATIONS

For the first scientific results obtained from the ground-based observations presented here, we refer, e.g., to the following publications:

- HD 49434: [2]
- HD 180642: [3]
- HD 50844: [4]
- HD 49330: [5]
- HD 50209: [6]
- HD 181231: [7]
- HD 51106 and HD 50747: [8]
- HD 50846 (AU Mon): [9]
- Wide Field Camera data: [10]

Also, analysis results have been presented at several conferences, e.g. [11], [12], [13], [14], [15], [16], [17].

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TABLE 1. Overview of the targets, their variable type, and the CoRoT field. The last three columns indicate if the star is observed spectroscopically (if yes, the amount of spectra is given), photometrically and/or spectropolarimetrically.

Target	Type	Field	# spectra	Photom.	TBL	Target	Type	Field	# spectra	Photom.	TBL
HD 50844	δ Sct	IR01	231	yes	-	HD 50170	solar-like	LRa2	-	-	yes
HD 50846	EB	IR01	32	-	-	HD 50870	δ Sct	LRa2	209	yes	-
HD 49330	Be	LRa1	127	-	yes	HD 51452	Be	LRa2	145	-	yes
HD 49933	solar-like	LRa1	-	yes	yes	HD 51193	Be	LRa2	145	-	yes
HD 49294	δ Sct	LRa1	86	yes	-	HD 52265	solar-like	LRa2	-	-	yes
HD 49434	γ Dor	LRa1	1487	yes	-	HD170987	solar-like	LRc2	-	-	yes
HD 50209	Be	LRa1	68	-	yes	HD171586	Ap	LRc2	40	-	-
HD 50747	SB2	LRa1	37	-	-	HD171834	γ Dor	LRc2	1347	yes	-
HD 50773	Ap	LRa1	-	-	yes	HD172189	δ Sct	LRc2	176	yes	-
HD 51106	SB2	LRa1	33	-	-	HD175726	solar-like	LRc2	-	-	yes
HD174936	δ Sct	LRc1	-	yes	-	HD181420	solar-like	LRc2	-	-	yes
HD174966	δ Sct	LRc1	365	yes	-	HD174532	δ Sct	SRc2	329	-	-
HD180642	β Cep	LRc1	248	-	-	HD 44195	hybrid	LRa3	-	yes	-
HD181231	Be	LRc1	72	-	-	HD 44283	δ Sct	LRa3	-	yes	-
HD181555	δ Sct	LRc1	694	yes	-	HD170580	β Cep	LRc4	98	-	-

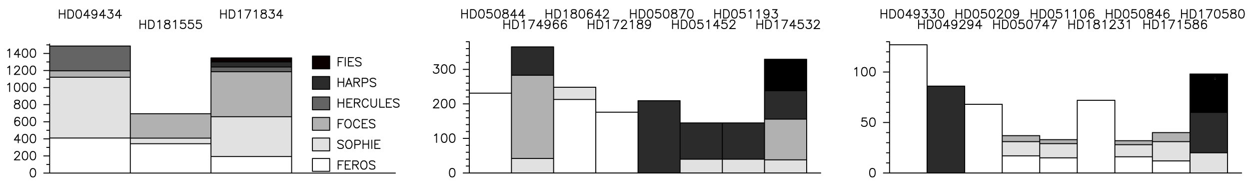

FIGURE 1. Accumulative histograms indicating the number of spectra obtained (from December 2006 to June 2009) for selected δ Sct, γ Dor, β Cep, Be and Ap stars with FEROS, SOPHIE, FOCES, HERCULES, HARPS and FIES. The colour code is explained in the left panel. Note the different scales on the Y-axis for the different panels. The target names are given above each column.

TABLE 2. Observatories, instruments and telescopes involved in the CoRoT ground-based campaign. The characteristics of the instruments (e.g. spectral resolution R, photometric filters) are given, as well as the amount of observing time awarded to the project. In the last column the P.I.s of the observations are listed.

Obs.	Instrument	Telescope	Characteristics	# nights per semester/year	P.I.
A. High-resolution spectrographs:					
ESO	FEROS	2.2m ESO/MPI	R∼48,000	2006-2008: 15n per sem.	E. Poretti
OHP	SOPHIE	1.93m	R∼70,000	2007-ongoing: 20n per sem.	P. Mathias
CAHA	FOCES	2.2m	R∼40,000	2007-ongoing: 10n per sem.	P. Amado
ESO	HARPS	3.6m	R∼80,000	2008-2010: 15n per sem.	E. Poretti
MJUO	HERCULES	1.0m McLellen	R∼35,000	2007-ongoing: 15-30n per sem.	K. Pollard
ORM	FIES	2.56m NOT	R∼67,000	2009: 4n per sem.	K. Uytterhoeven
ORM	HERMES	1.2m Mercator	R∼85,000	2009: 6n per sem.	K. Uytterhoeven
B. Multi-colour photometers:					
OSN	Danish photometer	0.9m	$uvby-\beta$	2006-ongoing: 75-100n per yr	S. Martín-Ruiz, E. Rodríguez
OSPM	Danish photometer	1.5m	$uvby-\beta$	2006-ongoing: 18n per yr	E. Poretti
KO	CCD	1m RCC	BVRI	2006-ongoing: 14-30n per sem.	M. Paparó
C. Spectropolarimeter:					
OPM	NARVAL	TBL		2007-ongoing: 15n per sem.	C. Catala
D. Multi-object spectrograph and (Wide Field) CCD cameras:					
ESO	FLAMES	VLT UT2		2008-ongoing: ∼3n per sem.	C. Neiner
ORM	WFC	2.5m INT	$uvby-\beta$	2007-ongoing: 2-4n per sem.	I. Ribas, C. Maceroni, L. Balaguer, K. Uytterhoeven
KO	CCD	1m RCC telescope	BVRI	2008-ongoing: 14-30n per sem.	M. Paparó