Report on the second run of the ESO Large Programme

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EXECUTIVE SUMMARY. The ground–based spectroscopic observations complementing the COROT ones have continued in June and July 2007. The log of the observations, a few preliminary results, tips for the next observers and a look to the future are given. The following actions/items are emphasized:

1. The FEROS spectroscopic runs on the CoRoT targets of LRc1 have been characterized by very good weather; the observers also demonstrated an excellent attitude. The spectra have been fully reduced. Long timeseries are available for LPV analysis on HD 181555 (δ Sct), HD 180642 (β Cep), and HD 181231 (Be);
2. There are several other targets in the IR01, SRc1, and LRc1 fields whose spectra are available to the CoRoT PIs;
3. Taking full advantage of the Chilean winter nights, observations of pulsating stars which were visible in the first and last hours of the nights ("filling" programs) have been performed;
4. Owing to the increasing quantity of ground–based data, the publication strategy needs to be defined. Some ideas are reported in Sect. 7.

1. Introduction

The ground–based spectroscopic monitoring of the CoRoT target continued from May to July 2007, taking full benefit from very good weather. Since there were several possible candidates belonging to SRc1 and LRc1, we have been forced to do a target selection. In particular, the δ Sct star HD 174966 (SRc1) has been dropped from ESO and OHP programmes.

Observations have been carried out in the framework of:

1. Large Programme (LP) at ESO-La Silla with the FEROS@2.2 instrument (10+5 nights). The targets HD 181555 (δ Sct), HD 180642 (β Cep), and HD 181231 (Be) have been observed;
2. Normal Programme at Calar Alto (CAHA) with the FOCES instrument. In addition to 10 nights in visiting mode, other nights have been allotted in service mode to compensate for the bad weather. 285 spectra have been collected on HD 181555 and 119 spectra on HD 174966, from May 21 to June 10. A detailed report has been distributed by P. Amado;
3. Normal Programme at Observatoire Haute Provence with the SOPHIE instrument at the 1.92 m telescope (12 nights from 13 to 25 June). The targets HD 181555 and HD 180642 have been observed and the spectra (66 and 36, respectively) have been reduced.

The goal of this second internal report is to circulate useful informations about the ESO observations within the team, also keeping the record of the observations. We remind you that Anne-Laure Huat (Meudon Observatory) and Pedro Amado (IAA Granada) will be the observers for the December (from 18th to 28th) and January (from 9th to 14th) runs with FEROS.

We also stress that the 2.2m telescope is not furthermore offered for ESO proposals, being limited to Chilean ones. We have to think about new strategies to secure observations after the end of our Large Programme (last runs in June-July 2008), since we can not simply resubmit an updated Large Proposal.

2. The spectroscopic data of stars observed in December 2006–January 2007

The spectra collected at ESO, OHP, and CAHA have been fully reduced (by M. Rainer, P. Mathias and P. Amado, respectively), put in the archive at Merate Observatory and made available upon request to all the CoIs. For each star we provide the calibrated and the normalized spectra as two different files. Some bugs in the reductions of the spectra of the first run have been solved. To give the possibility to the whole SG-BOWG to be familiar with the data format, the README file accompanying the spectra is listed in the Appendix.

Table 1 lists the observed targets and the (chair)persons at work on the specific stars. We also note:

1. A wide collaboration has been undertaken on the scientific case of the γ Dor variable HD 49434. The star has been observed not only at ESO and OHP, but also at Mt. John Observatory (New Zealand). Therefore, Karen Pollard and collaborators joined P. Mathias and K. Uytterhoeven. The

New Zealand team will also warrant observations in the 2007–08 season, both giving a full coverage in longitude and a simultaneous monitoring with the CoRoT one;
2. Extensive multicolour *uvby* photometry is available for HD 49434 and HD 50844. It has been performed at Sierra Nevada (responsible: S. Martin) and San Pedro Martir (responsible: E. Poretti) observatories during several years;
3. Preliminary reports on the frequency content of the δ Sct star HD 50844 have been prepared by Mantegazza & Rainer and by Zima. It is reasonable to assume that owing to the short duration of the IR01, it will be necessary to merge the results from space photometry, high–resolution spectroscopy and multicolour photometry to propose a satisfactory model of HD 50844.
4. We note that the PIs of the analysis of the CoRoT time-series are not yet designed for HD 50844 and HD 292790.

Table 1. Targets observed in 2006–07 European winter. The responsible(s) of the analysis of the spectroscopic data are listed in the last column.

Star	Type	Investigators
HD 49434	γ Dor	Mathias and Uytterhoeven
HD 50209	Be	Floquet and Hubert
HD 50747	Am, SB2	Dolez
HD 50844	δ Sct	Mantegazza, Rainer and Zima
HD 50846	Be, EB	Fremat and Desmet
HD 51106	Am, SB2	Dolez
HD 292790	F8	**Single Spectrum available**

3. The ESO runs in June and July 2007

Observations at ESO have been secured by Fabien Carrier (from June 25th to July 4th) and Juan Gutierrez–Soto (from July 16th to 21st). Table 3 summarizes the logs of both runs. The setup was the same as that listed in the Appendix of the First Report. We remind that the instrument must be set in the Object+Sky mode, the ADC (Atmospheric Dispersion Compensator) must be enabled, the binning is 1x1 in the fast readout and low gain modes. Overheads for focusing are confirmed to be around 10 min plus pointing. δ Circini≡HD 135240 has been used to better define the blaze function.

It is advised to use the same OBs in both parts of the ESO runs and to identify stars with their HD numbers.

3.1. Observing cycle

The targets for the ESO observations have been the β Cep star HD 180642, the fast rotating δ Sct star HD 181555, and the faint Be star HD 181231. Considering the expected periods, the specific requests from the different teams, and the calculated exposure times, we established the following sequence:

```
HD 181555 - HD 181555 - HD 180642 - HD 181555 -
HD 181555 - HD 180642 - HD 181555 - HD 181231 -
HD 180642 - ...
```

We estimated that the above sequence lasted 130-min, thus ensuring 5 spectra of HD 181555, 3 spectra of HD 180642 and 1 spectrum of HD 181231, and that the cycle was repeated 4–5 times during the night.

Both observers have been very clever in following the cycle and adapting it to the particular circumstances (e.g., by decreasing the exposure times in very good seeing conditions). As a result, the requested number of spectra has been largely exceeded despite the bad weather periods and the calibration overheads.

3.2. Length of the nights

The nights of the first 10-d run were about 11^h50^m long; however, the observer could stay on the COROT field only for 8^h40^m. We should take into account that the observations can be performed from to -4^h20^m to $+4^h20^m$. At these extreme hour angles the airmass of the CoRoT fields is 2.8, i.e., the critical telescope limit.

The 25-26 June night started at UT 22^h49^m≡ST 12^h25^m and ended at UT 10^h41^m≡ST 00^h20^m. The nights of the second 5-d run were about 10^h45^m long and the CoRoT field has still been observed for the maximum time.

3.3. Weather statistics

In total we had 130^h at our disposal to observe the COROT field. There have been four nights (29-30 June, 4-5, 16-17, and 20-21 July) partially disturbed by clouds and one half night (26-27 June) lost due to strong wind from the North. Therefore, we lost only 5^h for meteorological reasons, though some of the spectra collected on the poor quality nights can be useless. However, in presence of clouds the observers increased the exposure times of HD 181555 and, if necessary, dropped the faintest star, HD 181231, from the sequence. In such a way, they minimized the impact of bad weather on the data quality. During both runs the seeing was generally very good (Table 3), much better than during the January–February 2007 run.

3.4. Signal–to–noise ratio evaluation

The S/N values listed in Tab. 3 are the average between the values evaluated in the 5750-5760 Å and 4902-4910 Å ranges by using the MIDAS command `@@snr`. F. Carrier noted a bad pixel at 4901 Å.

4. The physical parameters of HD 181555

This primary CoRoT target has an unclear history regarding its physical parameter determination. Poretti et al. (2003, A&A 406, 203) report a main–sequence position on the basis of preliminary *uvby* photometry. Later, Poretti et al. (2005, AJ 129, 2461) report $M_V = 1.20$, $T_{\rm eff}$=7200 K, $\log g$=3.5, and [Fe/H]=–0.1 dex from a new set of *uvby* photometry. In the text it is noted "... This star shows the greatest discrepancy on its position in the CMD: the star was on the ZAMS assuming HIPPARCOS parallax (<10 mas) and uncertain *uvby*β photometry (see Fig. 8 in Paper I), but the new, more accurate set of *uvby*β photometry moves it toward a much more evolved status (...) The Strömgren M_V can be reconciled with the HIPPARCOS value admitting an error of 0.065 mag in the β value, which seems huge for such an index. On the other hand, parallax measurement could be inaccurate owing to two objects which appear very close to HD 181555 in the Guide

Star Catalogue." We note that very fast rotation and evolved status are in contradiction to each other.

A very reliable determination has been obtained by I. Ribas (priv. comm.) from IR photometry: $T_{\rm eff}$=7132±75 K. He also obtained R=1.91±0.20$R_\odot$. Such a value confirms the result from the new set of $uvby\beta$ photometry.

5. GAUDI stars

The current GAUDI spectra of some stars belonging to the SRc1 and LRc1 fields have a low S/N. Therefore, new ones have been obtained (Table 2). The PIs of these stars are invited to contact E. Poretti to receive them.

Table 2. Targets belonging to LRc1 and SRc1 observed in June-July 2007 at ESO. One spectrum has been taken for each star. These spectra are of better quality (see S/N column) than those currently available in the GAUDI archive

Star	V	Sp. Type	S/N
HD 174987	9.05	A2	200
HD 175294	7.40	K0	260
HD 175542	9.06	A0	200
HD 175558	8.30	F0	200
HD 175767	9.16	F0	200
HD 175679	6.16	G8III	>300
HD 181907	5.82	G8III	>300

6. Backup and filling programs

The very long nights gave the possibility to observe other targets at the beginning and at the end (*filling programs*). Therefore, the CoIs have been asked to propose some stars for those parts of the nights, i.e., having R.A. around 12^h (sunset stars) and 24^h20^m (sunrise stars). These stars have also been observed during the half night disturbed by strong wind from the North. A backup program (in case of continuous strong wind from North) has also been prepared, but not used.

The filling programs were related to the variable star classes which will be observed by CoRoT, both in the core and in the additional programs. The specific requirement for their selection was a scientific case based on a few spectra, not a time-series. The observation of these stars will allow to better define the physical conditions favouring the onset of the different types of pulsation. Thus, they are intended as a complementary work in the scientific background of the CoRoT mission. The very good weather and the excellent planning of the night prepared by the observers allowed us to monitor all the proposed stars in a, hopefully, very profitable way for the proponents. The following classes have been observed:

B stars; P.I.: M. Briquet: 22 stars. Three (HD 128585, HD 143309, HD 142883) have been observed 3 times, 9 have been observed twice (HD 80573, HD 80859, HD 84809, HD 118285, HD 152635, HD 152511, HD 11462, HD 104841, HD 131168), 10 have been observed once (HD 163254, HD 79039, HD 78405, HD 85012, HD 86659, HD 205879, HD 89688, HD 109026, HD 132200, V1008 Cen). The total number of spectra is 37.

Be stars; P.I. A.M. Hubert: 21 stars. Five have been observed three times (UU PsA, η PsA, 71 Cet, VV PsA, HD 20340), 7 have been observed twice (HD 99771, HD 100199, KP Mus, V843 Cen, V916 Cen, HD 103574, DG Cru), 9 stars have been observed once (HD 14850, HD 93683, V353 Car, HD 98001, HD 97792, HD 99146, HD 140926, HD 139790, HD 119682). The total number of spectra is 38.

HADS stars; P.I. E. Poretti: nine stars (AI Vel, VX Hya, V703 Sco, BQ Ind, RS Gru, BS Aqr, SX Phe, HD 224852, V Ind) have been observed from 3 to 11 times. The total number of spectra is 61.

ϵ Lup; P.I. K. Uytterhoeven: this very bright close binary system with two β Cep components has been observed 21 times.

7. Data reduction, analysis and publication policy

A general overview of the ground–based activities has been presented by E. Poretti at the SAIt (Società Astronomica Italiana) Congress, see astro-ph/0610459. A more detailed discussion of some, still preliminary, results has been made by K. Uytterhoeven at the HELAS meeting "Helioseismology, Asteroseismology and MHD connections" (Göttingen, August 20-24); the related contribution for the proceedings has been submitted.

No decision has been officially taken about the publication policy of the results of the ground–based observations. At the moment, the following statements can be fixed for each star:

HD 50844: a common paper discussing ground-based data (high–resolution spectrosocpy and multicolour photometry) and space photometry seems the best solution. There is no indication about the PI of the CoRoT data.

HD 49434: as expected, the frequency content of the photometric data from ground is very difficult to extract, owing to periodicities close to 1 d. The star will be observed by CoRoT in the incoming LRa1 and simultaneously in spectroscopy (ESO, OHP, CAHA, and New Zealand). The CoRoT PI is P. Mathias, who is also co–responsible of the spectroscopic ground–based analysis.

HD 181555: a common paper discussing high–resolution spectroscopy and space photometry seems the best solution. This δ Sct star is a fast rotator and the merging of photometric and spectroscopic outputs is probably the only way to model it. There is no indication about the PI of the CoRoT data.

HD 180642: a large amount of ground–based data has been collected with the collaboration of different teams. One or two papers based on multicolour ground–based photometry and on spectroscopy could be prepared. The CoRoT data PI is C. Aerts.

Be stars (HD 50209, HD 50846, HD 181231): HD 50209 has been observed by CoRoT in the IR01 and from ground at ESO+OHP; it is a Be star in a binary system. HD 50846 has been observed at ESO in the first run and it will be re–observed in the third one, simultaneously with the CoRoT monitoring in the LRa1. HD 181231 has been simultaneously observed by CoRoT and from ESO. The CoRoT PIs are A.M. Hubert and C. Neiner.

We stress once more that the FEROS spectra of HD 292790, HD 174987, HD 175294, HD 175542, HD 175558, HD 175767, HD 175679, and HD 181907 are available (Tab. 1 and Tab. 2).

Table 3. Log of the observing runs at ESO with the FEROS@2.2m instrument. The number of spectra and the S/N range are indicated for every star on each night.

Night	HD 181555	HD 180642	HD 181231	Seeing	Notes
	V=7.5	V=8.3	V=8.7		
Exp. Time	450 sec	900 sec	900 sec		
June 25-26	21	13	4	$0\farcs8$–$1\farcs8$	Clear all night
	[145-230]	[145-226]	[134-179]		
June 26-27	8	4	2	$1\farcs4$–$2\farcs2$	Strong wind, backup programme
	[100-205]	[170-195]	[150]		during 1st part of the night
June 27-28	23	16	4		Clouds, but not during COROT time
	>200	>200	>200		
June 28-29	22	15	5	$0\farcs6$–$1\farcs1$	Clouds, but not during COROT time
	[110-245]	[140-240]	[100-200]		
June 29-30	19	12	4	<$0\farcs8$	Clouds
	[190-240]	[190-250]	[180-220]		
June 30-July 1	28	20	6	<$0\farcs9$	Clear all night
	[190-240]	[190-250]	[190-220]		
July 1-2	30	22	6	$0\farcs4$–$0\farcs7$	Clear all night
	[180-240]	[190-250]	[190-220]		
July 2-3	29	22	6	$0\farcs5$–$1\farcs4$	Clear all night
	[190-240]	[200-250]	[200-210]		
July 3-4	28	19	5	$0\farcs5$–$1\farcs5$	Clear all night
	[170-230]	[190-250]	[190-200]		
July 4-5	19	12	4	$0\farcs7$–$1\farcs7$	Clouds
	[100-240]	[100-220]	[90-190]		
July 16-17	19	10	6	$0\farcs7$–$1\farcs5$	Thin clouds
	[140-250]	[120-220]	[120-200]		
July 17-18	22	12	6	$1\farcs0$	Clear all night
	[170-250]	[160-240]	[160-200]		
July 18-19	25	13	5	$0\farcs5$	Clear all night
July 19-20	26	14	5	$0\farcs6$–$0\farcs7$	Clear all night
	[180-230]	[170-280]	[200]		
July 20-21	24	9	4		Observations through clouds
	[80-240]	[200]	[150-210]		
Total	**343**	**213**	**72**		

This is a brief explanation of the files that can be found in the database
of the COROT ground-based observations.

The use of the data for publications must be agreed with the PIs
(E. Poretti for ESO, P. Mathias for OHP, P. Amado for Calar Alto).

For each observed target with FEROS there are two ASCII files, .dat and .nor.

The database contains also spectra taken in poor conditions,
so take care of their S/N (see header of the individual spectra).

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The names of the files have this structure:
Target_YearMonthDay_HourMinute.dat/.nor
where HourMinute is the UT start of the exposure.
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Both .nor and .dat files have 15 headerlines with the following information:

Name of the target
Date of the observation
UT start of the observation
Exposure time in seconds
Name of the original raw file
Proposal code and name of the P.I.
Observer and reducer
Heliocentric Julian Date at mid-exposure
Barycentric radial velocity correction in km/s
Mean signal-to-noise ratio*
Specific comments
Information found in each column.

* = the mean signal-to-noise ratio is computed for the FEROS spectra as the
median of the pixel-by-pixel signal-to-noise ratio on the wavelength range
(5805,5825), while for the SOPHIE spectra it is automatically estimated by the
reduction pipeline.

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Files .dat

These are the results of our semi-automated reduction pipeline.
The format is an ASCII table with five columns, with the following
content:

First column: the barycentric corrected wavelengths, in Angstroms.
Second column: the non-normalized flux, in arbitrary units.
Third column: the normalized flux*. The normalization is
the result of an automated procedure and can be unreliable
in some regions.
Fourth column: the signal-to-noise ratio**.
Fifth column: the number of the echelle order.

* = the normalized spectra are useful only for a quick look, but can not be
used for scientific purposes, because they are the results of an
automated normalization procedure.
** = the signal-to-noise ratio given is the exact value for each pixel,
computed from the counts, the gain and the read-out noise.

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Files .nor

These are the results of an automated normalization and orders merging procedure. The information stored in the .nor ASCII files are:

First column: the barycentric corrected wavelengths, in Angstroms.
Second column: the normalized flux, with the echelle orders merged.

The normalized spectra are useful for a first quick look but the following problems have to be kept in mind:

a) the normalization procedure is unreliable in case of fast rotation, binarity or the presence of emission lines.
b) The merging of the orders is not always accurate when strong absorption lines are found near the border of the orders. This problem results from the lack of continuum on both sides of the lines and from the low signal-to-noise ratio near the border, which is even more lowered by the absorption. In such cases part of the spectrum is truncated. Unfortunately, both the Halpha and the Hbeta lines are found near the border of the order in the FEROS spectra.

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splitordfiles.f and order.py

Either of these programs can be used to split a *.dat file into its different orders. For each order a separate file will be created.

e.g. HD049434_20070105_0200.dat observed with FEROS will be split into 39 files, with names HD049434_20070105_0200_??.dat

The programs require as input file an ASCII list with the names of the spectra. To run the program order.py, just type:

```
python order.py
```

To run the program splitordfiles.f, type the following sequence of commands:

```
g77 splitordfiles.f -o splitordfiles
./splitordfiles
```