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The first year of CoRoT in orbit

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Abstract. After the successful launch of the CoRoT (COnvection, ROtation and planetary Transits) satellite we are living in a new era of asteroseismology and extrasolar planet search. Regarding asteroseismology, the space photometry is simultaneously complemented by high–resolution spectroscopy and multicolour photometry from ground. Preliminary results on the γ Dor star HD 49434 and on the β Cep star HD 180642 are shown. We also report on the first two detections of planetary transits.

Key words. Stars: individual: HD 49434 - Stars: individual: HD 180642 - planetary systems

1. Introduction

The satellite CoRoT (COnvection, ROtation and planetary Transits) is giving us the possibility to disclose the interiors of stars, opening a new era (Baglin et al., 2006). The goal of CoRoT (successfully launched on December 27th, 2006) is twofold:

1. the study of the stellar interiors (the asteroseismic part);
2. the search for extrasolar planets (the exoplanetary part).

The mission has a unique instrument: a 27–cm aperture telescope equipped with two CCDs for each scientific case. To achieve the asteroseismic goal, CoRoT is performing high-precision long-duration (5–6 uninterrupted series of 150 d each) photometry. The selected CoRoT direction of pointing is a double–cone centered at $\alpha = 6^{\rm h}50^{\rm m}/18^{\rm h}50^{\rm m}$ (galactic Anticenter/Center), $\delta = 0°$. The radius of each CoRoT eye is 10°. For a more detailed description of the instrument and the latest news of the performances of the satellite we refer to http://smsc.cnes.fr/COROT/. Details about the Italian contribution to the CoRoT mission can be found in Poretti et al. (2007a) and Poretti et al. (2007b).

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2. The first asteroseismic targets

A fair number of pulsators (δ Sct, γ Dor, β Cep and Be stars) are among the CoRoT targets. The CoRoT photometry allows the detection of low–degree ℓ–modes, at an amplitude level three orders of magnitudes smaller than the current one. However, to obtain a full view of the stellar interior, including the rotation, the complete frequency spectrum is necessary. Figure 1 illustrates how in moderate and fast rotators the spectral resolution translates into spatial resolution, as a result of a one-to-one correspondece between the position on the stellar surface and the position in the line pro-

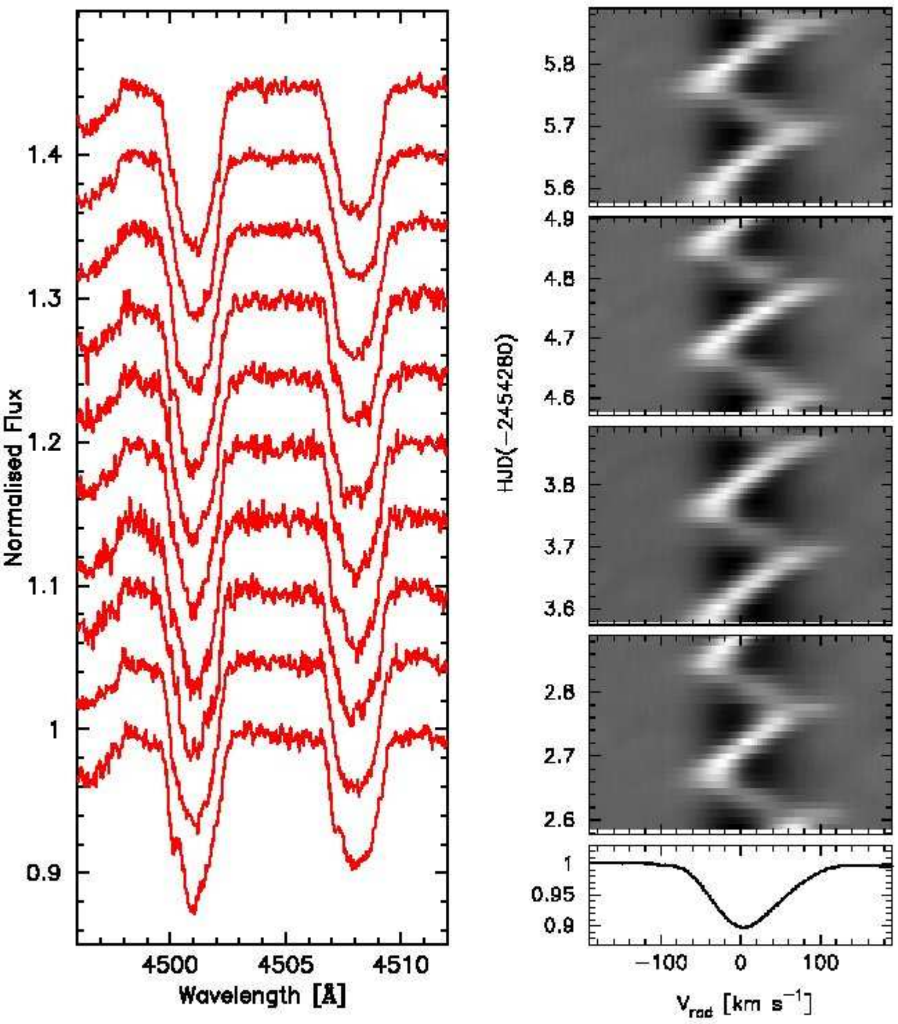

Fig. 1. Examples of results obtained on CoRoT targets from ground–based spectroscopic observations. *Left*: A selection of FEROS spectra of HD 49434, centered on the Ti II 4501.273 Å and Fe II 4508.288 Å profiles. The observed line-profile variations are a combination of several high-degree modes. The spectra are offset for clarity. *Right*: Grayscale representations of the cross-correlated FEROS spectra of HD 180642, for the nights of 1–4 July 2007. The residual profiles with respect to the average profile (given at the bottom) are plotted in a shade of gray: black (white) represents a negative (positive) residual flux. The dominant mode is a radial one, while low–amplitude nonradial modes have also been detected and identified.

file. In combination with rotation, non-radial modes produce line-profile perturbations visible as "moving bumps" in the line profiles. Depending on the travel direction of the wave, the bump will cross the line profile from red to blue, or from blue to red. A detailed analysis of the line-profile variations allows us to identify corresponding modes as the shape and the behaviour of the variations depend on the properties of the modes. For this reason a photomet-

Table 1. Asteroseismic targets observed in the framework of the ESO Large Programme LP178.D-0361.

Star		Type	CoRoT run
HD	50844	δ Sct	IR01
HD	50747	Triple system	IR01
HD	50846	Be, EB	IR01
HD	51106	Am, SB2	IR01
HD	181555	δ Sct	LRc1
HD	180642	β Cep	LRc1
HD	181231	Be	LRc1
HD	49434	γ Dor	LRa1
HD	49330	Be	LRa1
HD	50209	Be	LRa1

ric space mission as CoRoT must be accompanied by coordinated ground–based spectroscopic observations. In particular, we successfully applied for an ESO Large Programme, starting with ESO Period 78 (October 2006–March 2007). Several observing runs with the FEROS intrument at the 2.2m ESO-MPI telescope at La Silla (Chile) allowed us to monitor asteroseismic targets spectroscopically. Table 1 lists the targets observed in the first three ESO periods and belonging to the CoRoT Initial Run (IR01), to the first Long Run in the Center direction (LRc1) and to the first Long Run in the Anticenter direction (LRa1).

The spectroscopic data are needed to complement the photometric results, particularly for the identification of the azimuthal order m. This became very clear from the study of the β Cephei star θ Oph for which seven modes could be identified from combining spectroscopy and photometry. which led to tuning of the core overshoot distance ($0.44 \pm 0.07\ H_p$) and a proof of rigid rotation inside this massive pulsating binary (Briquet et al., 2007). The CoRoT target HD 180642 is providing a very similar approach at a much higher level of accuracy (Fig. 1, right panel; Briquet et al, in preparation). As a further extension to the γ Dor case, the identification of the main mode of pulsation of HD 195068 has been possible only through the Fourier Doppler Imaging technique (Jankov et al., 2006). A similar analysis has been recently carried out to investigate the CoRoT target HD 49434 (Fig. 1, left panel), with the detection of many high–degree modes (Uytterhoeven et al., A&A, submitted).

In most cases, the spectroscopic observations will also give access to the low–degree modes, via radial-velocity measurements, especially for stars with small $v \sin i$ values (Mantegazza & Poretti, 2002). In these cases, the ratio of mode amplitudes measured by radial-velocity variations and by CoRoT photometric variations will be used to identify the modes and to study their dynamics in the star's outer layers.

In all these recent examples, it would have been impossible to identify the $m-$values of the modes, a requirement for seismic modelling, from the photometric data alone.

3. The two exoplanets discovered by CoRoT

The reduction of the exoplanetary data is a delicate exercise since some unavoidable instrumental effects are superposed to the stellar variability. Therefore the detection of planetary transits is the final output of a long process. Notwithstanding these difficulties, two planetary transits have been announced immediately after the end of the observations. Barge et al. (2008) discovered in the IR01 data a Jupiter-size planet around a G0V star. Follow up spectroscopic observations (Barge et al., 2008) allowed to estimate the physical and orbital parameters of the star and confirmed the presence of the planet. CoRoT-Exo-1b is a giant planet with a large radius and very low mean density, and this can be consistent with a metal deficient planet (Burrows et al., 2007); this finding agrees with the apparently low value of the metallicity of the parent star. A second planet (CoRoT-Exo-2), orbiting around a very active G star, was discovered by Alonso et al. (2008) in the LRc1 data. In both cases the scatter outside the transit phases reaches a few part of 10^{-4} in flux unit (3.0 and 1.1, respectively). Table 2 lists the main parameters of the planetary systems whose discovery has been announced so far.

The photometric data of CoRoT-Exo-1 span a total duration of 55 d (IR01), with sampling of 512 s in the first 30 days, and

Table 2. Parameters of two planetary systems discovered by CoRoT in its first year in orbit (Barge et al., 2008; Alonso et al., 2008).

	Exo-1	Exo-2
Orbital parameters		
Period [d]	1.509	1.743
Inclination [deg]	85.1	87.8
Star's parameters		
Mass [$M_\odot$]	0.95	0.97
Radius [$R_\odot$]	1.11	0.90
$T_{\rm eff}$ [K]	5950	5625
Planet's parameters		
Mass [$M_{\rm jup}$]	1.03	3.31
Radius [$R_{\rm jup}$]	1.49	1.46
$T_{\rm eff}$ [K]	1898	1537

32 s in the rest of time. The photometric data of CoRoT-Exo-2 span a total duration of 152 d (LRc1), with sampling of 512 s in the first week, and 32 s in the rest of time. The change in time sampling was possible thanks to the "alarm mode", which detected two candidates planet hosts during the observations. CoRoT observed 36 and 78 planetary transits of CoRoT-Exo-1b and CoRoT-Exo-2b, respectively. All the data were cleaned from anomalous countings due to the crossing of the South Atlantic Anomaly and to changes of the CCD masks. These features have been noted by apposite flags during the reduction of the raw data operated by the CoRoT Data Center. Further details can be found in Barge et al. (2008) and Alonso et al. (2008).

4. Conclusions

The scientific output of the observations of the CoRoT satellite and of the complementary ground–based activities starts to rise. We are looking forward to get the best scientific return from this huge (scientific, financial and manpower) project that the astronomical community is undertaking.

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