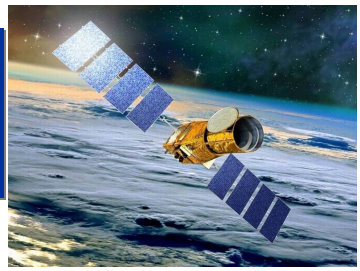
Close Binaries in the CoRoT space experiment



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COROT

Science
- CORE PROGRAMS: Astroseismology & Transiting Exo-planets
- Parallel Science (= Additional Programs, **AP**)

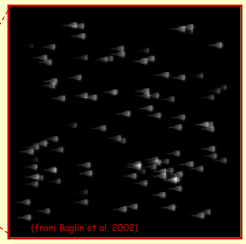
by high precision **(1-100 ppm)** photometry & continuous runs **(up to 150^d)** on the same field.

INSTRUMENTATION

- A 28 cm telescope (Focal length: 1200 mm, FoV 3.8°) in a polar inertial orbit [Altitude: 896 km; Period: 6174 s; Inclination: 90°]
- Focal plane: two pairs of 2kx2k CCDs (one for each core program)

Astroseismology field
- Defocused field
- 5 windows/CCD available
- Targets: 5.7 < V < 9.5
- time sampling 32^s (1^s)

Field example



OBSERVING MODES:

Inside the **CoRoT "Eyes":**
- **Long Runs (150^d)** field is constrained by seismology primary target
- **Short Runs** (10-20^d), anywhere inside eyes

Exoplanet field
- 6000 windows/CCD
- targets: 11.5 < V < 16.5
- time sampling 8^m (32^s)
- prism in front of the CCDs

➡ **very low resolution spectra**

= three band photometry for brighter stars.

CoRoT Eyes:

Circular fields of ~10° radius + orbital drift starting the second year (4'/y in α)

BINARIES IN COROT

Most **A**dditional **P**rograms (AP) will use the Exoplanet field where a few hundred windows will be dedicated to APs. CoRoT "eyes" contain a few hundred known eclipsing binaries*, but only few of them will fall in each of the 3.4□ fields. Many new binaries will be discovered by the planet transit search.

*) Known binary target lists in the CoRoT eyes are available from http://thor.ieec.uab.es/binteam/

EXPECTED NEW DISCOVERIES

Table 1 and Fig.1 (Maceroni and Ribas 2006) show an estimate of the expected number of binaries per Exo-field, by means of the Besançon Galaxy model (Robin et al. 2003). The constraints were:
- Spectral type G-M (Exoplanet search will privilege late-type stars) and Luminosity class V-IV,
- magnitude range V=10.5-15.5.

Eclipsing binaries were assumed to be 0.5 -1% of all monitored stars (as suggested by surveys as Vulcan,STARE, OGLE).
The results shall be multiplied by a minimum of five Long Run (150^d) fields + 10 Short Run (20^d) ones.
A total of several hundreds to ~ thousand binaries is expected.

TABLE 1

Sp	EBs per field (3.4 □)
G0-G4	7.2 - 31.1
G5-G9	3.2 - 10.5
K0-K4	2.9 - 11.9
K5-K9	0.35 - 0.8
M0-M4	0.09 - 0.17

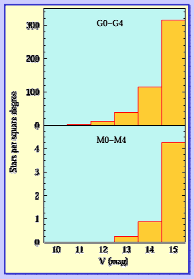


Fig.1 Computed distribution in magnitude of stars in the Anticenter (winter) field for some spectral types.

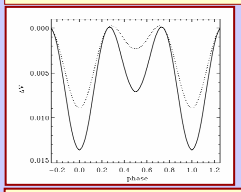
All CoRoT binaries will have an excellent photometry (10^{-3} – 10^{-4} precision, or better if a bright binary is selected as target in the astroseismology field).
The sampling (8^m Exo-, 32^s Seismo-field) and the high duty cycle (~94%) will provide complete phase coverage and monitoring on a long time baseline.

SCIENTIFIC PROGRAMS

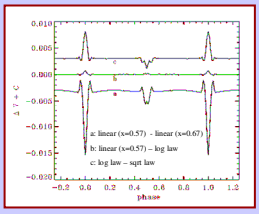
The community involved in CoRoT and AP on binaries has assumed the (informal) organization of a **"Binary Thematic Team" (BTT)**, coordinated by the authors. The BTT approved scientific programs (two applications for data of known binaries and archival data) for the first CoRoT runs (2006/2007) are aimed to: (Maceroni & Ribas 2006 for details)

- **derive basic stellar parameters** (masses, radii) for "well-behaved" systems, i.e. preferentially detached binaries. Exquisite, better than 1% accuracy is expected.
- study **second–order effects in the light curves** (limb & gravity darkening)

Measurable 2nd order effects



Typical effect of gravity darkening in a low inclination (i=65°), detached system (P=2.41^d, mass ratio q=0.8, fractional radii r_p=0.18 and r_s=0.15, luminosity ratio 0.36.Solid curve β=1.0, dotted: β=0.32



The difference in magnitude between synthetic light curves obtained with different assumptions on limb darkening (different values of the coefficient of linear law, or different laws). System parameters are the same of the figure above, but i=86°. The difference between linear laws is obtained changing the value of the coefficient. The difference between functional forms (square root or logarithmic law) is instead between laws whose coefficients correspond to the primary component temperature (8184 K).

- study the **manifestations of stellar activity** in late -type components by eclipse tomography, and derive information on rotational period and differential rotation (from spot migration).
- **Astroseismology in suitable eclipsing binaries**: advantage: masses, radii, inclination, and therefore the rotational velocity are known. In close binaries tidal frequencies could be excited. A proposal has been submitted (De Ridder, Aerts, Maceroni, Ribas) for a pointed Short Run in the Seismology field, dedicated to the binary IM Mon, the brightest binary in the CoRoT Eyes (which could therefore become the system with the best ever measured light curve).

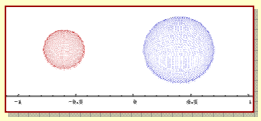
FIRST RUNS

The few known binaries which will be observed during the first year (two short and two long runs) can be found on the BTT Webpages, most data will anyhow come from newly discovered systems.

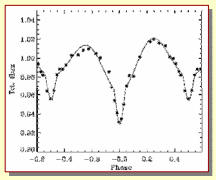
An interesting candidate target for a Short Run in the seismology field (still TBD) is the surprisingly poorly known, though quite bright, system **IM Mon** (V=6.54, P =1.19d), which is formed by two early-type (B5-B8 V) stars in a close - but still detached - configuration. IM Mon is, as well, a double-lined spectroscopic binary (Pearce 1951) with estimated component masses ~9 and 6$M_\odot$, it might therefore host a β Cep and/or a SPB pulsator.

The solution of the only available (poor) light curve by Gum (1951) indicates a close but detached configuration. Suggestion of Intrinsic variability has been reported by Sanyal & Sinvhal (1964) with a period ≅ ½ P_{orb} (tidal induced oscillations?). The primary star is close to corotation: according to CoRoT- Gaudi spectroscopic database the its vsin i = 120 kms^{-1} (i.e. the rotational period is longer than orbital one in for parallel orbit & rotation axes and R_p> 3 $R_\odot$)

The analysis of such a system is certainly challenging but can be quite rewarding.



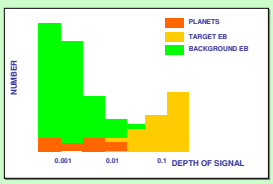
The solution with WD-Phoebe of the rather poor B light curve of IM Mon (Gum 1951) is shown (right) to illustrate that the best fit is obtained with a detached configuration (left). The light variation seems to be due to a superposition of an ellipsoidal variation and a low inclination eclipse (i=68°)



BINARIES AS A CONCERN

The results from the CoRoT light curve simulator for the exoplanet field (Auvergne et al. 2003) shows that background eclipsing binaries will be the main concern for the exo-planet transit detection, Fig. 4. The main source of false alarms will be eclipses from a binary system diluted by a foreground star (in agreement with Brown 2003).

Most planet 'impostors' will be revealed by detailed light curve and color analysis (eg. detection of second eclipse or color dependence of the transit), in a few cases photometric or spectroscopic follow-up will be necessary.



The number of planets and binaries vs eclipse depth according to Corotlux simulation (Guillot & Pont 8th Corot Week, see Corot webpages)

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- Robin, A. C., Reyle', C., Derriere, S. & Picaud, S. 2003, A&A, 409, 523
- Sanyal, A.& Sinvhal, S. D. 1964, The Observatory, 84, 211

CoRoT LINKS

- CoRoT: corot.oamp.fr
- BEST survey: berlinadmin.dlr.de/Missions/corot/caesp/best.shtml
- GAUDI database: sdc.laeff.esa.es/gaudi

CoRoT BTT

thor.ieec.uab.es/binteam