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Five Years of Exoplanet Observations with the CoRoT Space Observatory

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Abstract

The CoRoT space observatory was launched at the end of 2006 and has been delivering scientific data for over 5 years. Here we give an overview over the most relevant results from CoRoT's exoplanet detection program.

1. The CoRoT Mission

CoRoT is a mission with a shared dedication to exoplanet studies and to asteroseismology. It was constructed under leadership of the French space agency CNES with several international contributors (Austria, Brazil, Germany, Spain and the European Space agency ESA). The mission was initially scheduled for a 3-year flight time, but was then extended by 3 years until April 2013, with a further extension of 3 years currently foreseen. Its basic layout is that of an afocal telescope with 27cm aperture, and two sets of CCD detectors in slightly different focal planes, which are dedicated to asteroseismology and to exoplanets, respectively. A bi-prism in front of the exoplanet CCDs permits a measurement of the brighter targets in three colours red, green and blue. In the exoplanet focal plane, about 12000 targets within a field of view of 1.5° by 3° can be observed simultaneously with a cadence of 32 sec, though most data are downloaded only with a cadence of 512 sec. During 2009, however, the available field of view got cut to half, due to the failure of a CCD detector. CoRoT observations consist of 'Long Runs' of 2-5 months duration that are primarily devoted to exoplanet detection and to asteroseismology studies, and of 1-6 week long 'Short Runs', mostly for its additional science program.

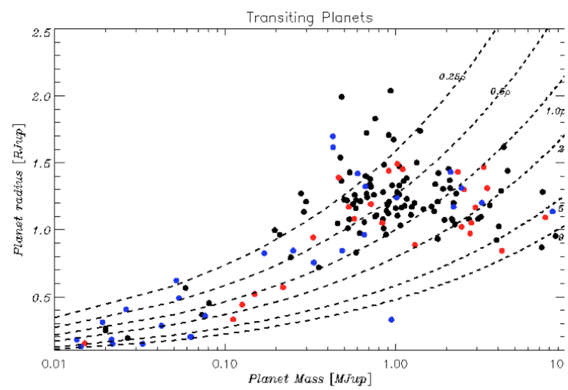

Figure 1: Mass and radius of CoRoT planets (red dots), ground detections (black dots) and planets found by Kepler (blue dots). Space-based observations are required to probe the domain of small sized planets except for M- dwarfs.

2. Results from CoRoT

Towards the end of 2012, CoRoT is expected to have completed the observation of about 180 000 stars in its exoplanet program, having covered an area of ~ 65 square degrees in some 30 pointings. These data have led to the identification of ~ 600 candidates for transiting planets. The CoRoT Exoplanet Science Team is undertaking a detailed analysis of these data, which leads to the rejection of some candidates and the priorizing of the others for further treatment. Most of them become then targets for an intense ground-based program of spectroscopic (radial velocities and spectral typing) and photometric follow-up observations. About 400 candidates have been subject to such observations, where over 90% turn out to be false positives. Nearly all of these are caused by eclipsing binaries in some configuration with the target star.

To date, 21 planets discovered by CoRoT have been published, with several more being in various stages of analysis and publication. These planets cover the entire range in the mass-radius plane of the currently known population of transiting planets (Fig. 1). Most of them are of the 'Hot Jupiter' variety, but are among the best-characterized ones, due to the high precision of their light-curves. Also, most of them have some 'special feature' that makes them interesting. Of special mention are several low-density inflated planets (e.g. Corot-1b, 4b, 5b, 12b, 16b); some of them with relatively long periods; e.g. Corot-4b has a period of 9.2 days. Several of the Hot Jupiters (e.g. 1b, 3b, 6b, 18b) orbit stars with low metal content, which is contrary to the usual metallicity relations found by RV searches. Several of the giants are rather massive with > $3M_{jup}$ (2b, 14b, 18b, 20b), with Corot-3b having a mass ($21.6M_{jup}$) that makes its assignment between planets and brown dwarfs ambiguous. The density of some of these cases is also very difficult to explain with current planetary formation models; e.g. Corot-20b with a mass of 4.24 M_{Jup}, a radius of 0.84 R_{Jup}, and an inferred density $\varrho = 8.9 \pm 1.1$ g cm^{-3} would require a dense core with about 1000 Earth masses. The massive planet Corot-2b shows also a beautiful beating pattern in its light-curve, caused by stellar activity, which made it into a prototypical case for some similar planets later discovered by Kepler. The first temperate transiting planet that is truly Jupiter-like was also discovered by CoRoT. This is Corot-9b with a nearly circular period of 95 days and an expected surface temperature of 250K and 430K.

Lastly, there are four small planets: Three Saturn-like ones (8b and a planetary system with 24b and c), and the first confirmed terrestrial planet, Corot-7b with a radius of about $1.7R_{Earth}$. This planet has probably been the most important discovery by CoRoT, being the first one that is definitively not gaseous. With its expected surface temperature of >3000K it has become the prototype for a new class of 'Lava-Ocean' planets, short-periodic ones with a bound rotation, where the star-facing side is an ocean of molten Lava. Based on this rich return from 5 years of space-observations, the CoRoT team is currently preparing for an extension of the mission for another 3 years, until spring 2016.

It is of mention that not only the original planet discoveries are important, but maybe even more, the subsequent interpretive work and the motivation for further follow-up observations, based on these discoveries. In fact, over 80% of the currently ~250 refereed publications on CoRoT-Exoplanets are such "further works". This is where the contribution of the wider community becomes important for the legacy of the mission.