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Planet Detection Capabilities of the *Eddington* Mission

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Abstract. *Eddington* is a space mission for extrasolar planet finding and for asteroseismic observations. It has been selected by ESA as an F2/F3 reserve mission with a potential implementation in 2008-13. Here we describe *Eddington*'s capabilities to detect extrasolar planets, with an emphasis on the detection of habitable planets. Simulations covering the instrumental capabilities of *Eddington* and the stellar distributions in potential target fields lead to predictions of about 10,000 planets of all sizes and temperatures, and a few tens of terrestrial planets that are potentially habitable. Implications of *Eddington* for future larger scale missions are briefly discussed.

1. The *Eddington* mission

The *Eddington* mission is a space telescope designed for two primary goals: asteroseismic studies and extrasolar planet finding. Both goals will be achieved through the acquisition of high-precision wide-field photometry, with a temporal stability that is possible only from space. The basic design is an f/3 triple-reflecting telescope with a 1.2m diameter aperture, 0.6m^2 effective area, and a 3° diameter field of view imaged by a 20-CCD mosaic camera. The telescope will be launched into an orbit around the L2 Earth-Sun libration point, from which the entire sky is accessible for observations. The first 2 years of the mission will be dedicated primarily to asteroseismic studies, with pointings lasting up to two months to a variety of targets. The mission's second part will be dedicated to planet finding by the transit method, where the telescope will survey a single stellar field for 3 years. In total, about 500,000 stars will be surveyed by *Eddington* as potential hosts for planetary systems.

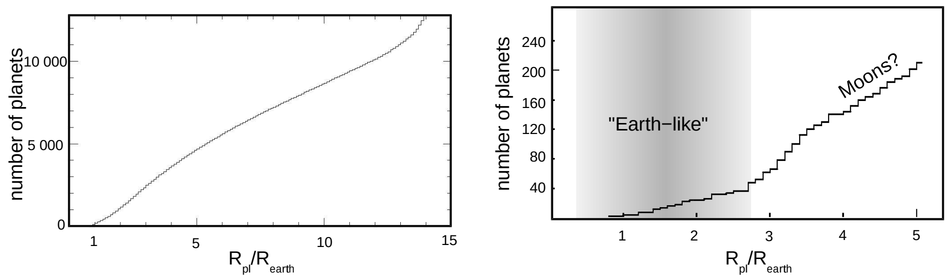

Figure 1. Expected count of detected planets. Left: all planets at any temperature or distance from the central star. Right: planets in the 'habitable zone' (250-350K). The field 'Earth-like' indicates the size range of planets suitable to support life (solid surface and ability to maintain atmosphere). Moons around larger planets may also indicate life sites.

In October 2000, *Eddington* was selected by ESA as a reserve mission for the F2/F3 launch window (2009-2013). More details about the mission can be found in the *Eddington* Assessment study (Favata et al., 2000) and in the *Eddington* web-site (http://astro.esa.int/SA-general/Projects/Eddington/). Here we will give a short overview about its planet detection capabilities.

2. Planet detections

The evaluation of *Eddington*'s planet detection performance consisted of two parts: First, we determined the kinds of planets this mission can detect, in terms of the planet's size, orbital period, and magnitude and type of central star (Deeg et al. 2000). Second, the numbers and characteristics of the detected planets were estimated. This employed Monte-Carlo simulations to fold *Eddington*'s 'detection space' with models of the Galactic stellar distribution, density and scale height (Robin & Crézé, 1986). With plausible exo-planet distributions, some 10,000 of planets of *any* size and orbital distance may be detected (Fig 1, left). Of the detected planets the vast majority are both large and in close orbits around their central stars. The most extreme ones, the 'Hot Giants', will be detected not only by transits, but also by the reflected light of their central star (even if they do not produce transits) yielding a large and nearly complete sample of these planets. For smaller planets there are fewer sufficiently bright host stars within the observational range, and they will be detected only by transits. The habitable zone corresponds roughly to orbital distances at which planetary surface temperatures of 250-350K are expected. Under the assumption that every main-sequence star has one planet in the habitable zone, a few hundred planets in that zone should be detected, among them a few tens of habitable planets with sizes of less then 2.5 R_{Earth}, which should have solid surfaces (Fig 1, right). Around larger planets within the habitable zone there exists the intriguing possibility that massive moons may be detected through the perturbations they cause on the arrival time of transit minima (Sartoretti & Schneider, 1999). These moons may themselves be harboring sites for life.

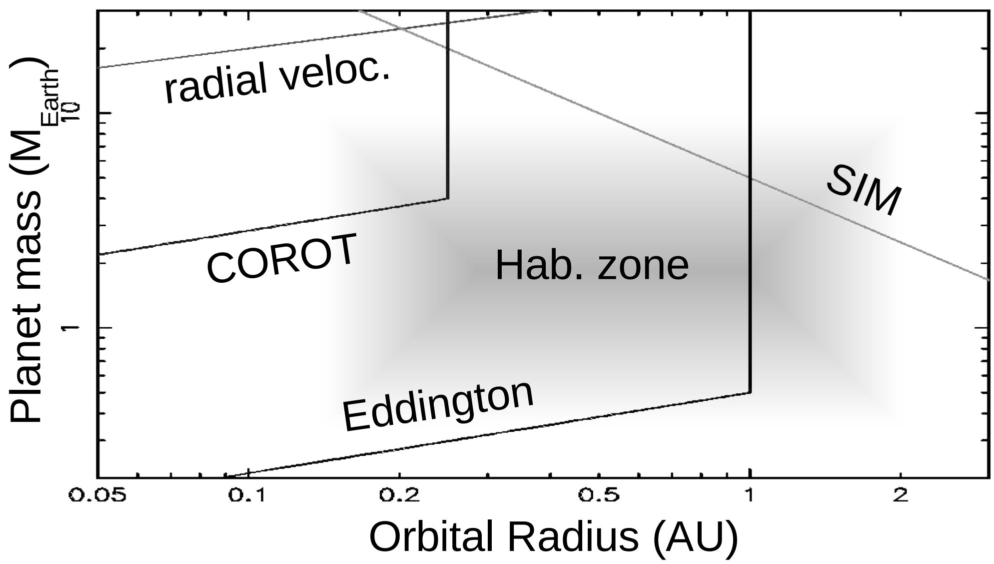

Figure 2. Comparison of planet finding capabilities of several missions. SIM's sensitivity is given for a star at 5pc distance. The limits for ground-based radial velocity searches are for a sensitivity of 1 m/s

3. *Eddington* in perspective

As Fig. 2 shows, *Eddington* is the first mission that will survey the habitable zone, and deliver a broad overview of the abundance of habitable planets in the Galaxy. This is an important step beyond missions like COROT and SIM, which may detect a few special cases of habitable planets. *Eddington* will deliver a large well-defined statistical sample of planets with known planet radii, orbital distances, and host star surface temperature and type. This is critical input for the design and target selection of future missions like Darwin and TPF that aim for detailed characterizations of Earth-like planets. *Eddington* moves us one step closer to resolving the age-old question: Are there other worlds like ours?

References

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