Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310011154

The SEE-COAST concept

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Abstract. The SEE COAST concept is designed with the objective to characterize extrasolar planets and possibly Super Earths via spectro-polarimetric imaging in reflected light. A space mission complementary to ground-based near IR planet finders is a first secure step towards the characterization of planets with mass and atmosphere comparable to that of the Earth. The accessibility to the Visible spectrum is unique and with important scientific returns.

1. Historic and context

Radial Velocity technique has been one of the most prolific method to identify extrasolar planets in the past decade (374 objects listed in http://exoplanet.eu). The comparison with our own Solar System already suggests a large diversity (in mass, eccentricity, semi-major axis ...). One of the next step is the study of exoplanet atmospheres and we must be also prepared for diversity. In that context, direct detection is required as we need to collect the planetary photons to perform for instance spectroscopy. But also, a few self-luminous planets have been already detected either from the ground and space using direct imaging, Kalas *et al.* 2008, Lagrange *et al.* 2009, and temperature and mass have been estimated from evolutionary models. In addition, direct imaging covers a parameter space that is complementary to Radial Velocity as it is more sensitive to long period. The ever-growing interest for Super Earths (telluric planets that are more massive than the Earth) has led us to propose a space telescope operated in the visible for spectroscopic and polarimetric analysis of these objects. SEE COAST (Super Earth Explorer - Coronagraphic Off-Axis Space Telescope) was first proposed to Cosmic Vision at ESA in 2007 but not selected. The science potential and requirements are briefly described.

2. Astrophysical requirements and instrumental concept

The Core Science program of SEE-COAST is to explore the diversity of planets especially focusing on Super Earths and mature Jovian planets as a goal (young/massive giants, brown dwarfs and debris disks are also part of the program). We anticipated that in the coming years Radial Velocity instruments will provided many targets accessible with SEE-COAST. Several tools are considered for this study :

• Spectroscopy: a spectral resolution of 40 to 80 in the visible and near IR (0.4-1.2 μm) is required to measure the presence of several molecular species like H_2O, O_2, CH_4, CO_2.

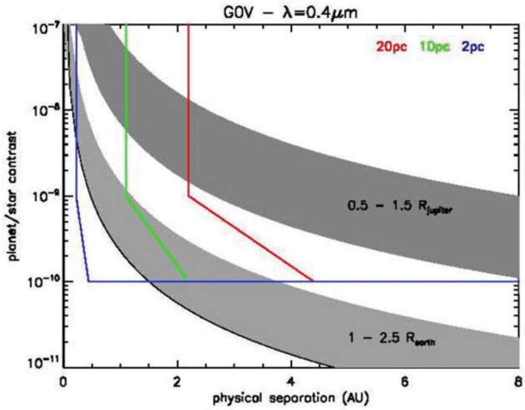

Figure 1. Star to planet contrast compared to instrumental specifications (colored curves) scaled according to wavelength and star distance (for an albedo of 0.5 and a G0V star).

If the radius is known, the albedo can be inferred from the reflected flux. Rayleigh scattering at short wavelengths gives the column density and constraints on pressure.

• Polarimetry: the polarimetric signal of jovian and telluric planets depends on wavelength and shows strong complementarities with spectroscopy to characterize planetary surfaces and clouds (Stam 2008).

• Variability: spectral and polarimetric signal are expected to vary on seasonal basis. Several visits are therefore requested to detect changes in the planetary climate.

A small 1.5m telescope in space if equipped with high contrast imaging facilities and appropriate instruments can carry out this program for nearby stars (<20 pc), nicely complementing planet finders on 8-m class telescopes for instance. It would prepare for more ambitious programs that aim to detect Earth analogs and search for trace of life. The main requirements for SEE COAST are summarized in Figure 1 which shows the theoretical contrasts in reflected light for 2 classes of planets, the giants and tellurics, compared to instrumental specifications. Telluric planets are accessible for very nearby stars within 5 AU providing small inner working angle ($2\,\lambda/D$) and large contrast (10^{-10}) are met. Even an Earth-like planet can be detected if any around the closest star. Spectroscopy will be feasible on giant planets within 10 AU for stars closer than 40 pc. The shortest wavelengths (0.4 μm) are clearly more favorable for detection (contrast curves scale linearly with λ). Young planets are also preferential targets for SEE COAST. At large temperatures (>600-800 K) the thermal emission produces a significant signal at 1.2 μm and translates into contrasts of about 10^{-9} for tellurics and 10^{-7} for giants around M stars (independently of separation). Hence, spectro-polarimetry of young objects is feasible around distant stars (50-100 pc). Instrumental aspects of the mission and technical developments are detailed in Schneider *et al.* (2009). The SEE COAST concept will be further elaborated and proposed to the next ESA Cosmic Vision call for missions.

References

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