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The ARIEL Mission Reference Sample

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Abstract

We present here an optimal list of targets observable by ARIEL (Atmospheric Remote-sensing Exoplanet Large survey), one of the three European Space Agency M4 mission candidates competing for a launch in 2026. In aprticular, we describe the assumptions made to estimate an optimal sample of exoplanets – including both the already known exoplanets and the "expected" ones yet to be discovered – observable by ARIEL and define a realistic mission scenario. The current ARIEL design enables the observation of 1000 planets during its four year mission lifetime. This nominal list of planets is expected to evolve over the years depending on the new exoplanet discoveries. Among the 1000 planets a good fraction of super-Earths and earth-sized planets will be included. While ARIEL will focus mainly on warm and hot planets, we briefly discuss its capability to study temperate planets around cool dwarfs like the ones orbiting TRAPPIST1.

1. Introduction

The main purpose of this paper is to estimate an optimal list of targets observable by ARIEL or a similar mission in ten years time and quantify a realistic mission scenario to be completed in 4 year nominal mission lifetime, including the commissioning phase. With this aim, it is necessary to consider both the already known exoplanets and the "expected" ones yet to be discovered. Here we describe the assumptions made to estimate an optimal sample of exoplanets observable by ARIEL and define the Mission Reference Sample (MRS). It is clear that this nominal list of planets will change over the years depending on the new exoplanetary discoveries. A fraction of the final sample will include alse super-earth and earth-sized planets. The TRAPPIST-1 planets are a good chance to prove what ARIEL can understand from these kind of planets. In Section 2 we show a possible sample of planet for the ARIEL space mission. In Section 3 we briefly talk about the characterisation of the TRAPPIST planets.

2. The ARIEL reference sample

The ARIEL primary science objectives call for atmospheric spectra or photometric lightcurves of a large and diverse sample of known exoplanets covering a wide range of masses, densities, equilibrium temperatures, orbital properties and host-stars. Other science objectives require, by contrast, the very deep knowledge of a select sub-sample of objects. To maximise the science return of ARIEL and take full advantage of its unique characteristics, a three-tiered approach has been considered, where three different samples are observed at optimised spectral resolutions, wavelength intervals and signal-to-noise ratios. (a summary of the three-tiers is given below in table 1). In order to estimate the number of planets in the solar system neighbourhoods we use the statistics of [Fressin et al., 2013] In Fig 1 we show a possible MRS with all the three tiers nested together. This is just one of the possible configurations for the MRS, and one would expect the ARIEL MRS to evolve in response of new exoplanetary discoveries in the next decade.

3. The TRAPPIST -1 Planets

TRAPPIST-1 is a M8V star with radius $(0.117 \pm 0.0036)\, R_{\odot}$, mass $(0.0802 \pm 0.0073)\, M_{\odot}$ and effective temperature (2559 ± 50)K [Gillon et al., 2016]. [Gillon et al., 2017] announced the discovery of 4 earth-sized planets transiting around TRAPPIST-1, in addition to the three ones previously reported by [Gillon et al., 2016]. It is the first time that 7 rocky planets are found orbiting around one star. Many experts have been arguing about the atmosphere of these planets, and their habitability, in the last few months. [Bolmont et al., 2017] studied the TRAPPIST-1 system in the XUV wavelength and they concluded that the innermost planets, TRAPPIST-1 b, c and d may have lost water during their revolution around their host star. [Wolf, 2017] showed that all planets may host liquid water on their surface, TRAPPIST-1 e being the most likely candidate. Only the spectroscopic characterisation of their atmosphere can tell us whether these planets are habitable or not. [Barstow and Irwin, 2016] demonstrated that JWST can characterise the atmospheres of the three innermost planets closest, i.e. TRAPPIST-1 b, c and d.

The aim of this paper is to study the detectability of the planetary atmospheres using the instruments on board of the ARIEL space mission. We consider three possible atmospheric configurations: solar atmosphere with $\mu = 2$, a medium water-dominated atmosphere with $\mu = 18$ and a nitrogen-rich atmosphere with $\mu = 28$.

4. Figures

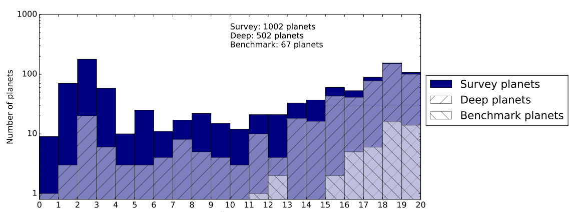

Figure 1: Overview of the ARIEL MRS, comparing the number of planets observable in the three tiers during the mission lifetime.

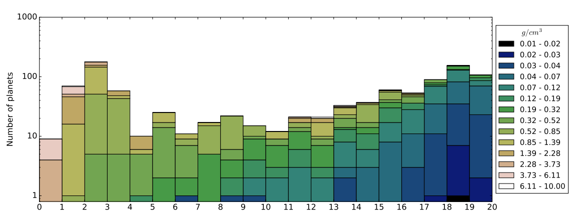

Figure 2: ARIEL MRS Tier 1 planets organised in size-bins. Different colours indicate differences in the simulated planetary densities.

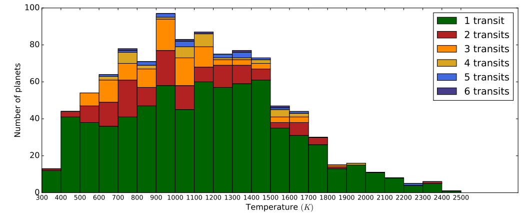

Figure 3: ARIEL MRS Tier 1 planets organised in temperature-bins. Different colours indicate the number of transits/eclipses needed to reach Tier 1 performances.

5. Tables

You will find a sample of an included table below. Please use the LaTex table environment in order to include a table.

ARIEL 3-tiers	
Survey (∼37%)	Low Spectral Resolution observations of a large sample of planets in the Vis-IR, with SNR ≥7
Deep (∼60%)	Higher Spectral Resolution observations of a sub-sample in the VIS-IR
Benchmark (∼3%)	Very best planets, re-observed multiple time with all techniques

Table 1: Summary of the survey tiers and the detailed science objectives they will address.

6. Summary and Conclusions

Here we demonstrated that the current ARIEL design enables the observation of ∼1000 planets during its four-year lifetime, depending on the physical parameters of the planet/star systems which one wants to optimise. Said optimal sample of targets fulfils all the science objectives of the mission. While we currently know only ∼200 transiting exoplanets which could be part of the mission reference sample, new space missions and ground-based observatories are expected to discover thousands of new planets in the next decade. NASA-TESS alone is expected to deliver most, if not all, ARIEL targets.

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