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An Updated Study of the Ariel Mission Reference Sample

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Abstract

Ariel has been selected as ESA's M4 mission for launch in 2028 and is designed for the characterisation of a large and diverse population of exoplanetary atmospheres to provide insights into planetary formation and evolution within our Galaxy. The analysis of Ariel spectra and photometric data will deliver a homogenous catalogue of planetary spectra which will allow the extraction of the chemical fingerprints of gases and condensates in the planets' atmospheres, including the elemental composition for the most favourable targets. It will also enable the study of thermal and scattering properties of the atmosphere as the planet orbit around the star.

Here we present a study of Ariel's capability to observe currently-known exoplanets and predicted TESS discoveries. We use the Ariel Radiometric model (ArielRad, [2]) to simulate the instrument performance and find that ∼2000 of these planets have atmospheric signals which could be characterised by Ariel. This list of potential planets contains a diverse range of planetary and stellar parameters. From these we select an example Mission Reference Sample (MRS), comprised of 1000 diverse planets to be completed within the primary mission life, which is consistent with previous studies.

1. Introduction

As of May 2019, over 3900 exoplanets have been discovered (around 3000 of which transit their stars) as well as 4500 Kepler candidate planets. Additionally, TESS is predicted to find more than 4500 planets around bright stars [3] and other surveys will find thousands more. Ariel has a designed mission life of 4 years including a 6-month commissioning and calibration phase. Additionally scheduling constraints, such as telescope housekeeping, slewing between targets and data downlink reduce the available science time. Assuming that telescope downtime corresponds to 15 %, Ariel will have 3 years of usable science time during its nominal life. Given the current instrument design, the capability of the Ariel spacecraft to meet the science goals within this time has been assessed from the population of known planets and predicted TESS detections.

2. Methodology and an Example Mission Reference Sample

An initial Ariel mission reference sample has been undertaken by choosing a very diverse, and as complete as possible, combination of star/planet parameters while minimising the number of repeated observations by selecting the planets around the brightest stars. Here, we chose three main parameters to classify the potential targets by: stellar effective temperature, planetary radius and planetary equilibrium temperature. Each parameter is split into a number of classes and Table 1 summarises these distinctions. We bin the planets by these 3 parameters, and where possible, ensure that at least 2 planets within each bin are contained within the Mission Reference Sample. Future selections will also classify planets by their density and the metallicity of the host star. These five basic characteristics are thought to have a large impact on the chemistry and thus choosing planets with a broad range in these parameters should yield a multifarious exoplanet population for study.

Adopting this strategy we obtain a distribution of planets by radius and temperature as displayed in Figure 1. Planets selected for Tier 3 are also included in Tier 2 and, in turn, Tier 1 planets incorporate all those studied in Tier 2. 10% of mission time is also reserved for the so called "Tier 4": observations that don't fit into the three tier system (e.g. phase-curves).

3. Summary and Conclusions

We find that Ariel should be able to observe ∼1000 planets over the primary mission life and this sample

Parameter	Class	Bounds
Stellar Effective Temperature	M	T_s <3955K
	K	3955K < T_s <5330K
	G	5330K< T_s <6070K
	F	6070K < T_s <7200K
Planetary Radius	Earth/Super-Earth	R_p <1.8 $R_\oplus$
	Sub-Neptune	1.8$R_\oplus$ < R_p <3.5$R_\oplus$
	Neptune	3.5$R_\oplus$ < R_p <6$R_\oplus$
	Jupiter	6$R_\oplus$ < R_p <16$R_\oplus$
	Massive Jupiter	R_p >16$R_\oplus$
Planetary Equilibrium Temperature	Temperate/Warm	T_p <500K
	Very Warm	500K < T_p <1000K
	Hot	1000K < T_p <1500K
	Very Hot	1500K < T_p <2500K
	Ultra Hot	T_p >2500K

Table 1: Bounds used to classify potential planets to ensure a varied population of planets within the Mission Reference. Sample

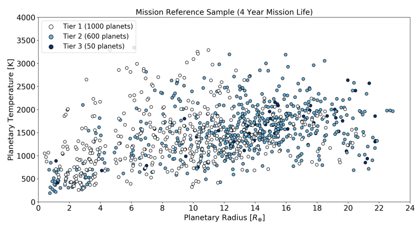

Figure 1: Example ARIEL Mission Reference Sample [1]

of the exoplanet population will have a diverse range of sizes, temperatures and stellar hosts. Trade-offs between the number and type of planets observed will form a key part of the selection process and this list of planets will continually evolve with new exoplanet discoveries replacing predicted detections. The Ariel target list will be constantly updated and the MRS reselected to ensure maximum diversity in the population of planets studied during the primary mission life.

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