Temperate exoplanets observable with Ariel : an update

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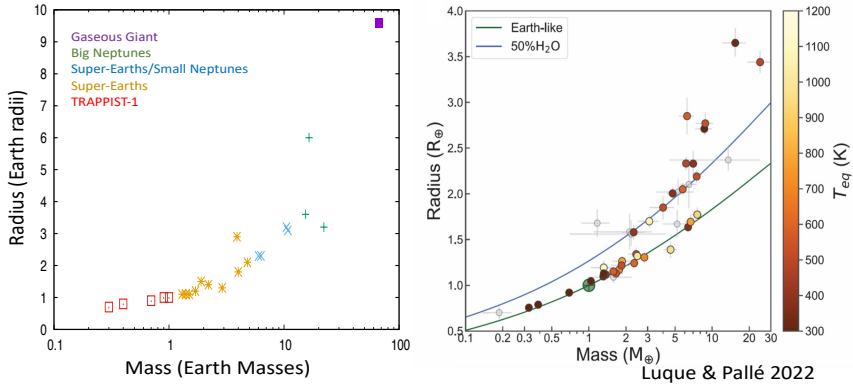
Objective of the study

- The Ariel mission was originally designed for targets with T > 500 K
- We have addressed the question: could colder targets be observable with Ariel in the Tier 2 spectroscopic mode (R = 10 at λ < 2 μm, 50 at 2 μm < λ < 4 μm, 15 at λ > 4 μm) ? Under which conditions ?
- Why study colder objects?
  - To enlarge the sample of targets available for Ariel
  - The 300-600 K range is between the ice condensation and the refractory condensation range -> less condensates are expected -> a higher transmission signal can be expected
  - Temperate targets are interesting for potential habitability
- Why the Tier 2 mode?
  - Spectroscopy is needed to constrain the nature of the atmospheric composition
- Preliminary conclusions (from our previous studies):
  - Temperate Jupiters and Neptunes around G-M stars could be observable in the T2 mode
  - 1 target identified: TOI-178 g
  - Encrenaz, Exp. Astr. 46, 31, 2018 ; Exp. Astr. 53, 375, 2022

The method

- We start from the Edwards-Tinetti list (ET22)
- We consider all candidates with Te < 550 K and T2 < 35, as calculated by ArielRa (T2 = number of transits in Tier 2 mode to achieve S/N =7)
  - Total number of candidates: 26
- T2 are calculated assuming a molecular weight of 2.3 (H_2-rich atmospheres)
- We check their revolution period P to have [P*T2] < 3 years, taking into accoun their visibility as a function of their coordinates (α, δ) (cf. ET22)
- We consider 5 classes
  - Gaseous giants(> 50 M_E) - > 3 candidates -> 1 selected
  - Big Neptunes (15 – 50 M_E) -> 4 candidates -> 3 selected
  - Super-Earths/Small Neptunes (5-15 M_E) -> 4 candidates -> all selected
  - Super-Earths/Small Neptunes (1.5 - 5 M_E) -> 8 candidates -> all selected
  - Exo-Earths (< 1.5 M_E) -> 7 candidates (probably not observable with Ariel in Tier 2 mode)

Ariel Temperate Candidates for the Tier 2 Mode: Mass vs Radius



The candidates : Gaseous giants/Big & small Neptunes (M > 5 M_E)

#	Candidate	Stellar mass (MS)	Mass (ME)	Radius (RE) T	Teq (K)	Period (days)	T2
1	TOI-1227 b	0.17	57.6	8.7	512	60	13
2	Au MIC c	0.5	22.2	3.2	479	18	13
3	TOI-3884 b	0.28	16.5	6.0	474	4.5	1
4	TOI-1231 b	0.49	15.4	3.6	339	24.2	12
5	TOI-1759 b	0.61	10.8	3.1	456	19	22
6	LTT-3780 c	0.40	6.3	2.3	363	5.3	25
7	LP-791-18 c	0.14	6.0	2.3	351	5.0	22

5, 6 and 7 are considered as sub-Neptunes in the literature
-> All targets should be observable in the Tier 2 mode of Ariel
(Martioli et al. 2022, Nowak et al. 2020, Cloutier et al. 2020, Crossfield et al. 2019)

The candidates : Super-Earths/Small Neptunes (1.5 M_E – 5 M_E)

#	Candidate	Stellar mass (MS)	Mass (ME)	Radius (RE) T	Teq (K)	Period (days)	T2
8	TOI-270 d	0.39	4.8	2.1	398	11.3	15
9	TOI-776 b	0.54	4.0	1.8	530	8.2	32
10	TOI-178 g	0.65	3.9	2.9	483	20.7	19
11	LTT 1445 A b	0.26	2.9	1.3	440	12.2	8
12	L 98-59 c	0.27	2.2	1.4	534	3.7	7
13	L 98-59 d	0.27	1.9	1.5	422	7.4	6
14	LHS 1140 c	0.19	1.7	1.2	411	3.8	28
15	LTT 1445 A c	0.26	1.5	1.1	527	3.1	9

Observation of these targets in the Tier 2 Mode will allow us to discriminate between small Neptunes and supeEarths

Results

- 7 potential targets (M > 5 M_E) are presumably H_2-rich -> OK for Ariel in T2 mode
- 8 targets are either small Neptunes or super-Earths -> T2 should be recalculated assuming a molecular weight of 18 g/mol (for H_2O-dominated atmosphere) or 44 g/mol (for CO_2-dominated atmosphere)
- Exo-Earths are probably not observable with Ariel, as a heavy molecular weight is expected (T2 should be recalculated for 18 g/mol and 44 g/mol) -> The TRAPPIST-1 system is not expected to be observed in the T2 mode

Future work

- Run ArielRad with molecular weights of 18 g/mol (H_2O) and 44 g/mol (CO_2) in the case of super-Earths/small Neptunes
- Evaluate the detectability of the candidates in the different cases
- For the most favorable targets, calculate synthetic spectra for different atmospheric compositions, including the possible effect of clouds
- Evaluate the uncertainties on Teq and T2 (in particular: there are strong variations on Teq in the different databases -> strong effect expected on T2)