ARIEL

Investigating the Signatures of Planetary Formation

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on behalf of the ARIEL "Planet Formation" Working Group

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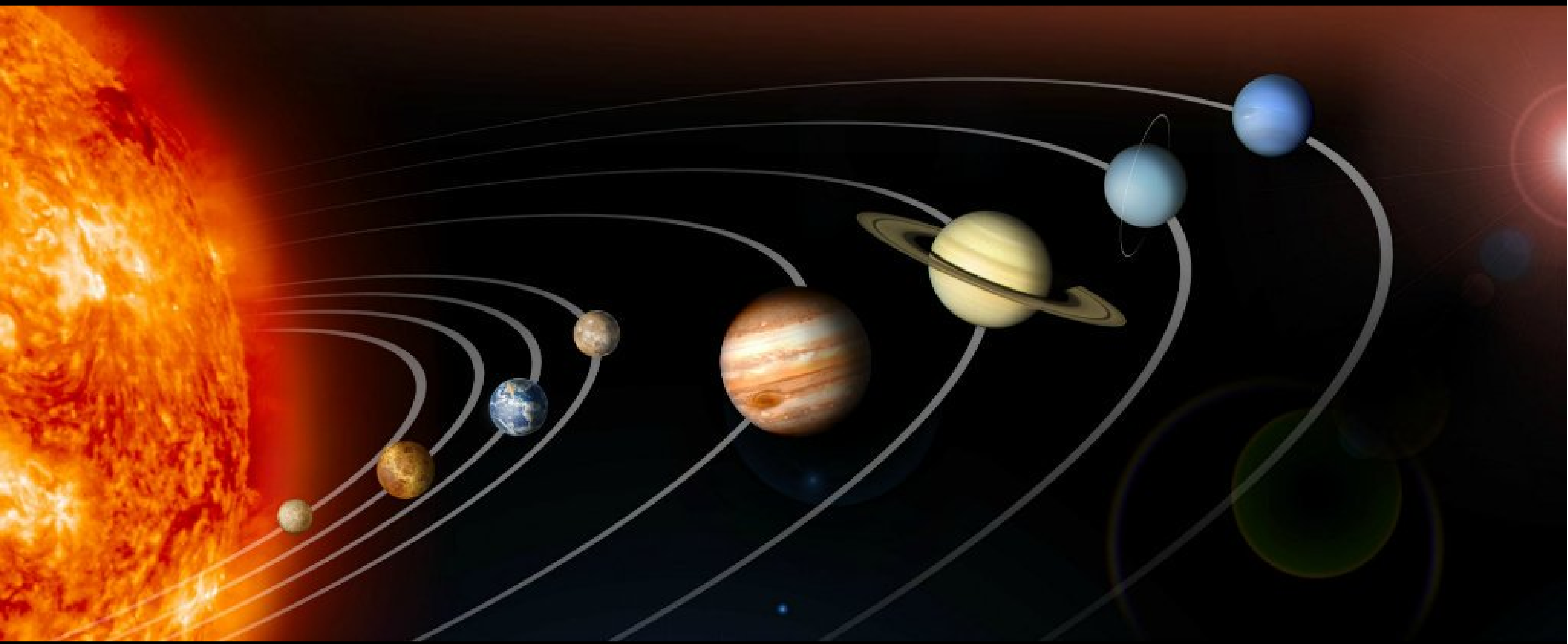
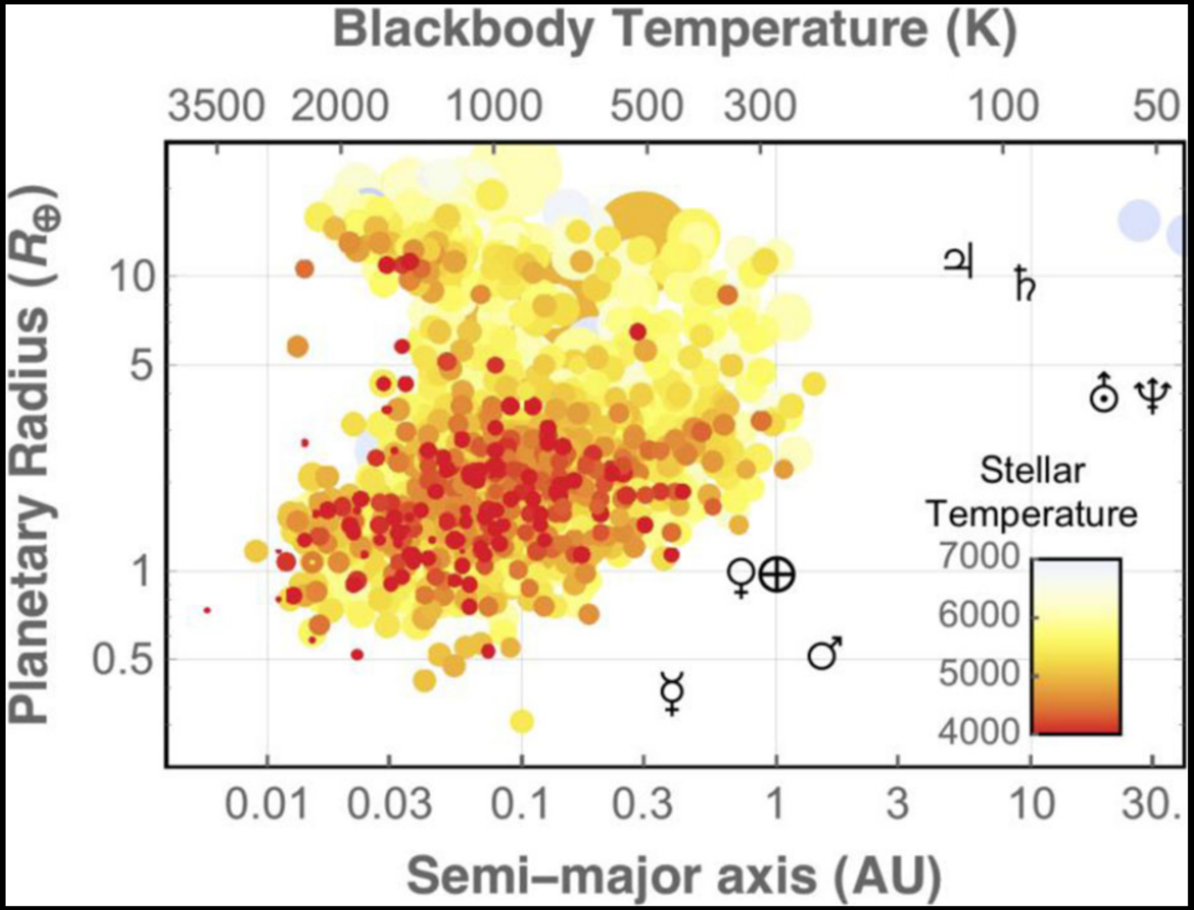
Planetary Formation and the Solar System

The **classical view**, derived from the observations of the Solar System, was that planetary formation was a **local, orderly process** that produced regular and stable planetary systems with the different kinds of planets possessing characteristic and quite **different mass ranges**.

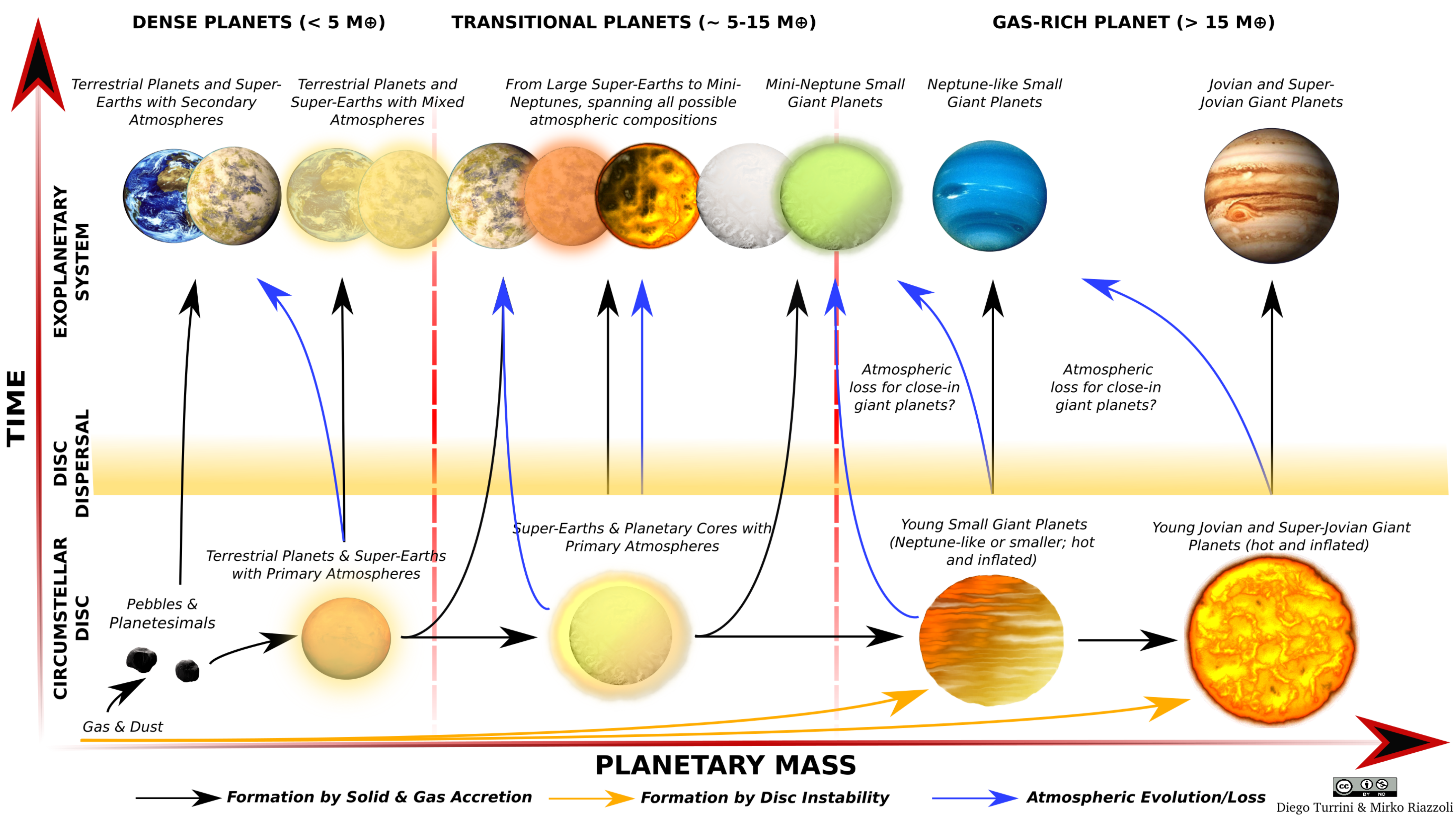


Planetary Formation and Exoplanets

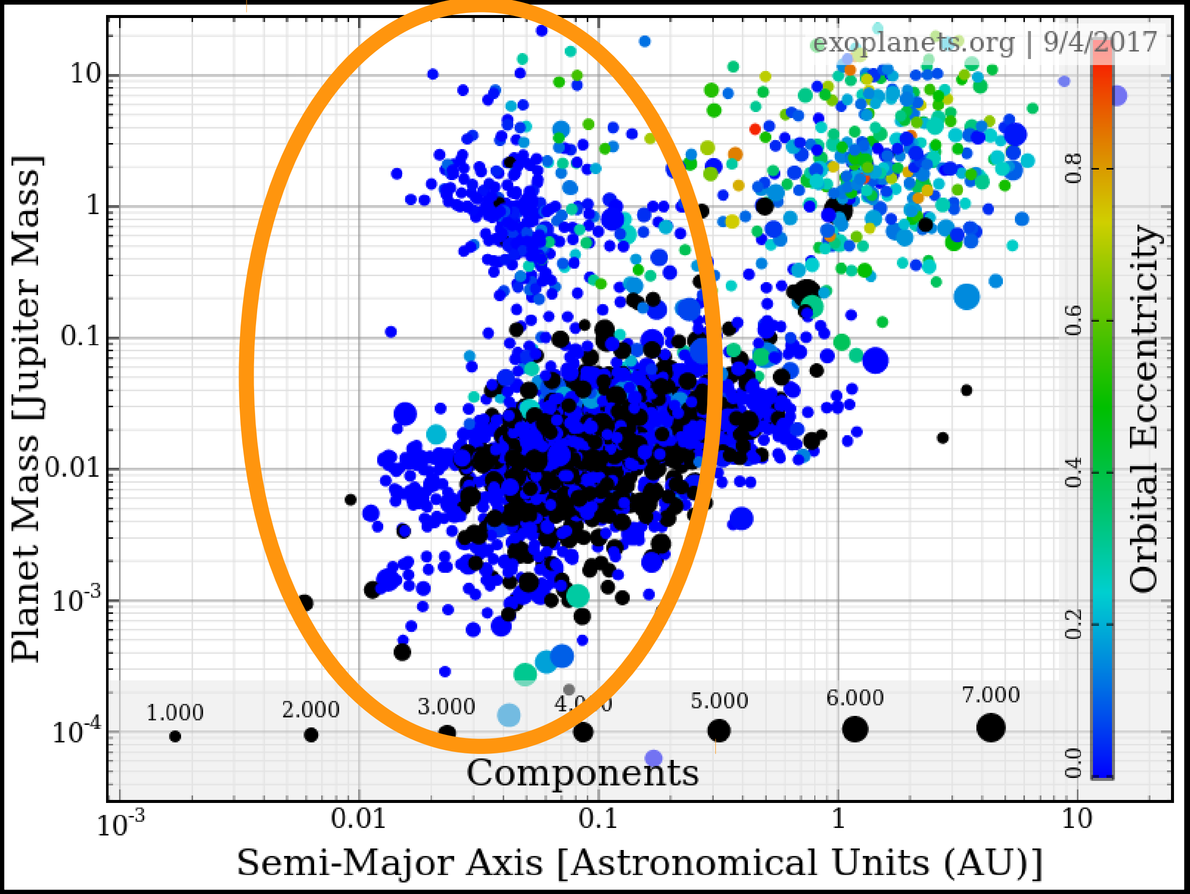


With 3800+ planets in 2700 exoplanetary systems discovered in our galaxy, we now know that the family of planets possesses much greater **diversity** than previously thought and that planetary masses and sizes likely span a **continuous range**.

Different Routes, Similar Outcomes



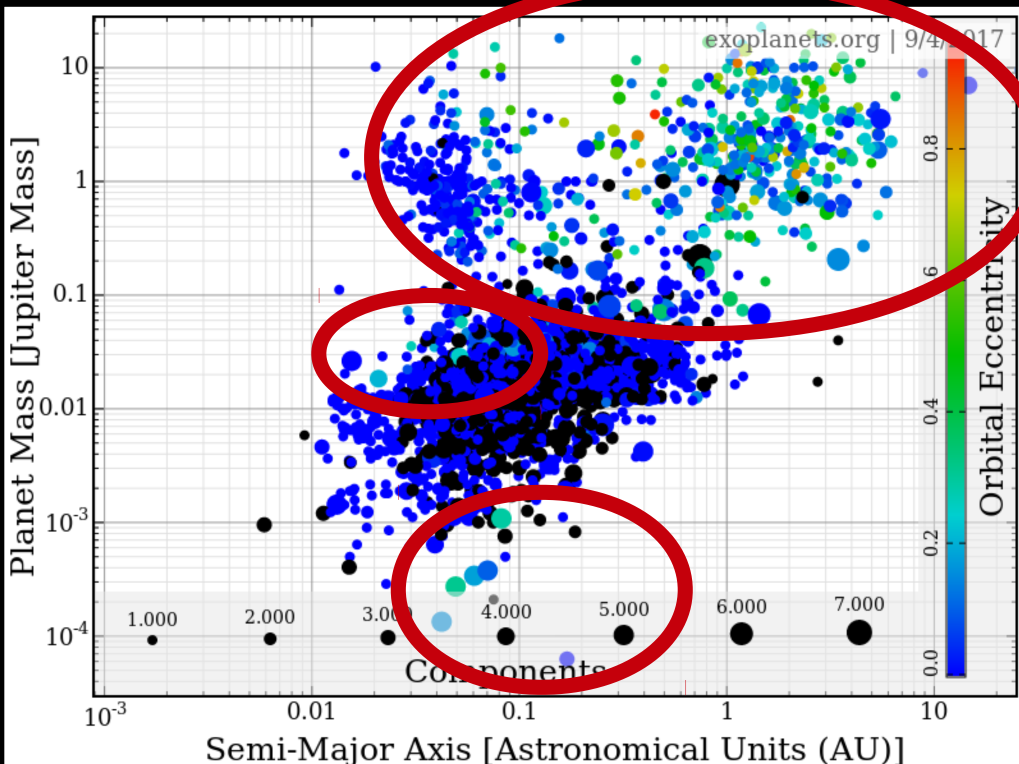
Exoplanets: Proofs of Migration

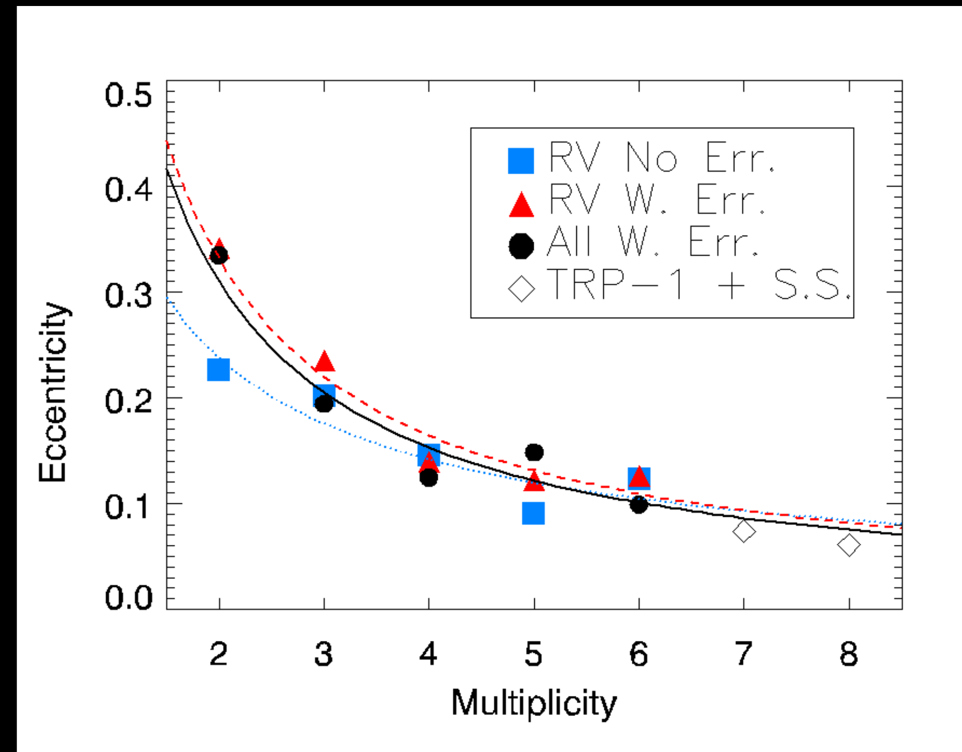


When we were limited to the Solar System, the problem in the study of planetary formation was: how do we prevent the planets to migrate?

The existence of an ***extended population of "hot" exoplanets***, however, revealed that this is not the general case

Exoplanets: Hints of Chaos



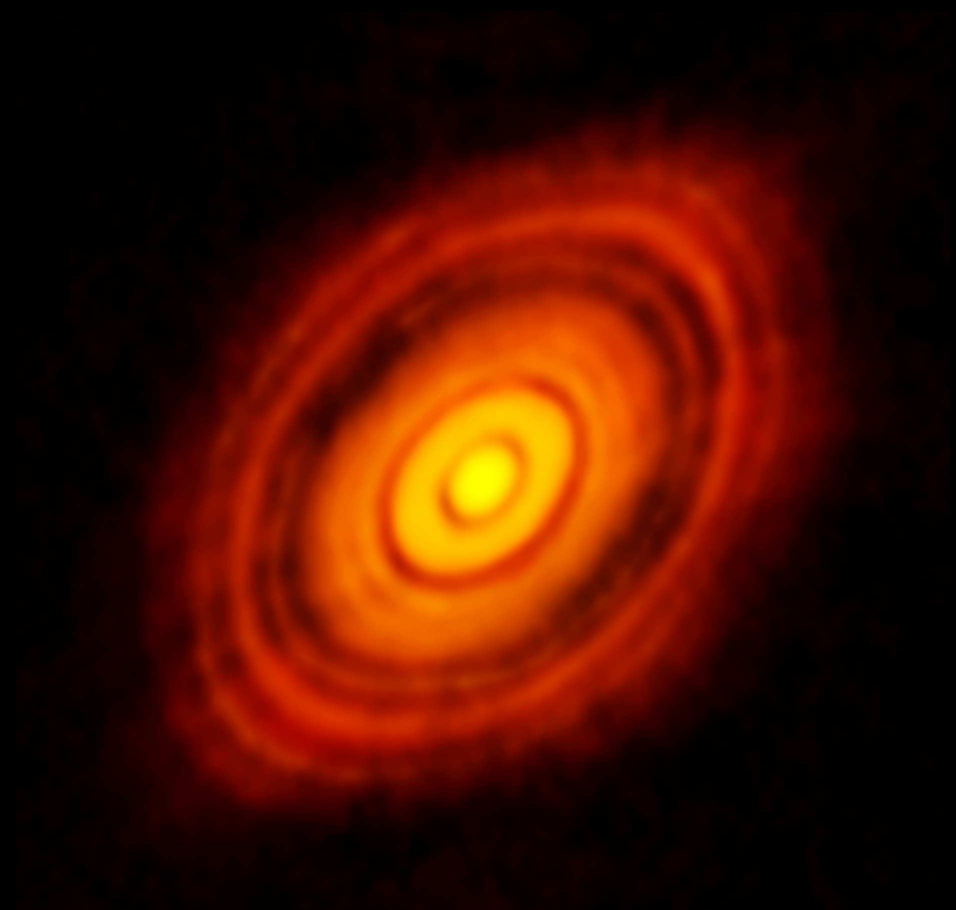


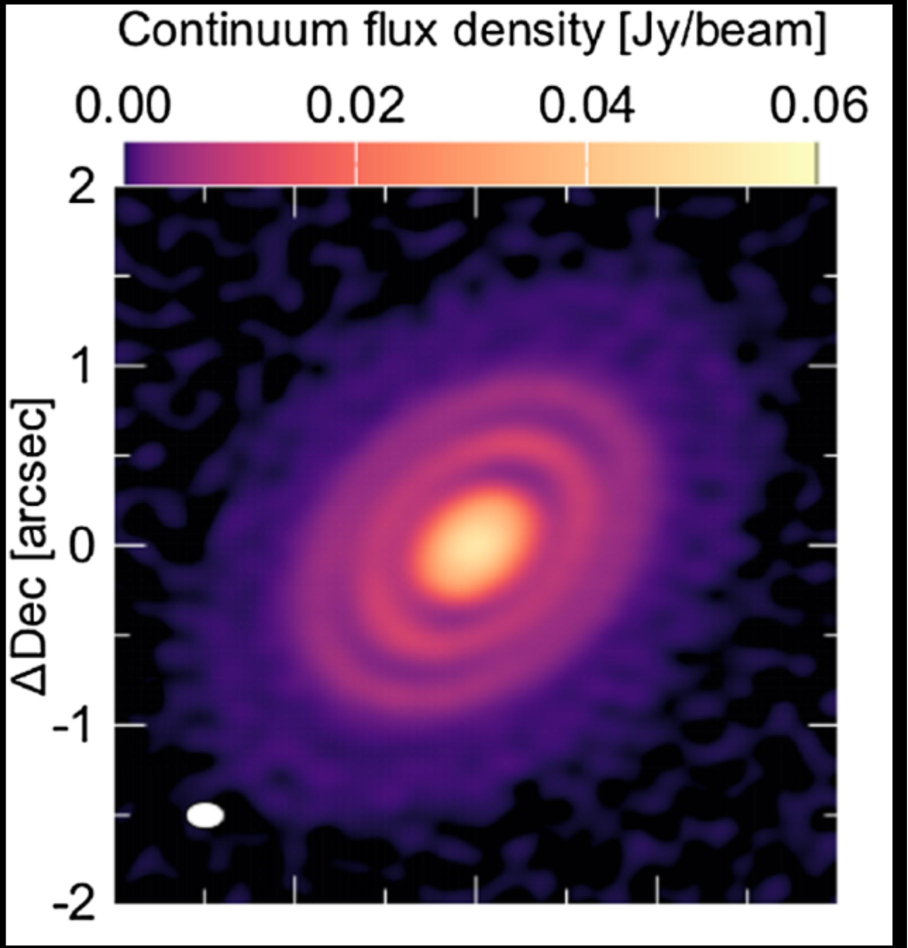
A significant fraction of exoplanets has **large orbital eccentricities**, whereas in the Solar System the eccentricities are of the order of a few 10^{-2} (except for Mercury)

Exoplanetary systems populated by fewer exoplanets show, on average, larger eccentricities than those possessing higher multiplicity, suggesting **past phases of chaotic evolution** (Zinzi & Turrini 2017, Turrini & Zinzi in prep.)

Planetary Formation and Circumstellar Disks

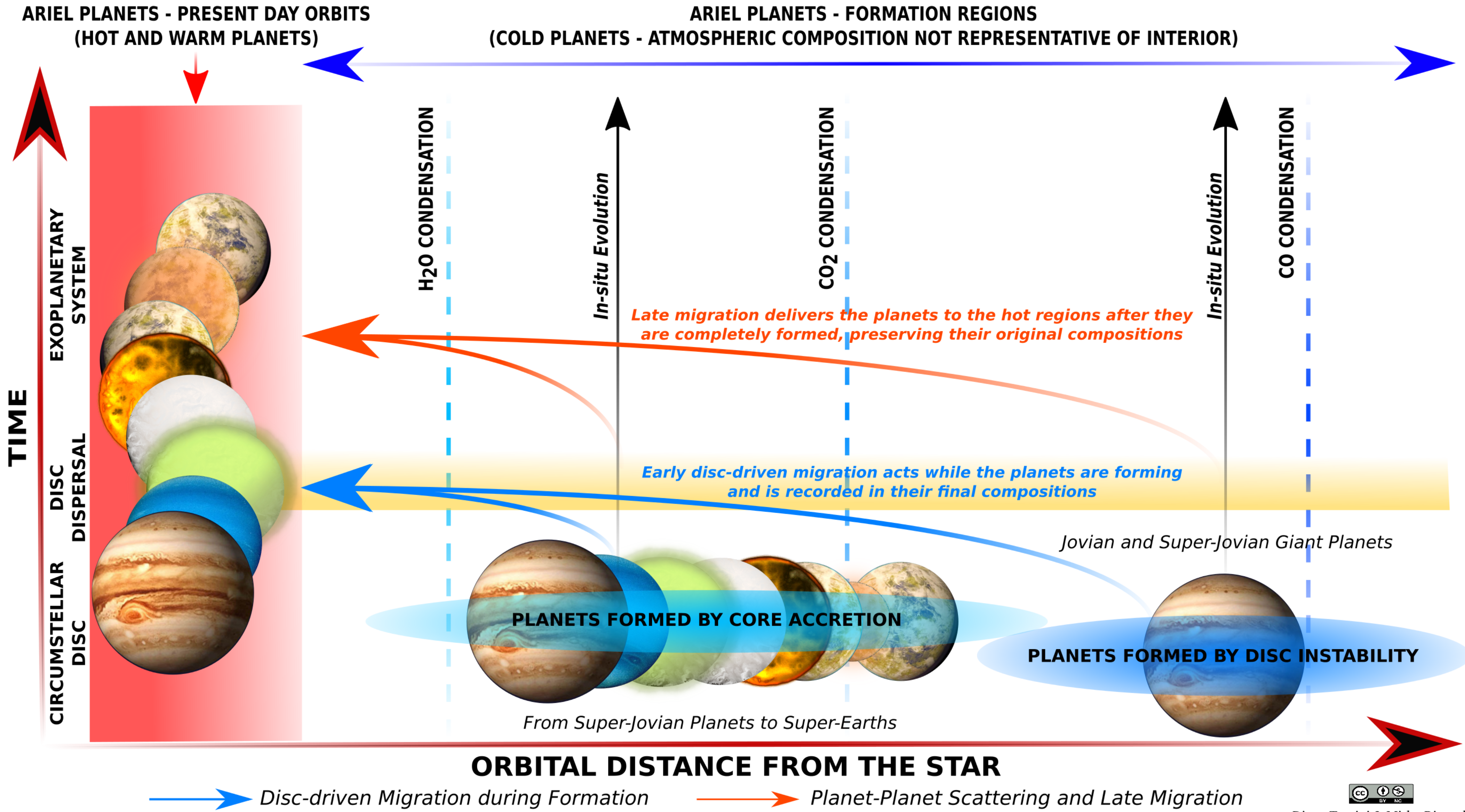
Resolved observations of circumstellar discs reveal signatures of giant planets forming **earlier and further out** than expected.



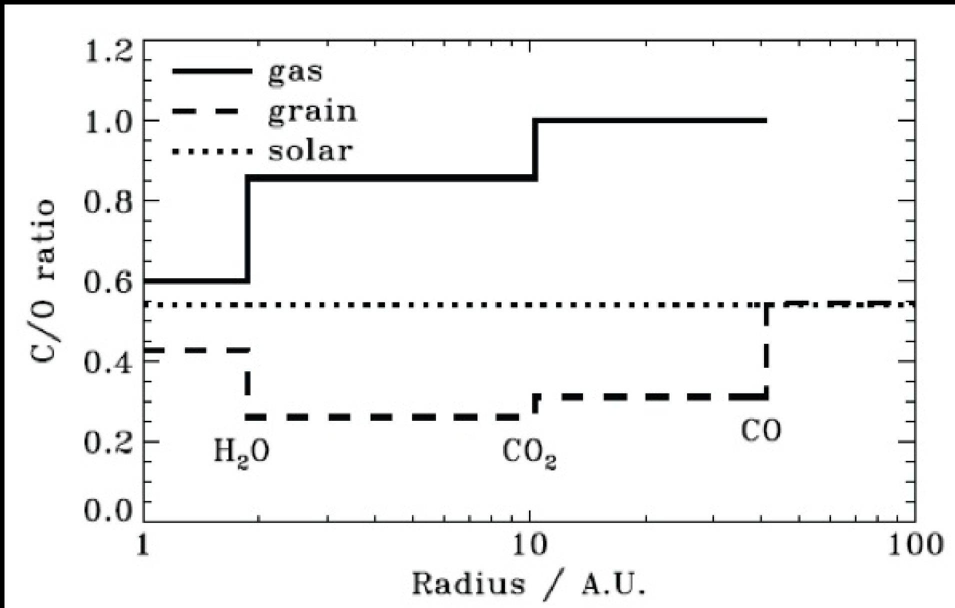


Top: *the 1 Myr-old circumstellar disc of HL Tau, where three giant planets are possibly residing at ~10, ~30 and ~70 au (Dipierro et al. 2015)*. Left: *the 5 Myr-old circumstellar disc of HD163296, where three giant planets are possibly residing at ~60, ~100 and ~160 au (Isella et al. 2016, Liu et al. 2018)*

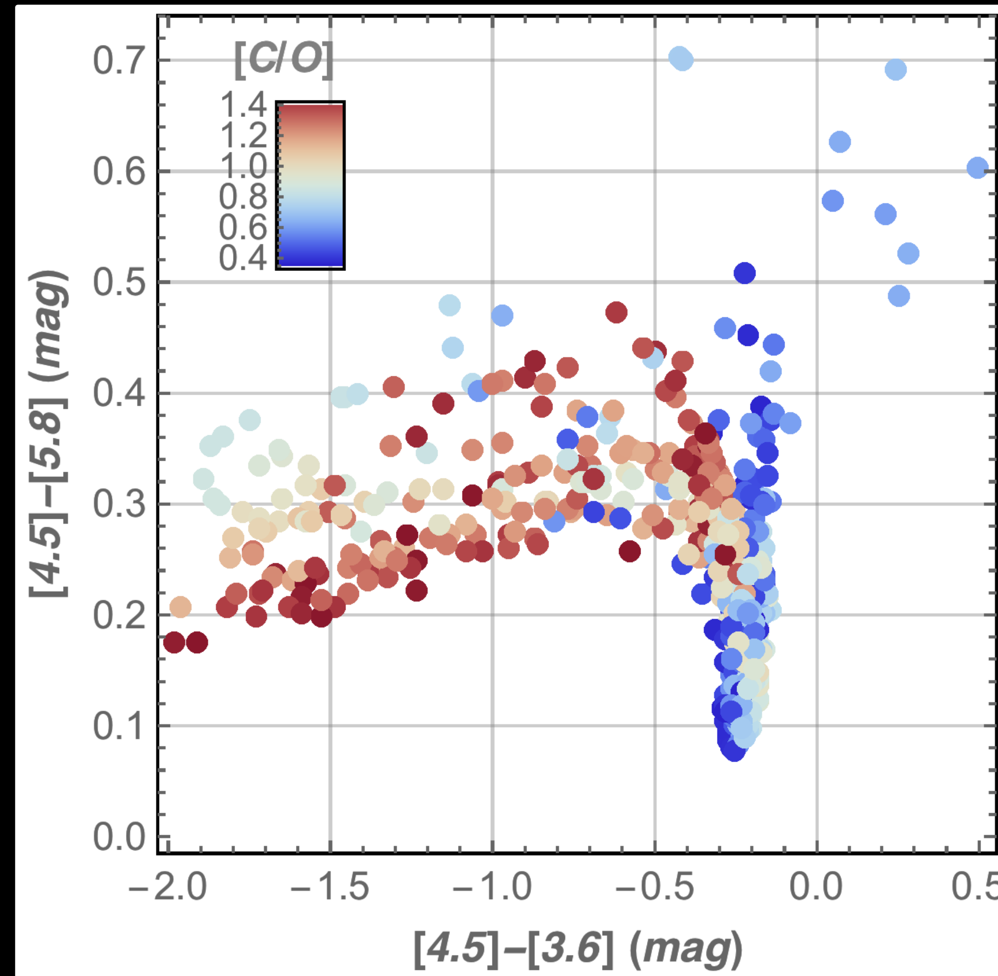
Planetary Migration: ARIEL's Best Ally



Diving into Diversity: ARIEL Survey



Oberg et al. 2011



Triaud 2015; Mollière et al., 2016

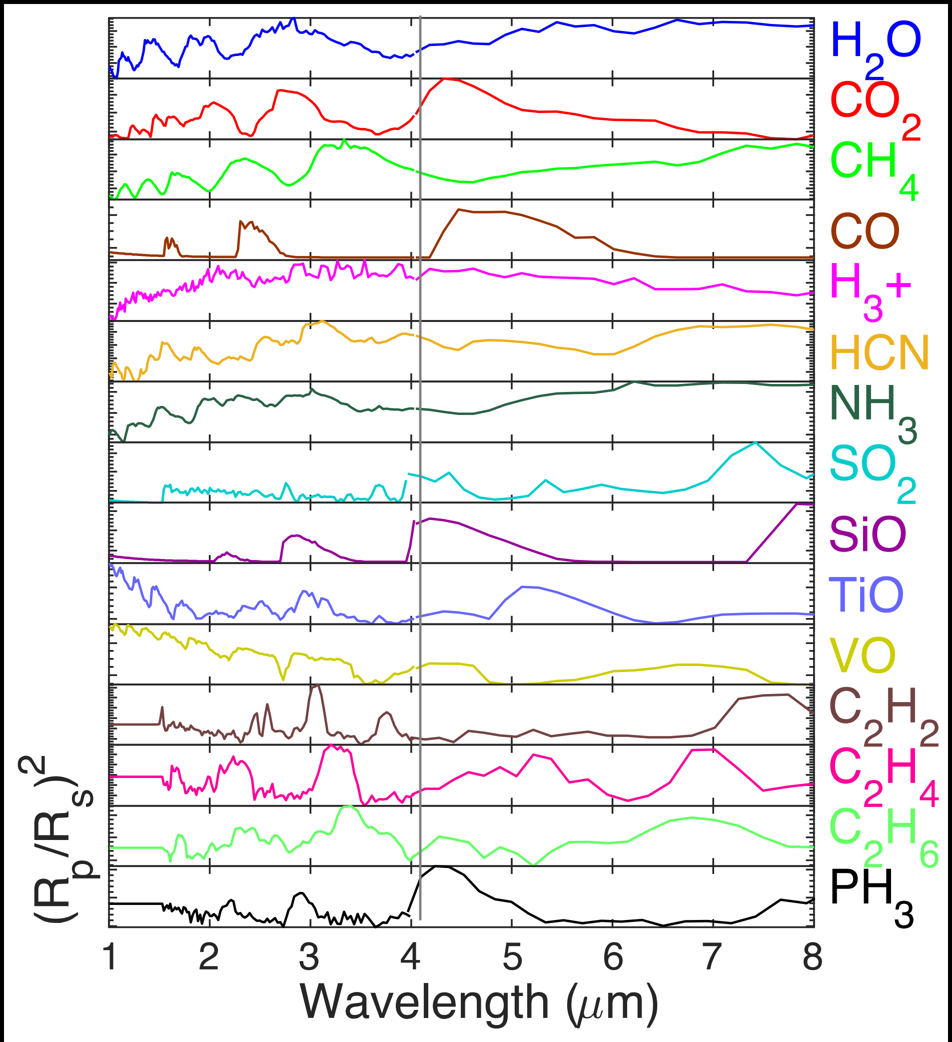
Colour-colour diagrams and colour-magnitude diagrams in the IR and VIS will allow to identify families of planets.

Diving into Diversity: ARIEL Deep Survey

ARIEL spectral coverage includes molecules associated to elements in **all cosmochemical groups**:

- Lithogenous and refractory elements (Si, Ti, Al, Ca...)
- Moderately and highly volatiles elements (S, Na, F, P…)
- Atmophile elements (C, O, N)

Combined with the high atmospheric temperatures and input tidal energy of its target planets, this coverage makes ARIEL a unique tool to **study planetary composition in a statistic way**.



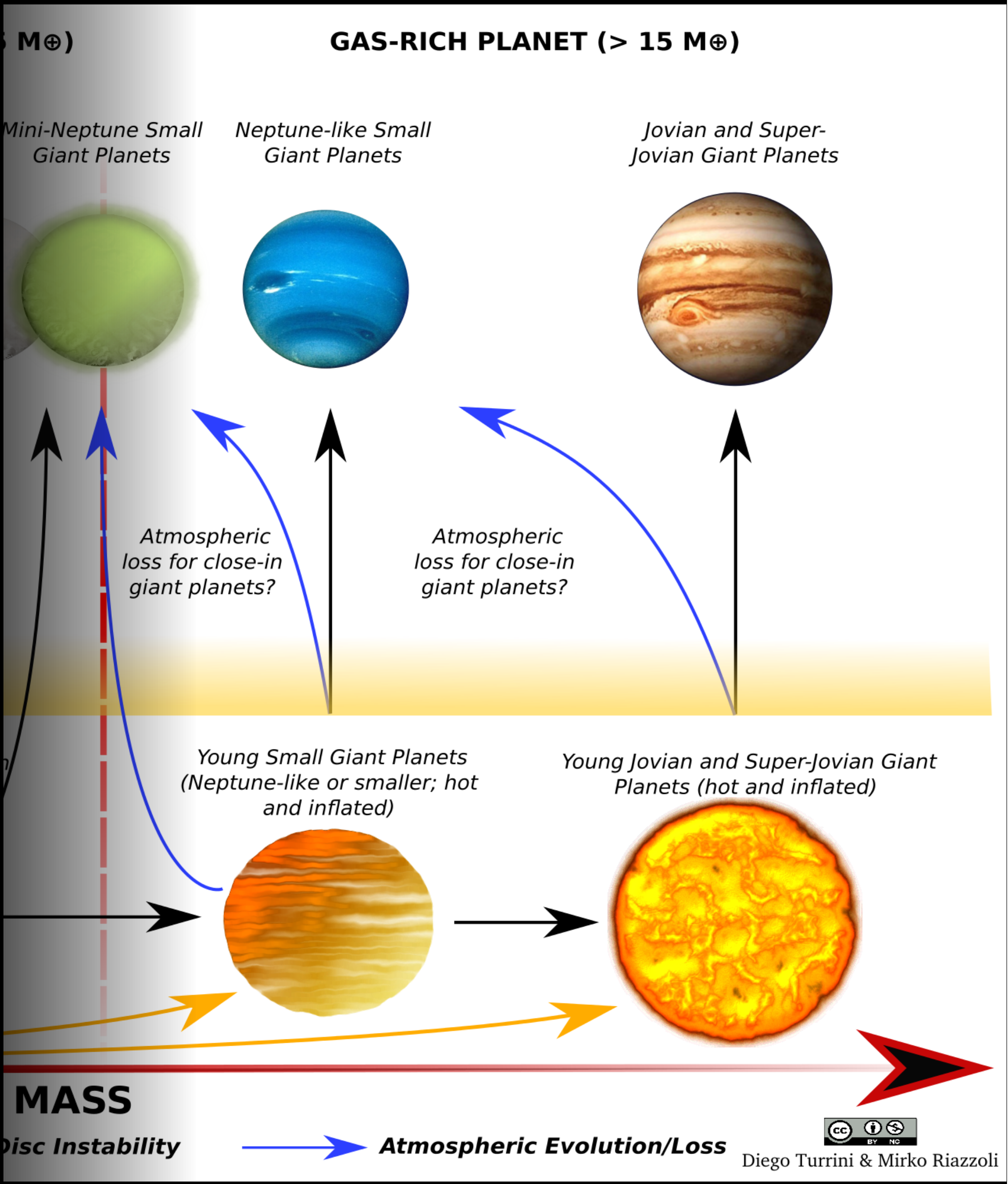
Tinetti et al. 2015, 2018

Probing Giant Planets' Interiors

In the case of giant planets, ARIEL's observations will provide the first window into their interior composition.

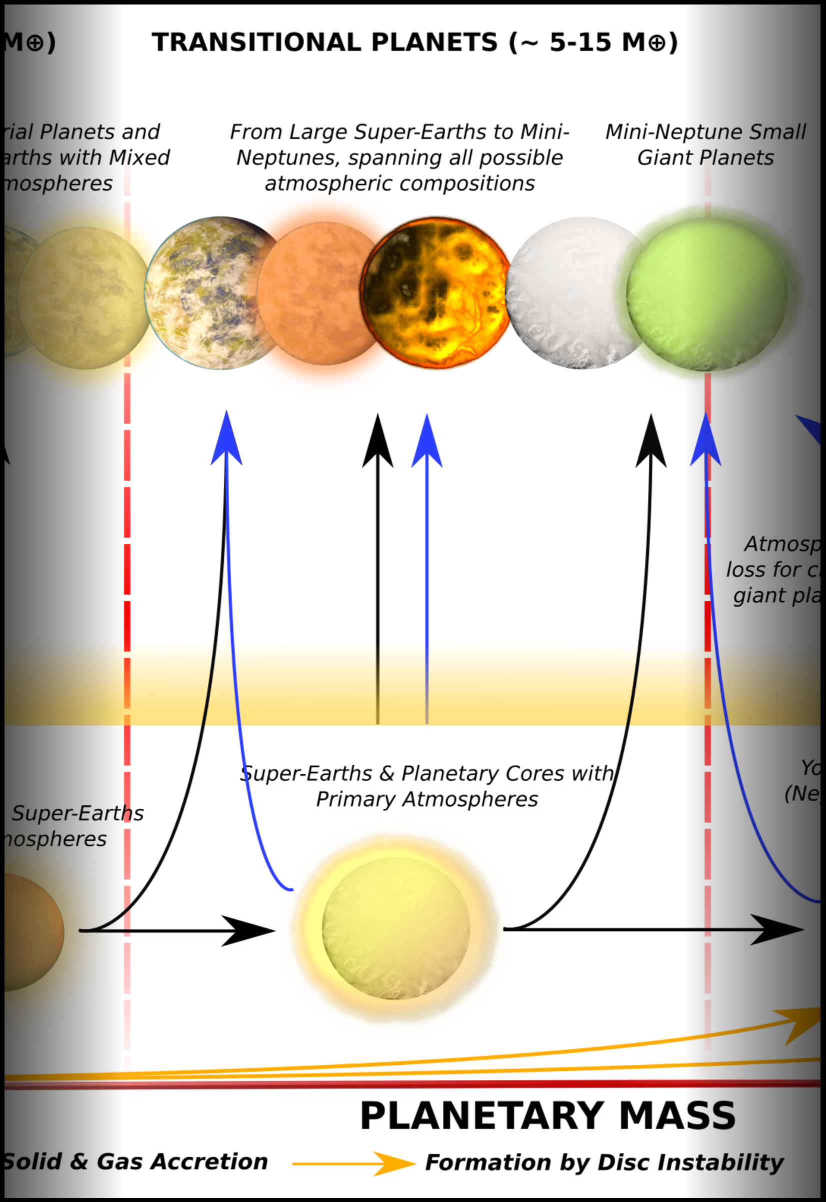
Retrieving the relative abundances of molecules belonging to different cosmochemical groups will allow to:

- assess whether the atmospheric/interior composition deviates from a **solar pattern**;
- constrain the **rock/ice/gas ratio** in the planetary interior;
- estimate the amount of **solid material accreted** by the planets with the gas.



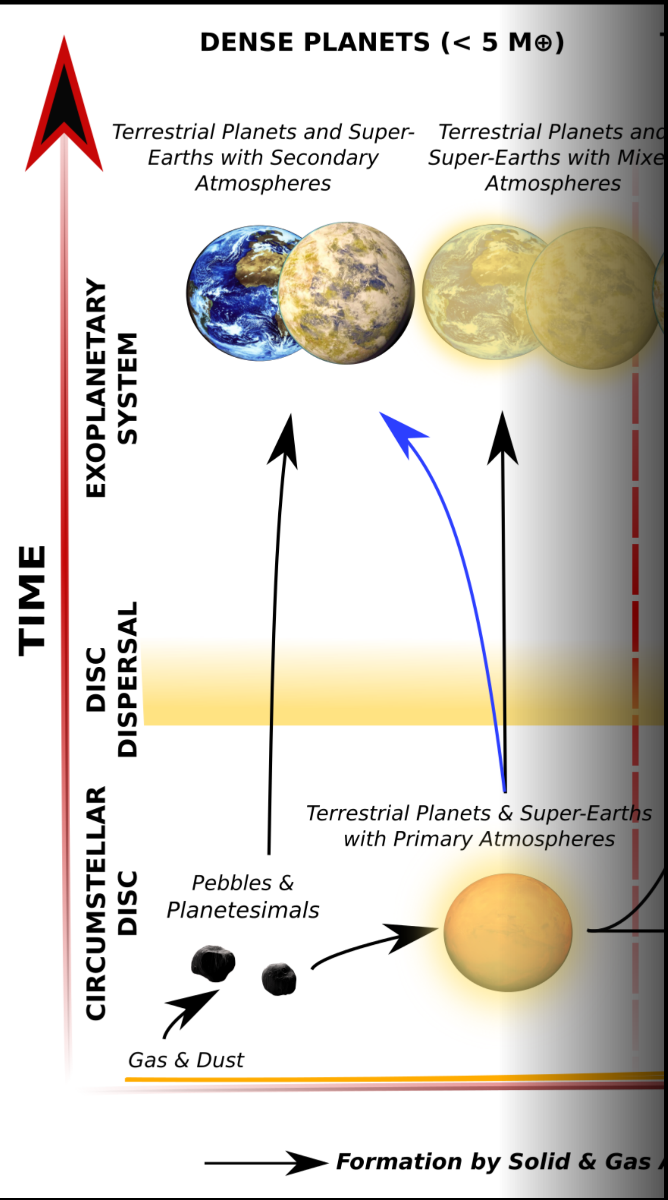
Exploring the Transition Region

We currently don't know if the **transition** between giant planets and terrestrial planets is **sharp** (like in the Solar System) or **continuous** (as the mass spectrum of exoplanets suggests).



ARIEL's atmospheric characterization will allow to assess the **mean molecular weight** of exoplanets in the transitional mass range and probe this transition for the first time.

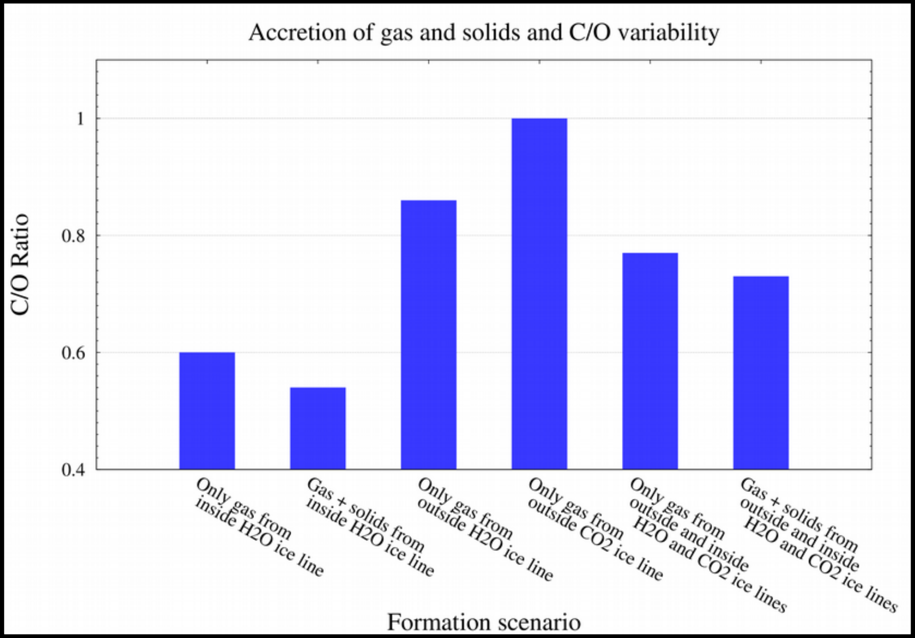
Hunting for Water and H/He



By looking to the presence of **H and He** (through the mean molecular weight) in the atmospheres of **terrestrial planets** ARIEL will confirm whether such planets are a **late product** (as in the case of the Solar System) or they can **form early** in circumstellar disks.

Similarly, by looking to the presence of **water** in their atmospheres in planetary systems with and without **giant planets** ARIEL will confirm whether the latter are a **required** ingredients (as in the accepted paradigm the Solar System) or **just one path** for water delivery to take place.

ARIEL's *Planet Formation* WG in Phase B1



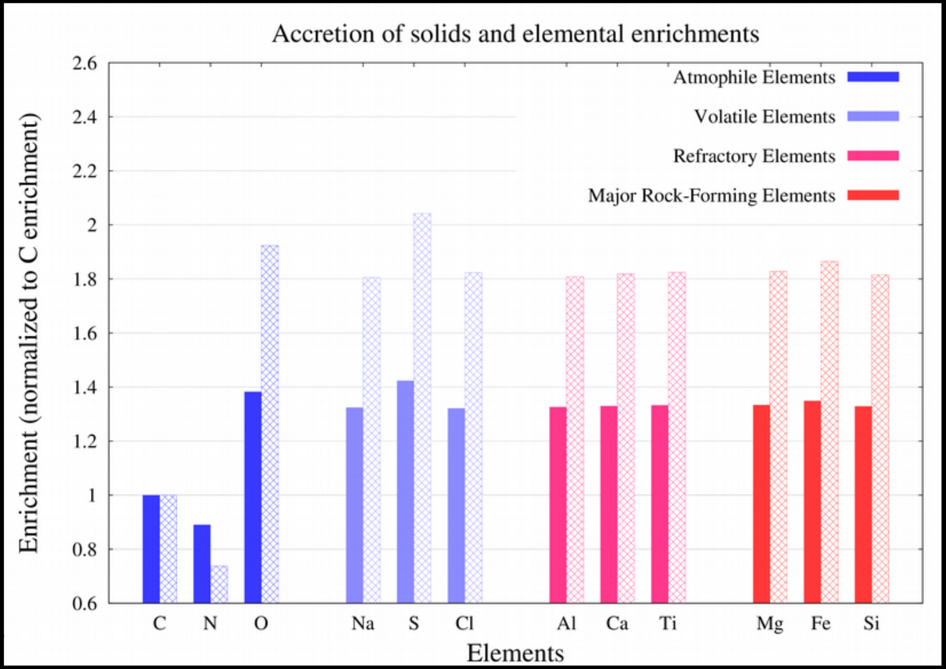
Turrini et al. 2018

ARIEL "Planet Formation" WG in Phase B1 is currently composed of **35 researchers** from **12 countries** participating to the ARIEL's consortium.

INAF contributes with **15 researchers** with diverse backgrounds (planet formation, circumstellar disks, exoplanets, Solar System, payload).

The focus of the activities of the "Planet Formation" WG during Phase B1 will be on:

- **consolidating chemical tracers** previously identified (e.g. C/O, H_2O);
- **identifying new chemical tracers** of interior composition (e.g. Al, Si, S)
- **assessing their diagnostic power** to study the formation and migration of planets



Turrini et al. 2018