Revealing the diversity of small worlds with K2 and HARPS

Under the supervision of Alexandre Santerne and Magali Deleuil

Théo Lopez - PhD Students Day - November 30th 2017

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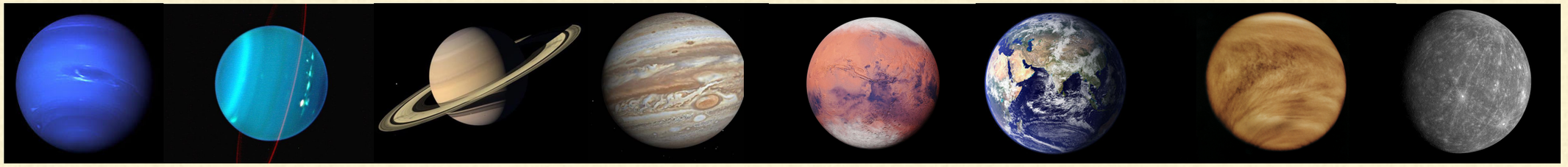
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

The diversity of planets in the solar system

Massive planets:
Gaseous

Low-mass planets:
Solid



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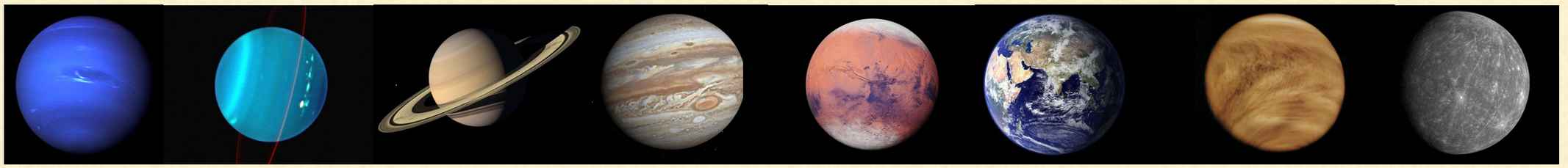

What about the diversity of planets in other systems ?

The diversity of planets in the solar system

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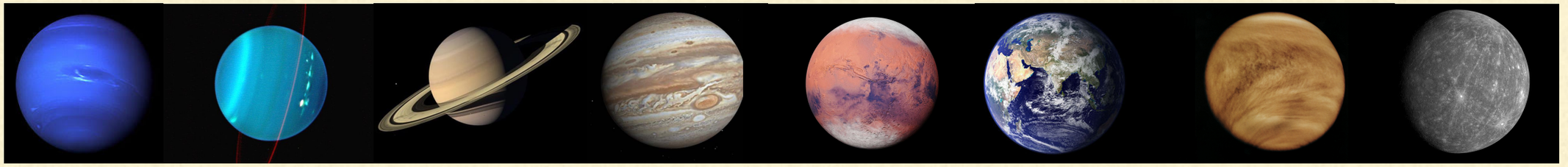
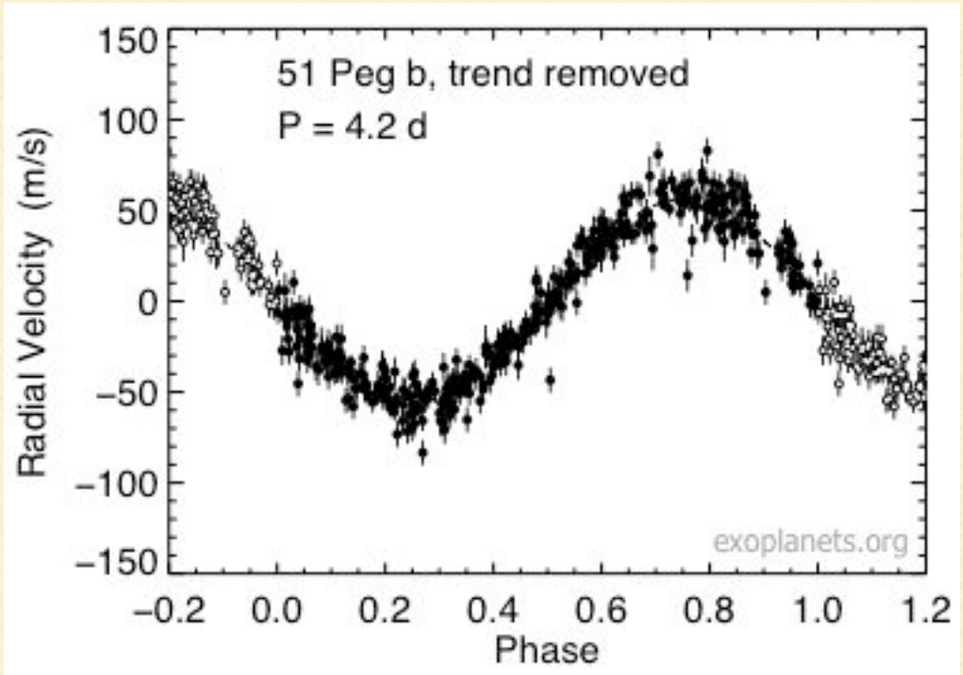
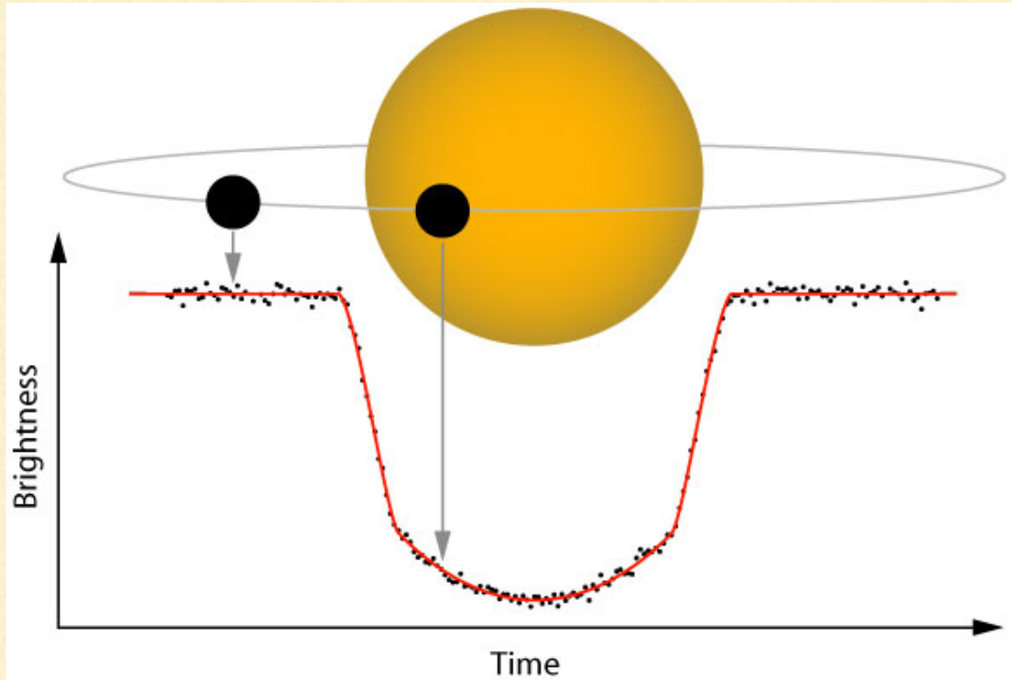


What about the diversity of planets in other systems ?

Interesting to constrain planetary formation models and understand how planets, including the Earth, formed and what is the occurence of Earth-like planets.

Combine RV and transits to constrain the planetary compositions





↓

Planet **mass**

↓

Planet **radius**

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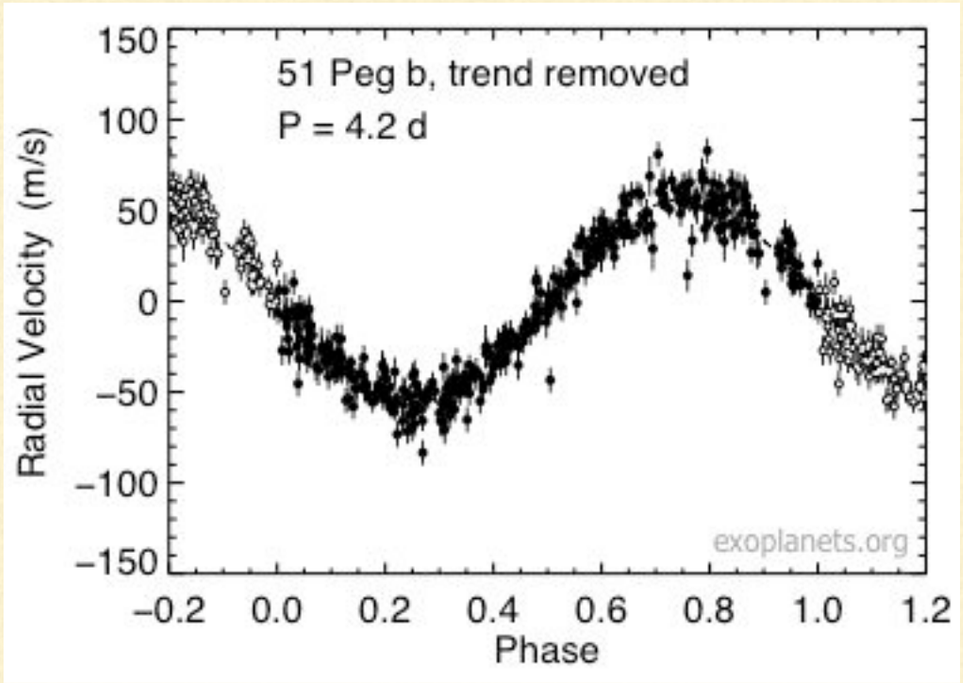
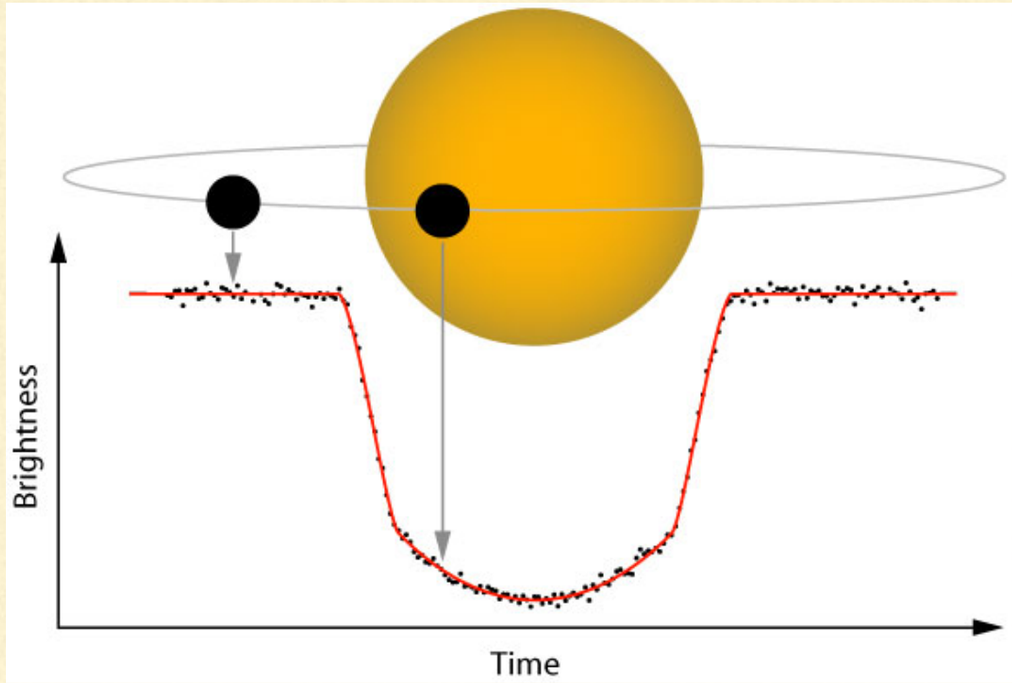


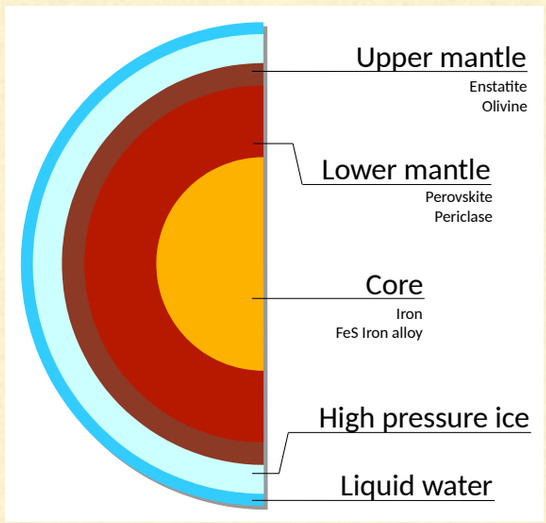


Planet **mass**

Planet **radius**

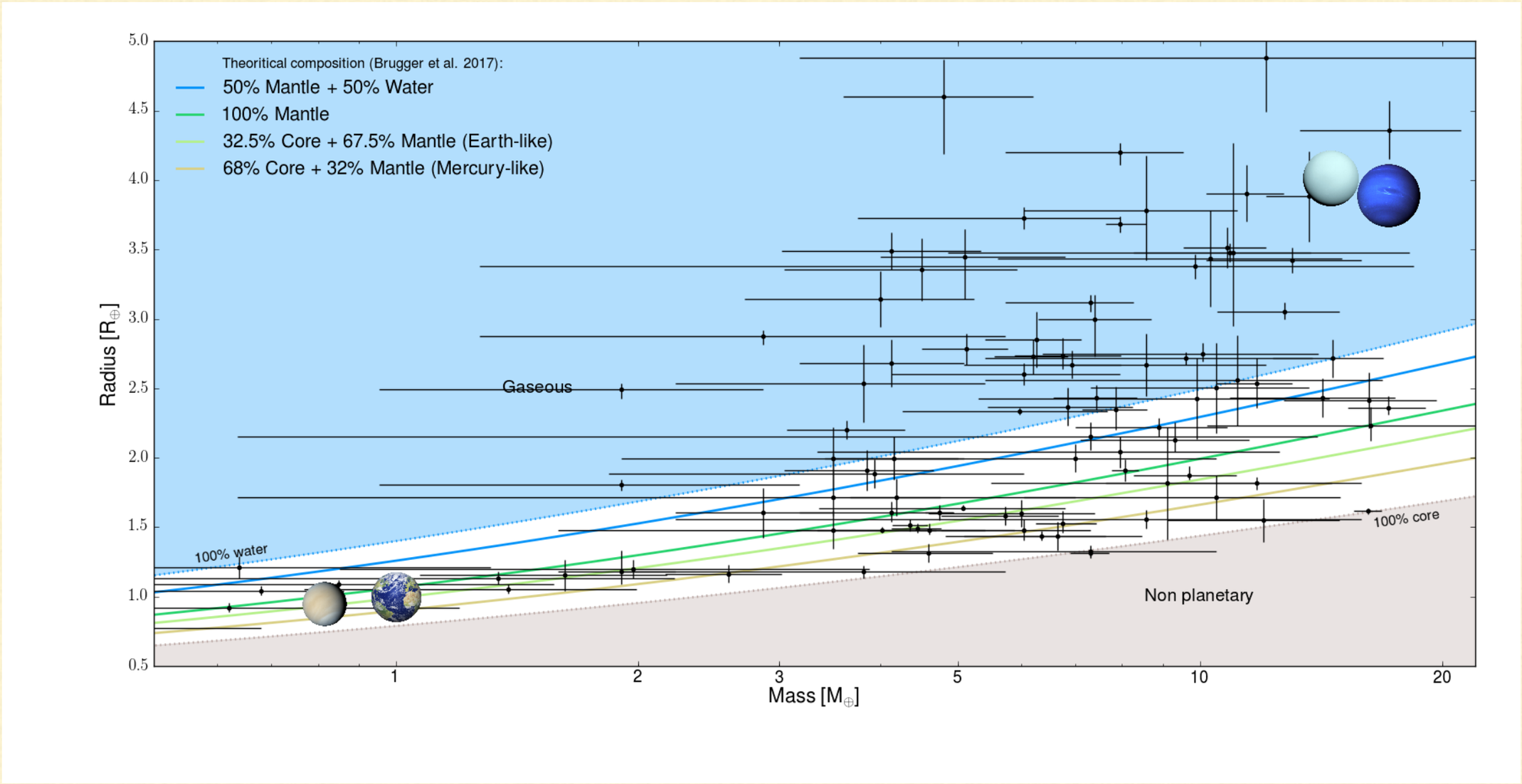
Density

Internal structure



Brugger et al. 2017

The diversity of small exoplanets

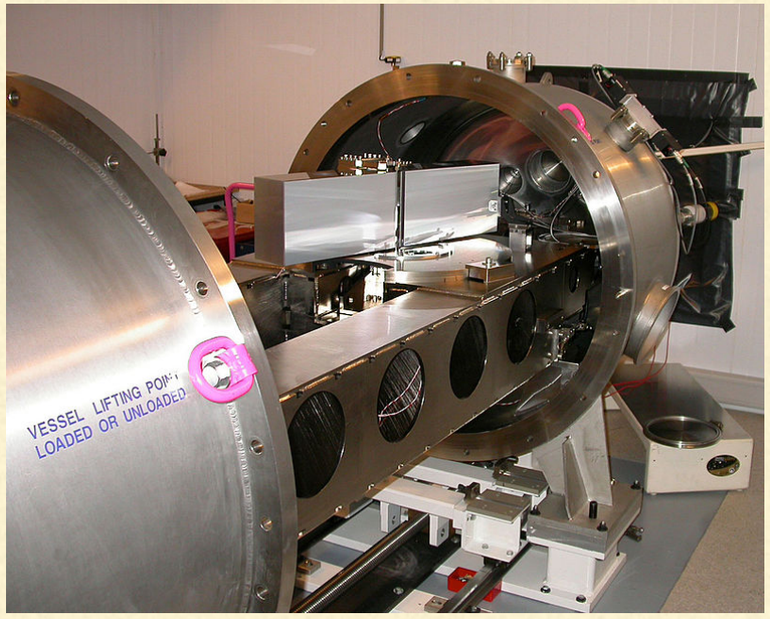


- **Unexpected diversity** of small exoplanets from what we see in the Solar system. The boundary between gaseous and solid planets is not clear.
- These planets **do not fit in with the formation models**.
- But, **high uncertainties** on the mass for most of them.

A large observing program on HARPS

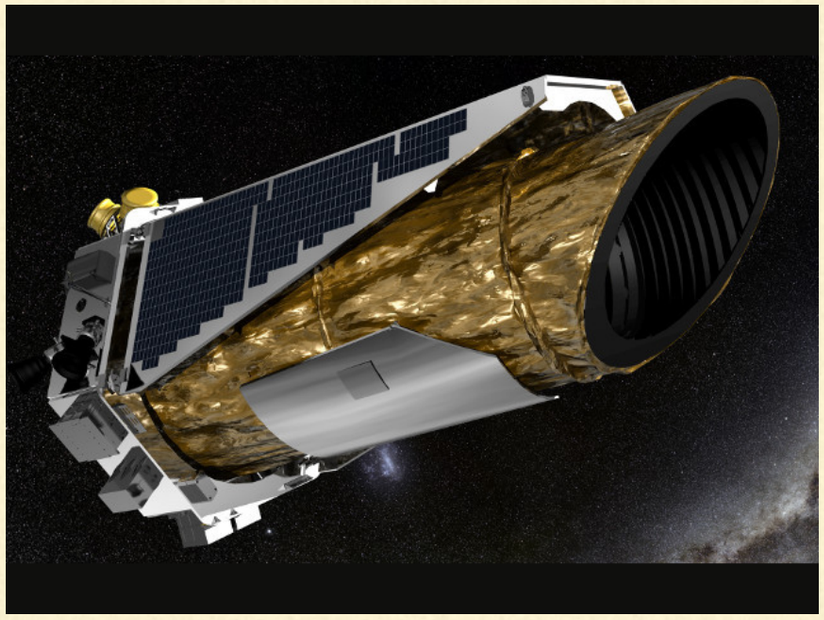
Objective: Detect and characterize a dozen of low-mass planets with **high constraints on the masses**

- 70 nights on **HARPS** (La Silla - ESO) over 2 years (2016-2018)
- High precision Kepler-**K2** photometry



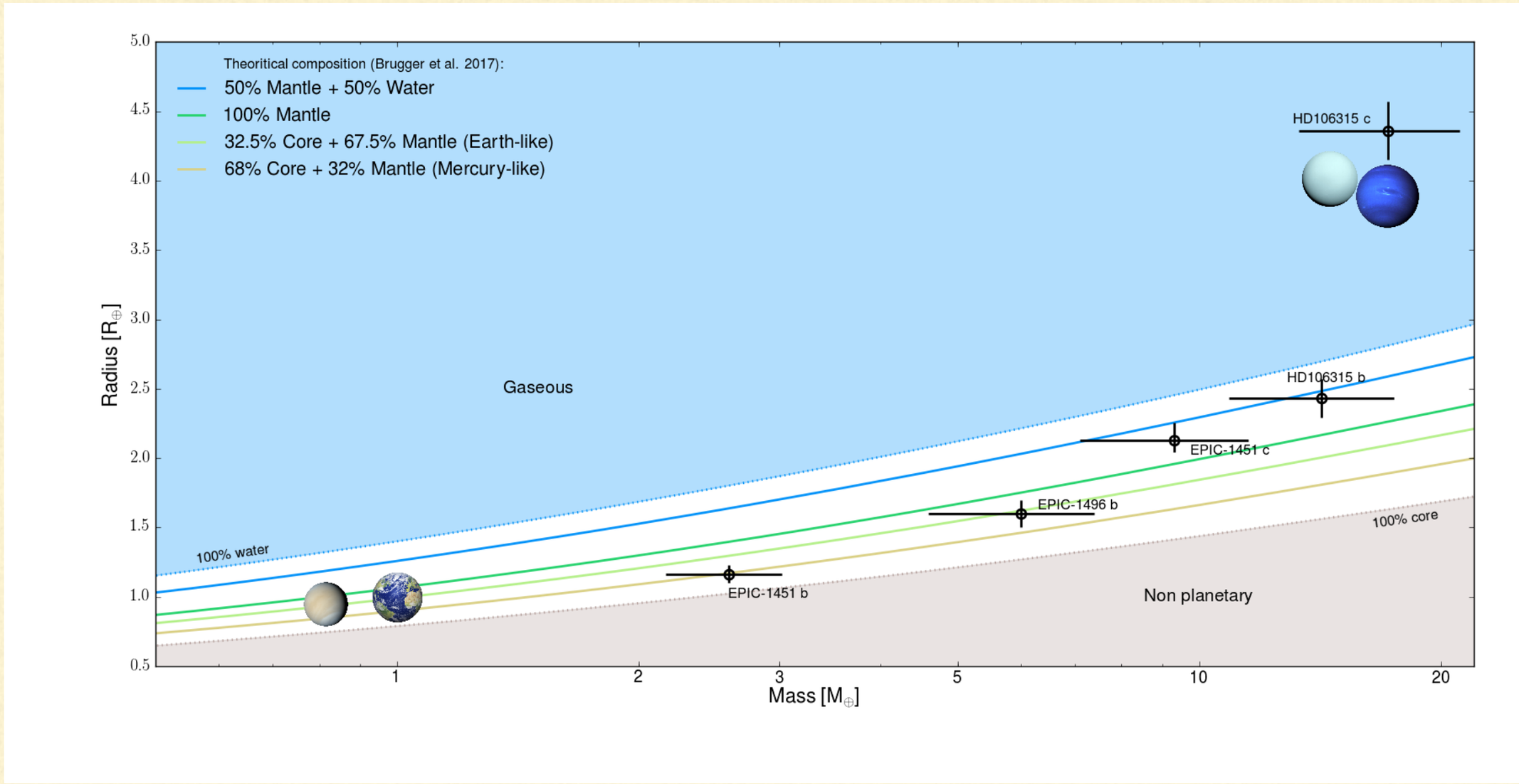
The HARPS spectrograph

Credits: ESO



The Kepler satellite

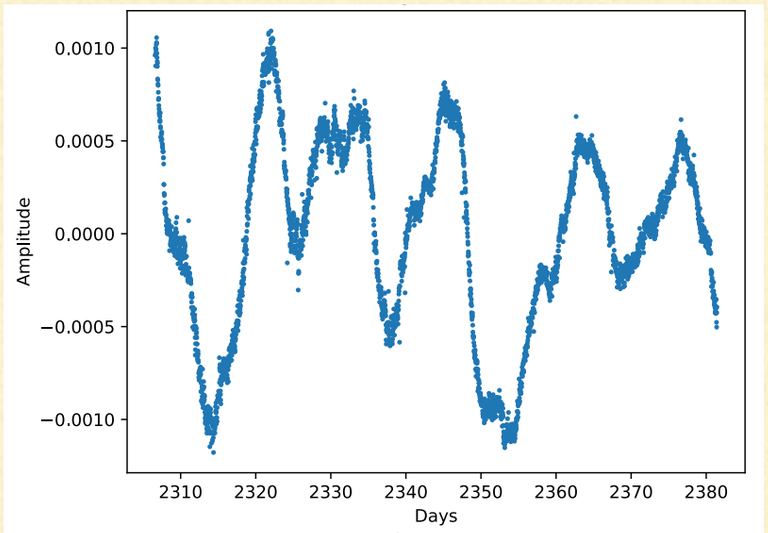
Early results



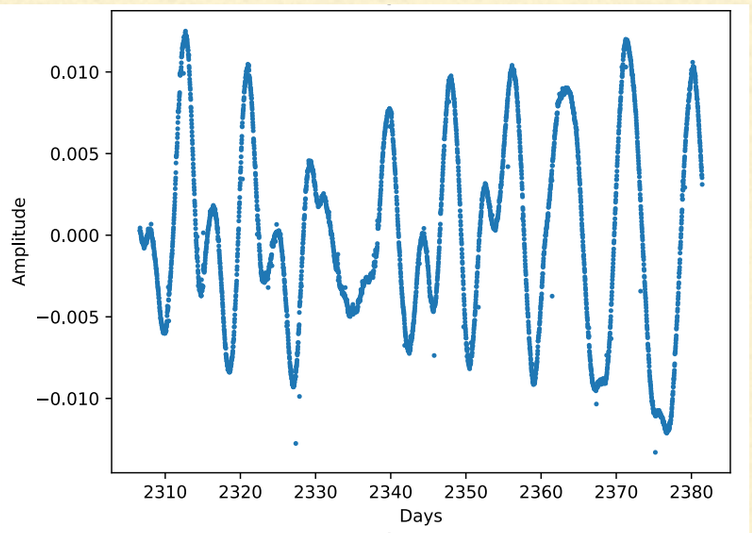
Already 5 planets detected and well characterized (Barros et al. 2017; Santerne et al., submitted) and a dozen currently observed, to be published in the next two years.

Understanding stellar activity: the first joint photometry, radial-velocity and polarimetry campaign

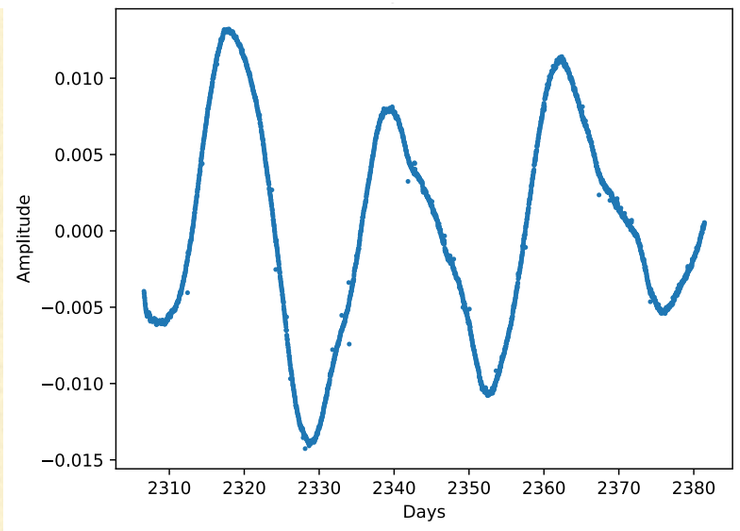
Observations of 4 active stars from early December 2017 to mid-February 2018:



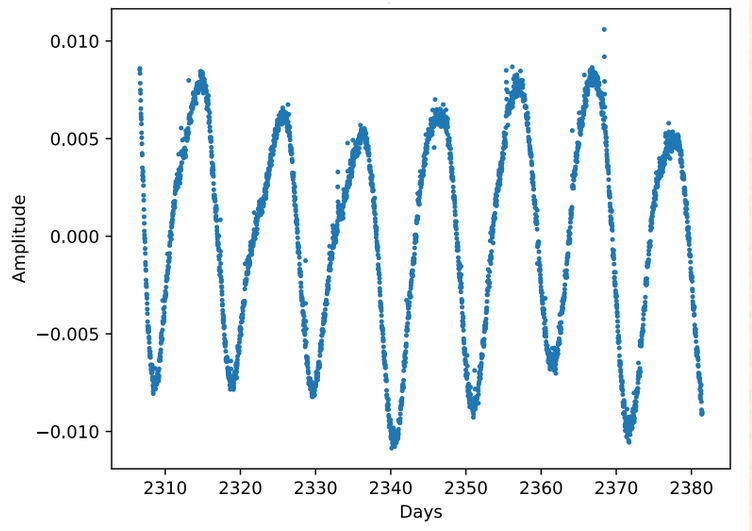
Late-G star



K star



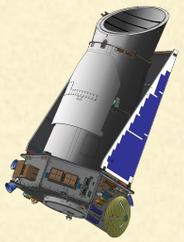
K star



Early-M star

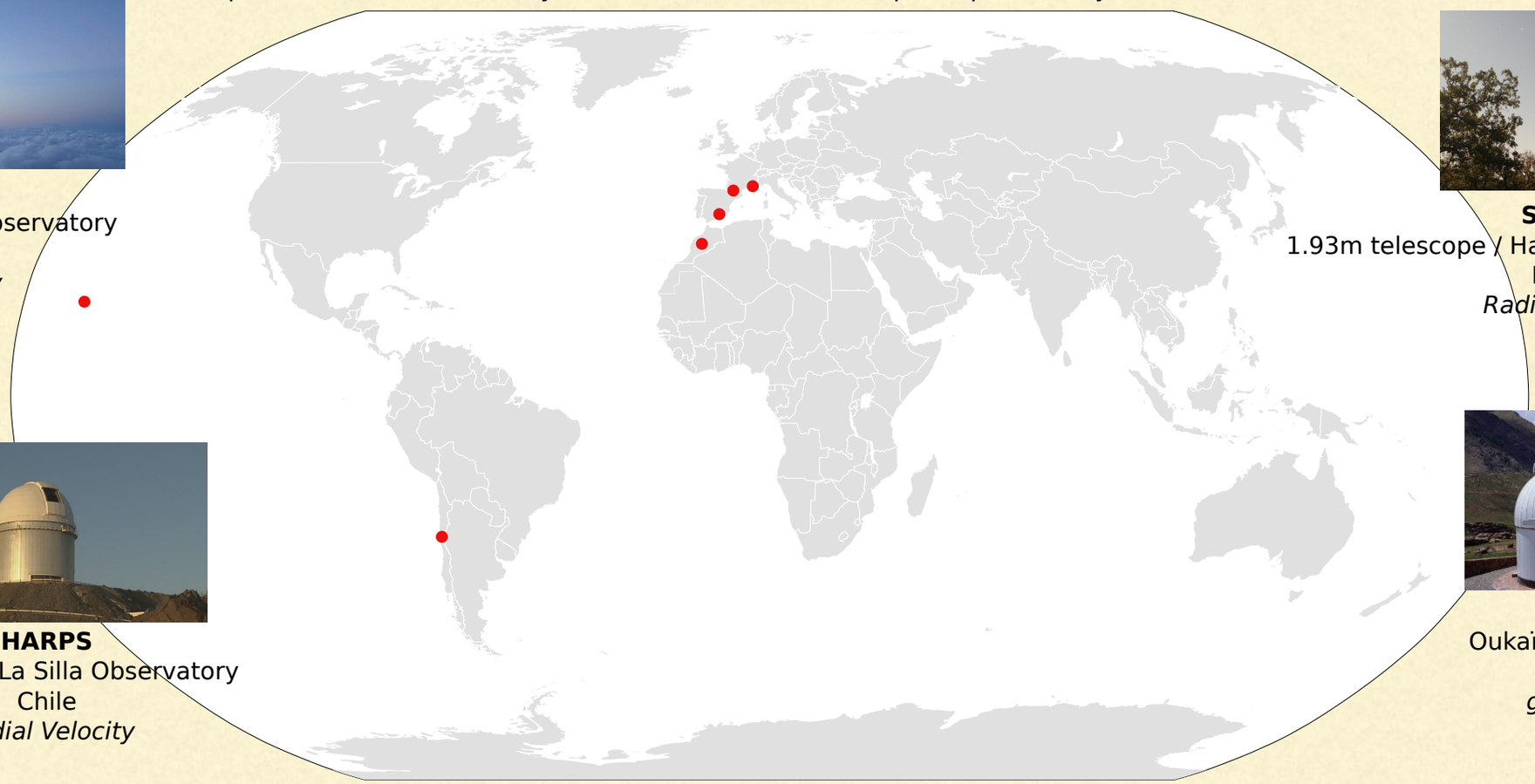
CARMENES
3.5m telescope / Calar Alto Observatory
Spain
Optical + NIR Radial Velocity

NARVAL
Telescope Bernard Lyot (2m) */ Pic du Midi Observatory*
France
Spectropolarimetry



K2
Kepler telescope / NASA
Space
Photometry

ESPaDOnS
CFHT (3.5m) / Mauna Kea Observatory
Hawaii / USA
Spectropolarimetry



SOPHIE
1.93m telescope / Haute-Provence Observatory
France
Radial Velocity

HARPS
ESO-3.6m / La Silla Observatory
Chile
Radial Velocity

TRAPPIST-N
Oukaïmeden Observatory
Morocco
griz photometry

The *K2* stellar activity campaign

December, 7th 2017 to February, 22nd 2018

Supported by:

Credits: Alexandre Santerne

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3.5m telescope / Calar Alto Observatory
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Optical + NIR Radial Velocity

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Thank you for your attention

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The *K2* stellar activity campaign
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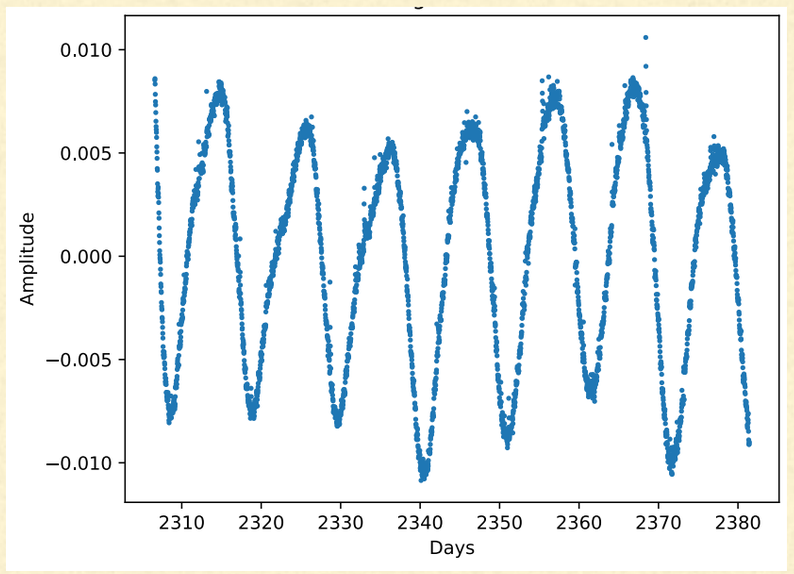
Stellar activity: the limiting factor

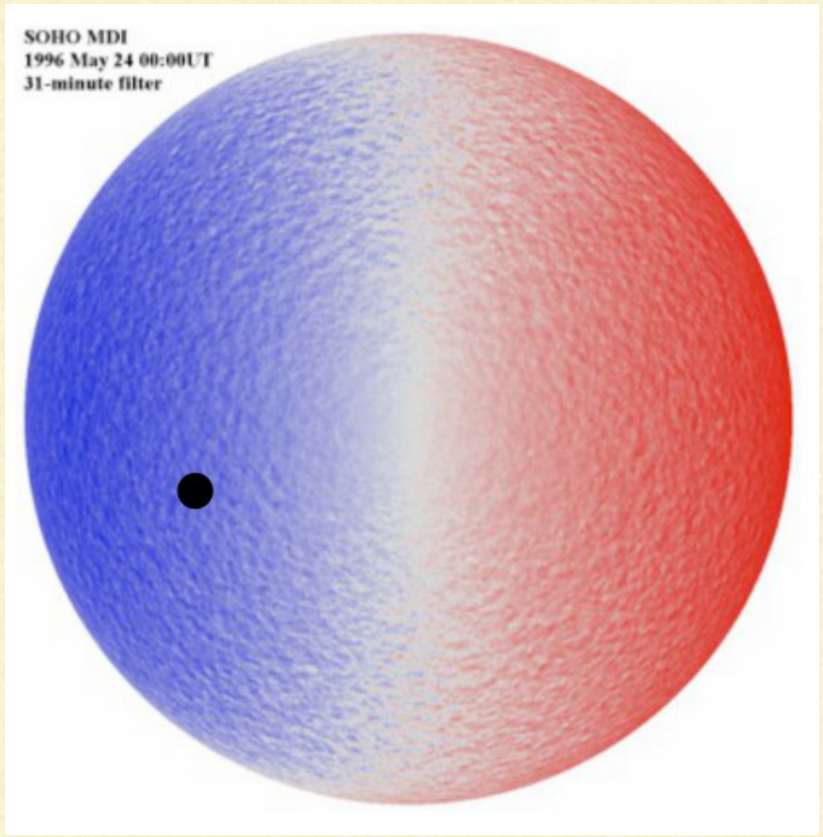
The magnetic fields inside stars induce inhomogeneities on the stellar surfaces which impact the measurements and our ability to detect planets.

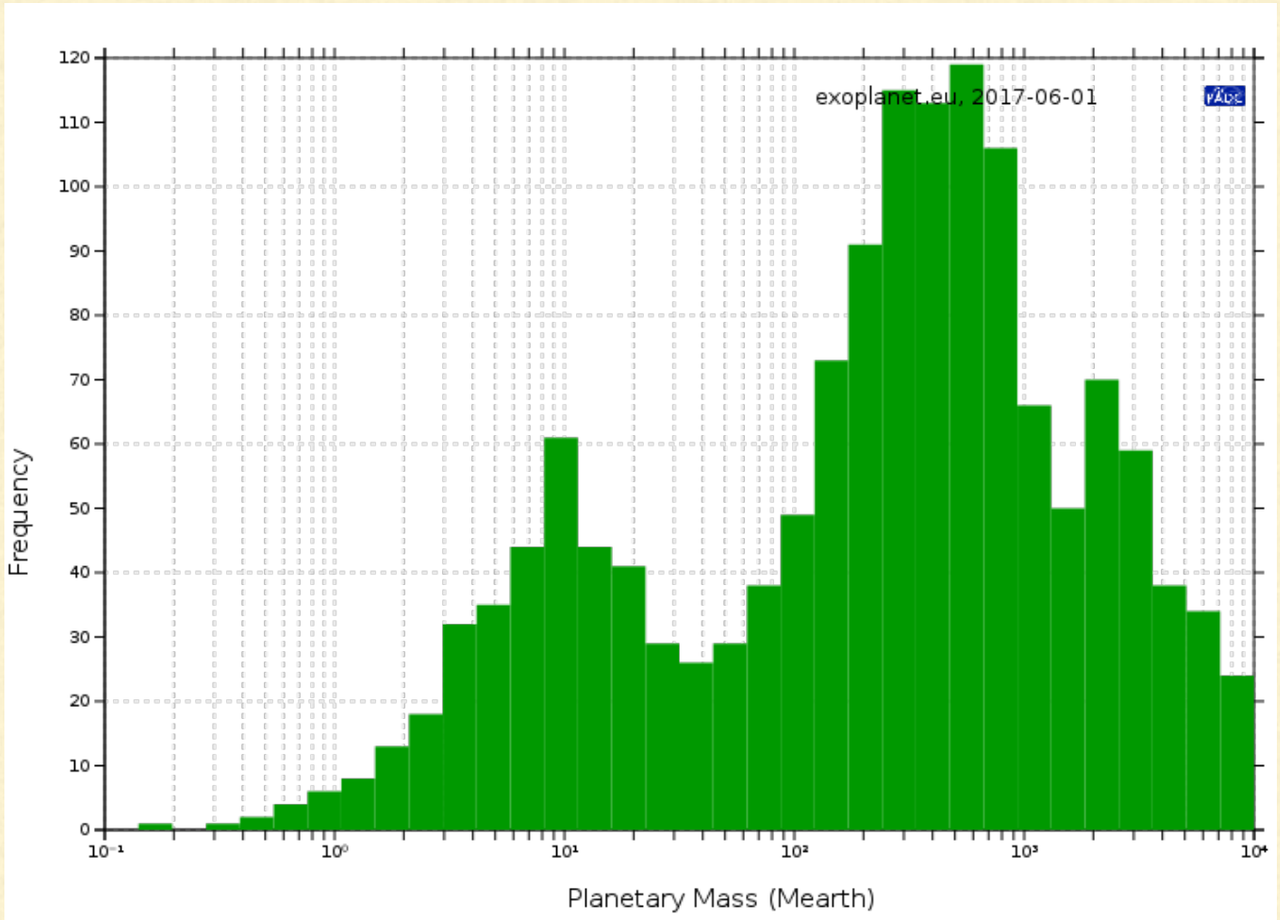
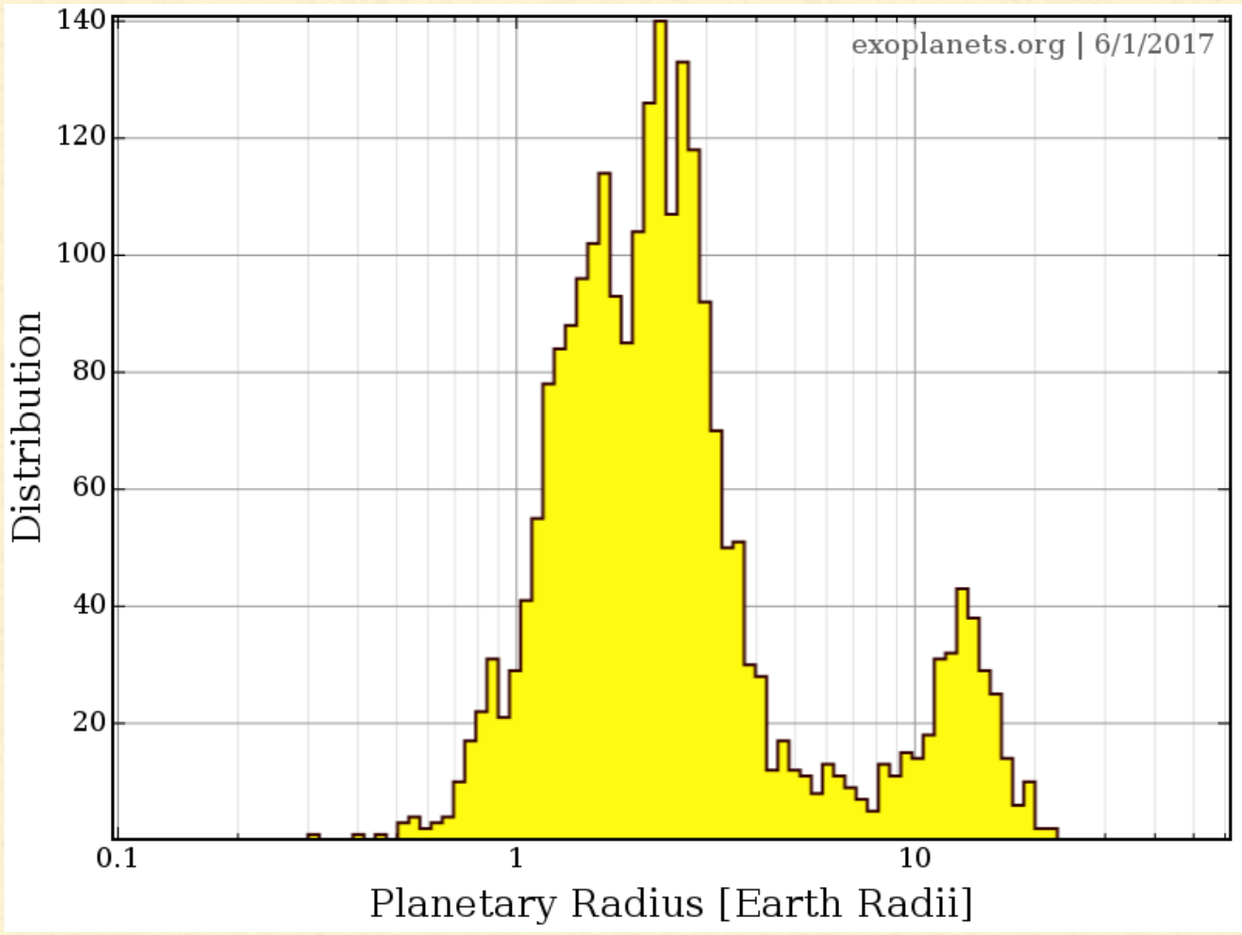
Impact on the photometry

Credits: Pete Lawrence



Impact on the radial velocity



Removal of a contribution to the total RV

	JUPITER	SATURNE	NEPTUNE	URANUS	TERRE	VENUS	MARS	MERCURE
Mass (Earth mass)	318	95.2	17.2	14.5	1	0.82	0.11	0.06
Radius (Earth radius)	11.2	9.46	3.88	4.01	1	0.95	0.53	0.38