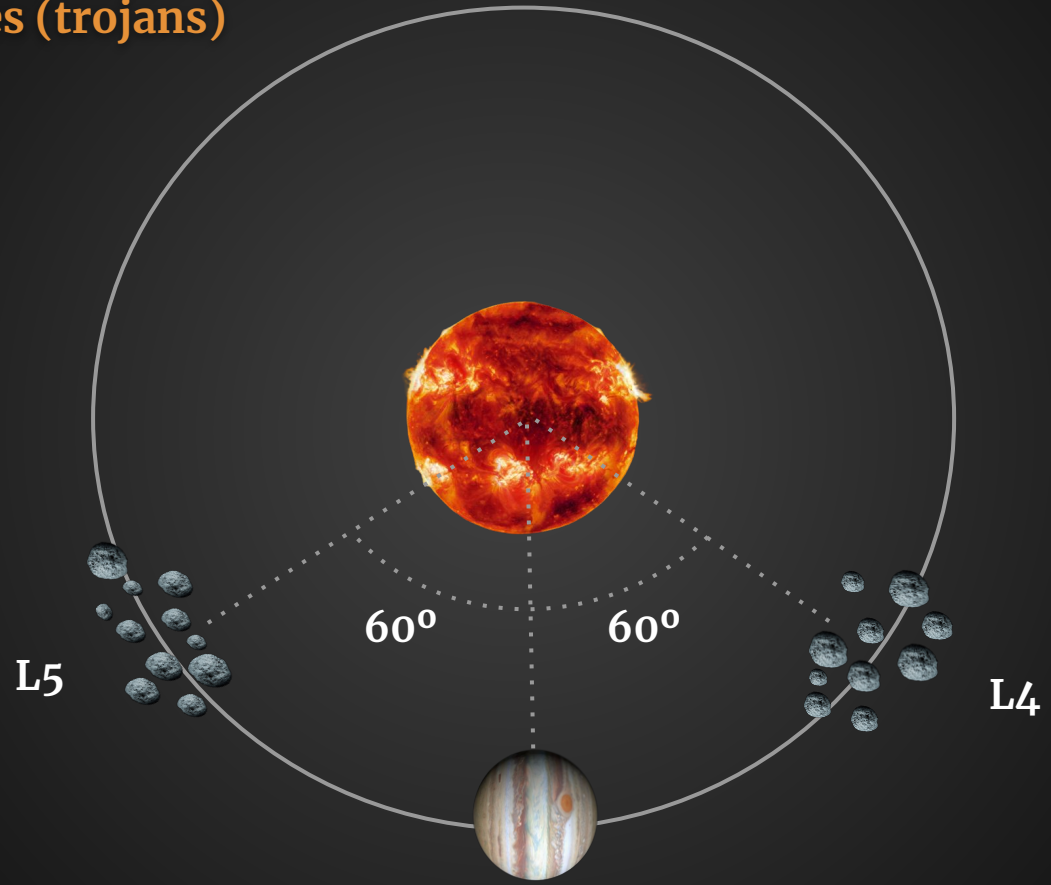
In the search for exotrojan planets

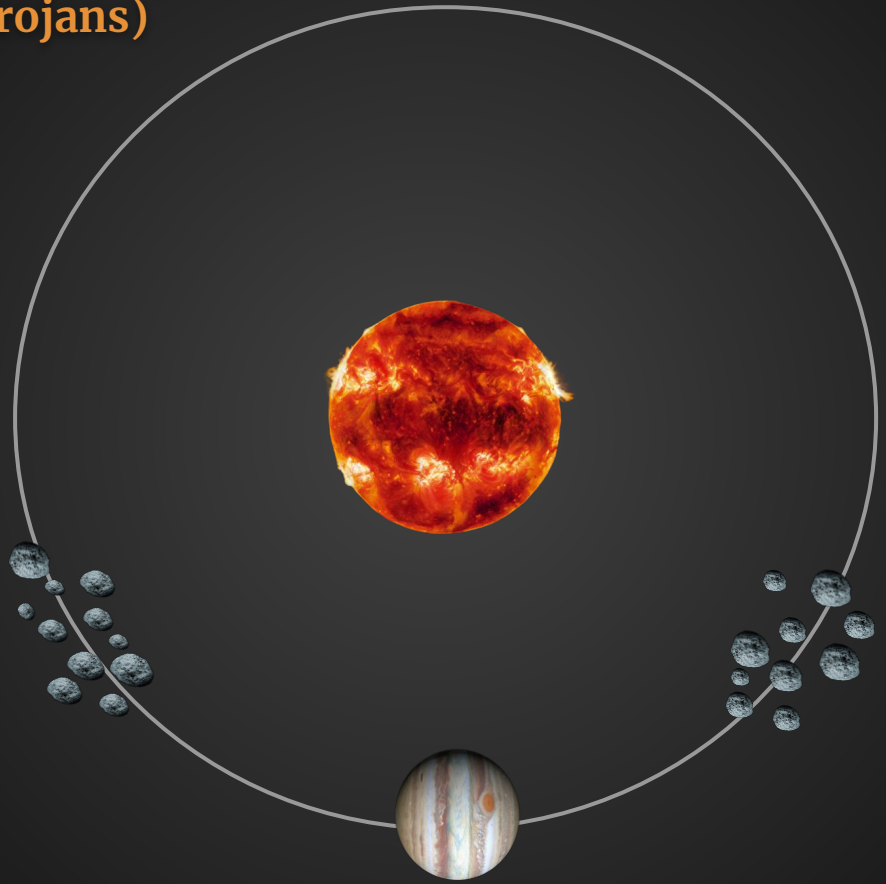
Olga **Balsalobre-Ruza**
obalsalobre@cab.inta-csic.es

PhD Supervisors: Jorge **Lillo-Box** & Nuria **Huélamo**

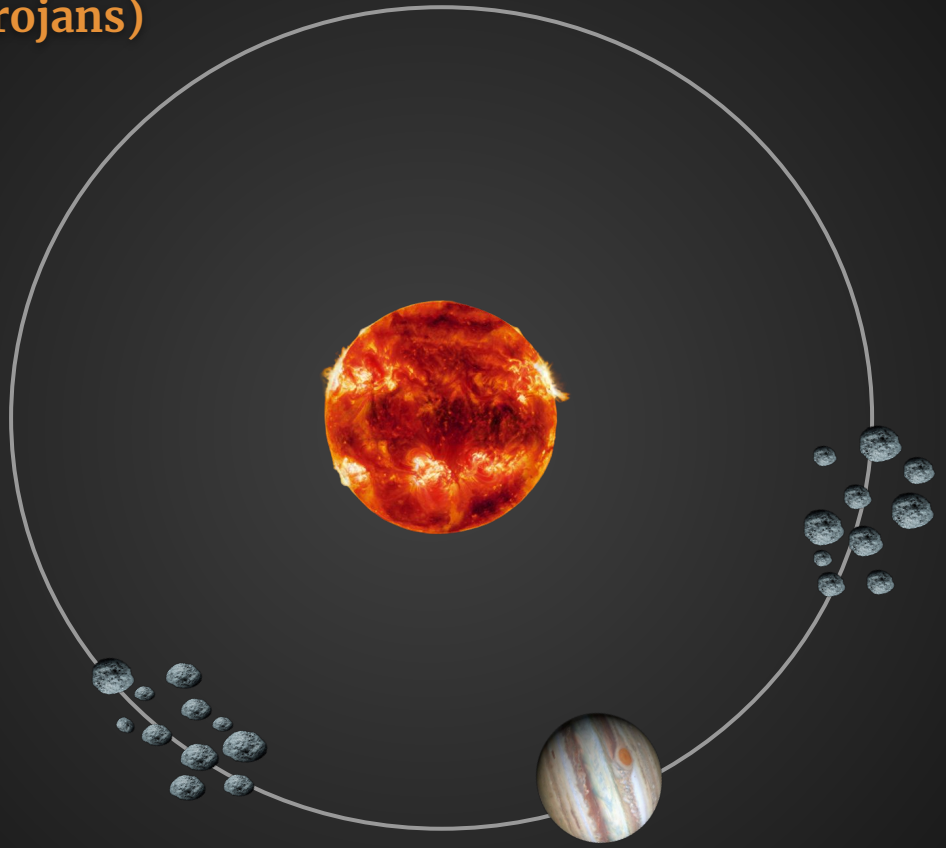
Co-orbital bodies (trojans)



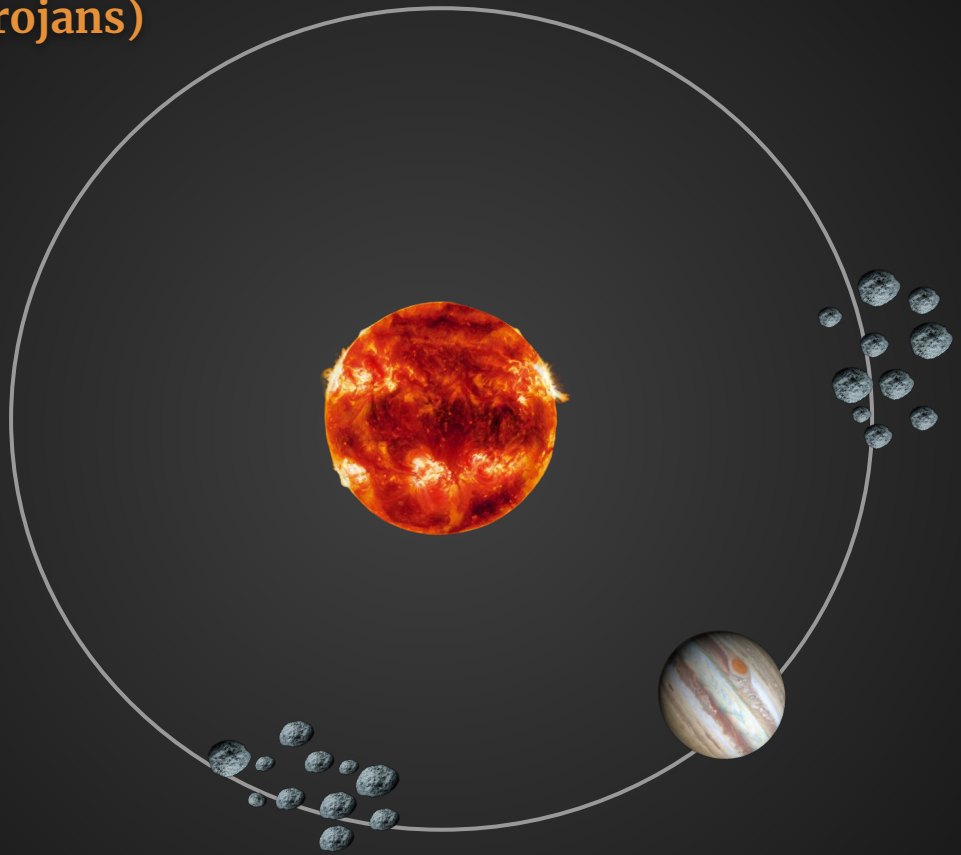
Co-orbital bodies (trojans)



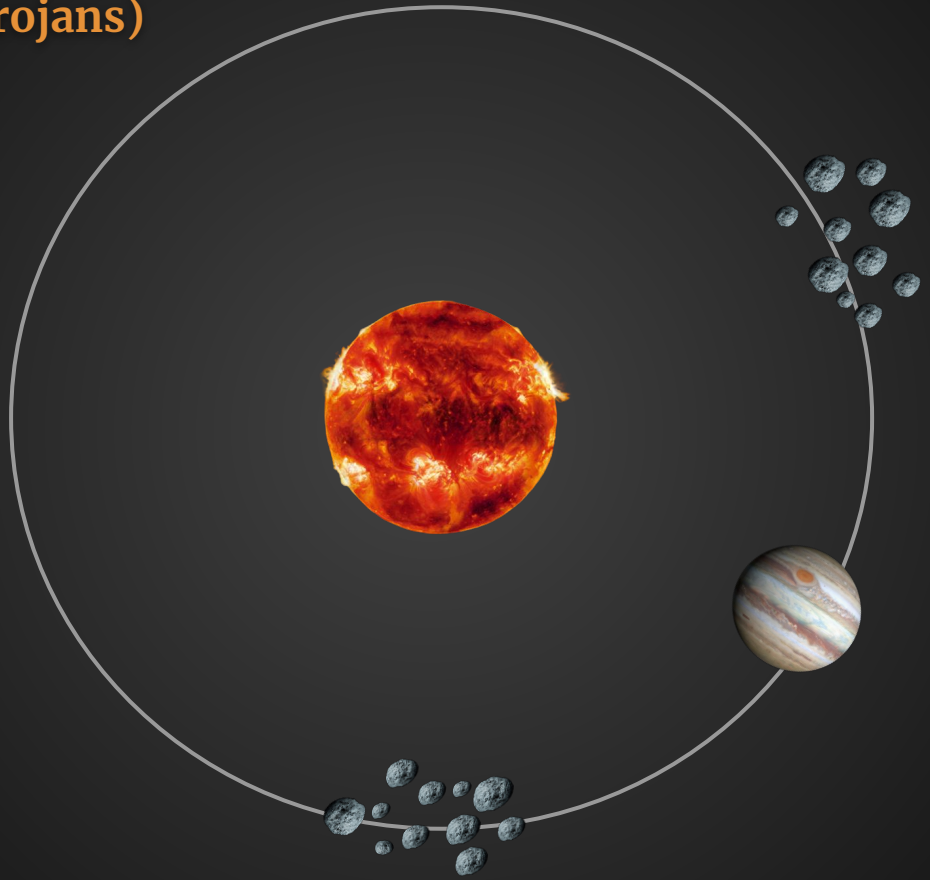
Co-orbital bodies (trojans)



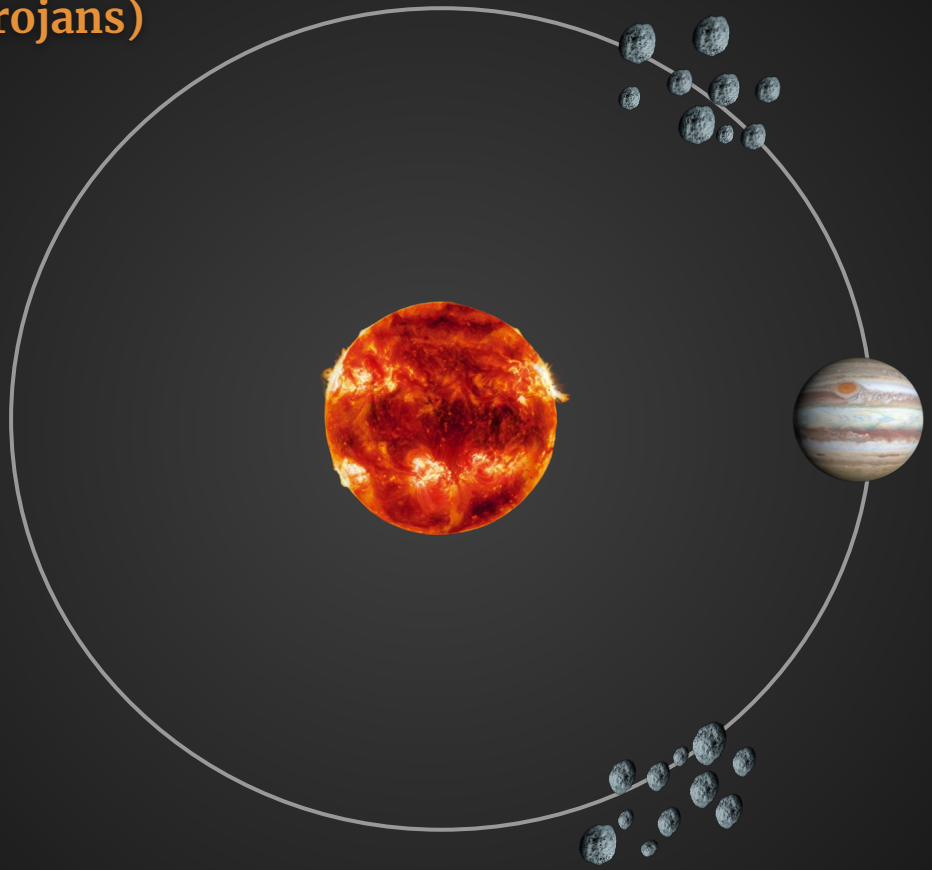
Co-orbital bodies (trojans)



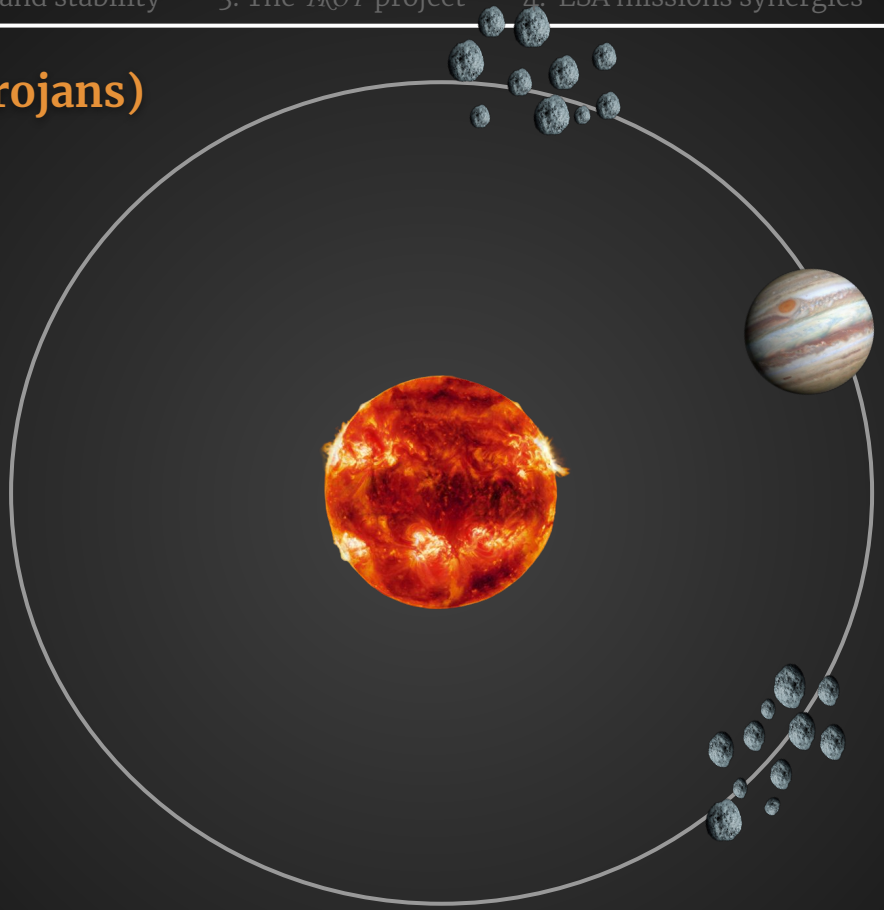
Co-orbital bodies (trojans)



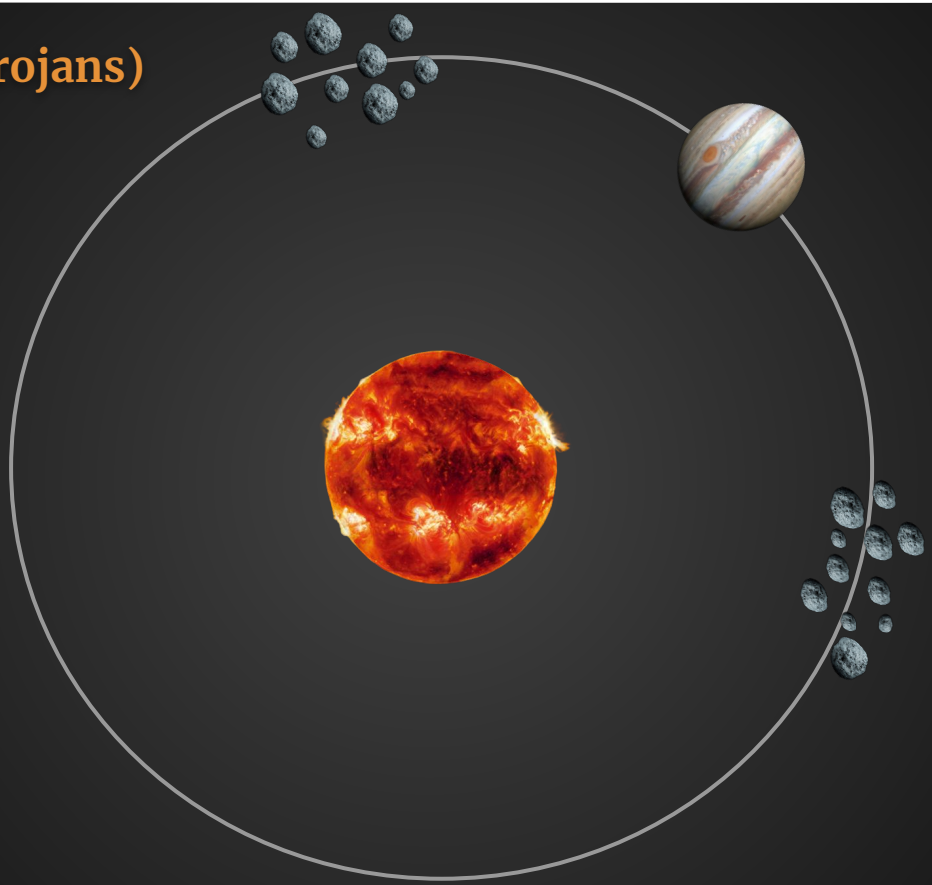
Co-orbital bodies (trojans)



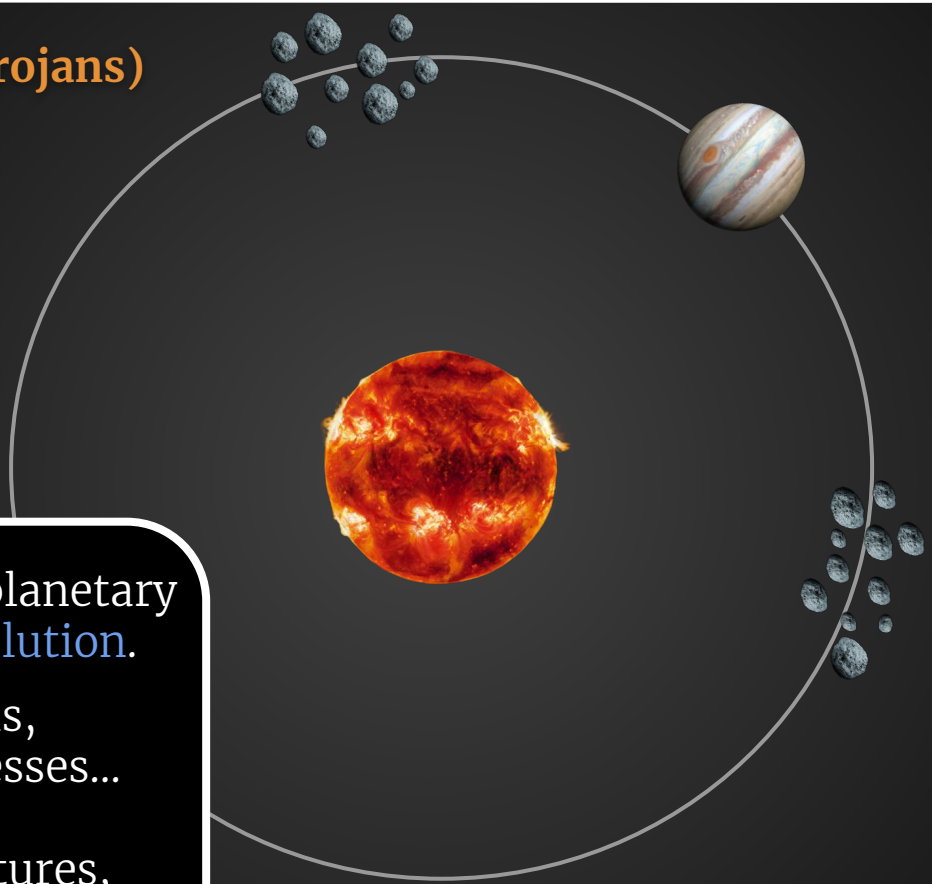
Co-orbital bodies (trojans)



Co-orbital bodies (trojans)



Co-orbital bodies (trojans)

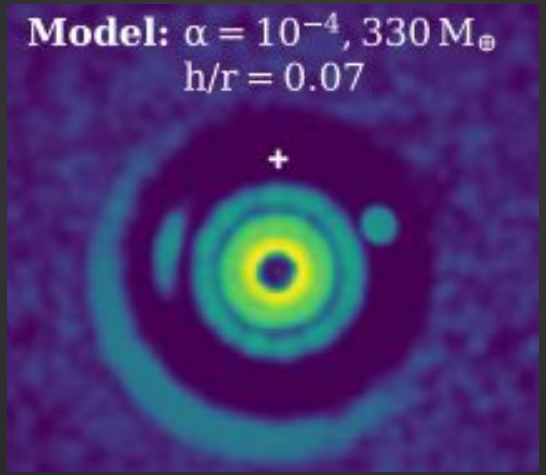


They are tracers of planetary formation and evolution.

- Initial conditions, materials, processes...
- Migrations, captures, instabilities...

In situ

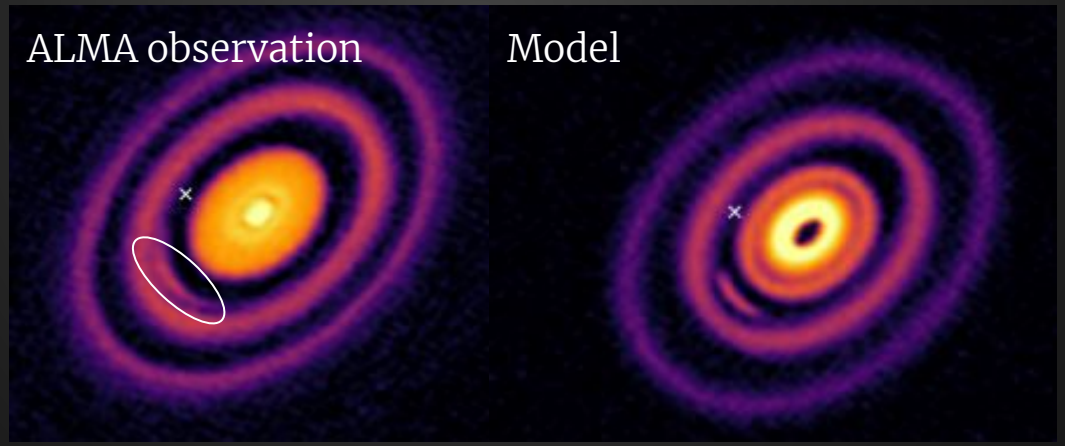
- **Hydrodynamical models** show accumulation in the Lagrangian points of protoplanets (e.g., Zhang et al., 2018; Montesinos et al., 2020)



In situ

- **Hydrodynamical models** show accumulation in the Lagrangian points of protoplanets (e.g., Zhang et al., 2018; Montesinos et al., 2020)

- Hints of dust trapping in a Lagrangian point in **HD 163296** (Andrews et al., 2018; Isella et al., 2018; Rodenkirch et al., 2021)

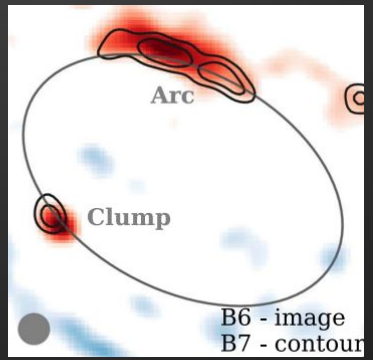


In situ

- **Hydrodynamical models** show accumulation in the Lagrangian points of protoplanets (e.g., Zhang et al., 2018; Montesinos et al., 2020)

- Hints of dust trapping in a Lagrangian point in **HD 163296** (Andrews et al., 2018; Isella et al., 2018; Rodenkirch et al., 2021)

- Emission detection at **10σ** with ALMA strongly compatible with dust in **L4 and L5** of an undetected planet in **LkCa 15** (Long et al., 2022)

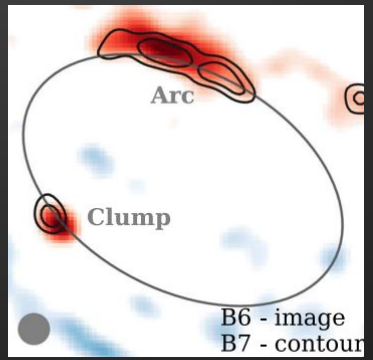


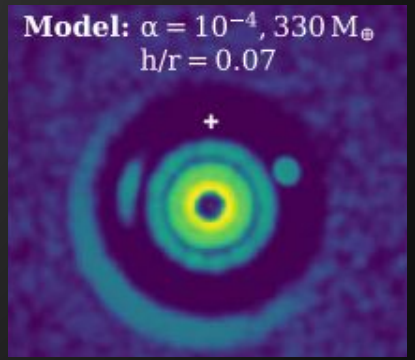
In situ

- **Hydrodynamical models** show accumulation in the Lagrangian points of protoplanets (e.g., Zhang et al., 2018; Montesinos et al., 2020)

- Hints of dust trapping in a Lagrangian point in **HD 163296** (Andrews et al., 2018; Isella et al., 2018; Rodenkirch et al., 2021)

- Emission detection at **10σ** with ALMA strongly compatible with dust in **L4 and L5** of an undetected planet in **LkCa 15** (Long et al., 2022)





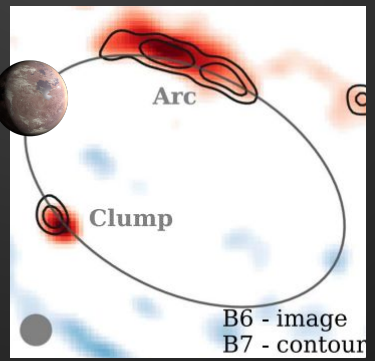
In situ

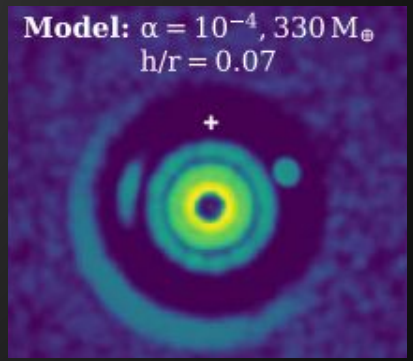
- **Hydrodynamical models** show accumulation in the Lagrangian points of protoplanets (e.g., Zhang et al., 2018; Montesinos et al., 2020)

- Hints of dust trapping in a Lagrangian point in **HD 163296** (Andrews et al., 2018; Isella et al., 2018; Rodenkirch et al., 2021)

- Emission detection at **10σ** with ALMA strongly compatible with dust in **L4 and L5** of an undetected planet in **LkCa 15** (Long et al., 2022)

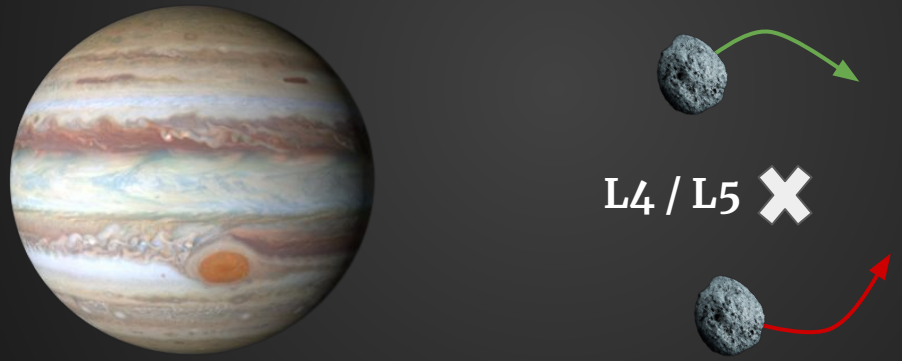
Indirect method for detecting protoplanets **below the detection limit** !!!





Captures

- Co-orbitals in **retrograde** and/or **inclined orbits** in the Solar System (e.g, Wiegert et al., 2017; Namouni & Morais, 2017)



Captures

- Co-orbitals in **retrograde** and/or **inclined orbits** in the Solar System (e.g, Wiegert et al., 2017; Namouni & Morais, 2017)

- Simulations show that **migrations** can **partially deplete** from local trojans **but also** they are able to **capture** and retain new ones (Lykawka et al., 2010)

Stability condition

(Laughlin & Chambers, 2002)

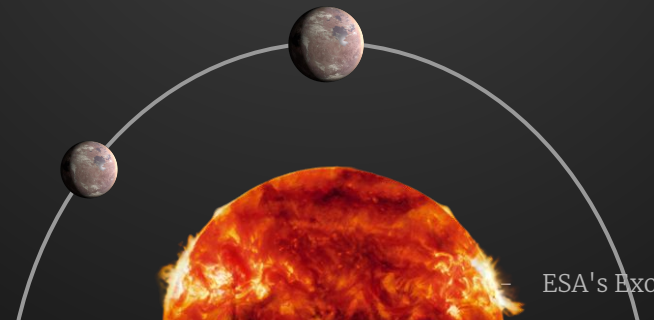
$$27\,(m_{trojan} + m_{planet}) < M_{star}$$

Stability condition

(Laughlin & Chambers, 2002)

$$27\,(m_{trojan} + m_{planet}) < M_{star}$$

Soft constraint that allows similar co-orbital masses !

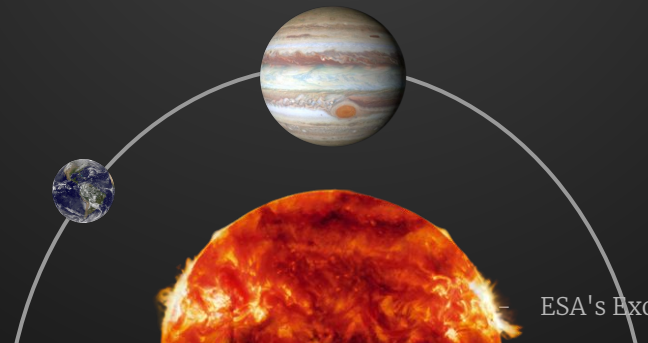


Stability condition

(Laughlin & Chambers, 2002)

$$27\,(m_{trojan} + m_{planet}) < M_{star}$$

Soft constraint that allows similar co-orbital masses !



The *TROY* project

1. Genesis
2. Stability
3. Detection

The *TROY* project

1. Genesis
2. Stability
3. **Detection**

Detection method: Radial velocities (RVs) + transit data from a confirmed planet

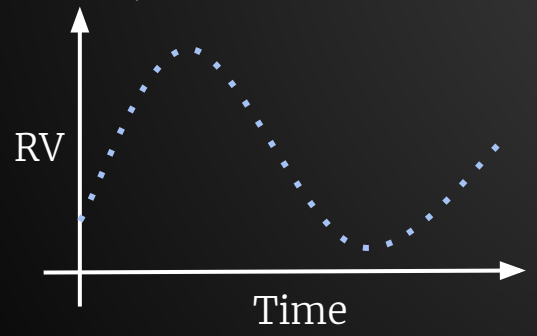
(Leleu et al., 2017)

The TROY project

1. Genesis
2. Stability
3. **Detection**

Detection method: Radial velocities (RVs) + transit data from a confirmed planet

(Leleu et al., 2017)



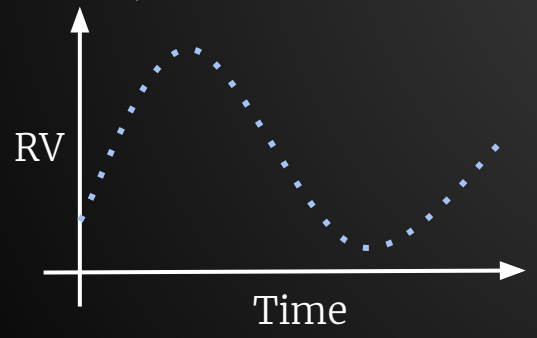
$$\alpha \propto m_{trojan}/m_{planet}$$

The TROY project

1. Genesis
2. Stability
3. **Detection**

Detection method: Radial velocities (RVs) + transit data from a confirmed planet

(Leleu et al., 2017)



$$\alpha \propto m_{trojan}/m_{planet}$$

- $< 0 \rightarrow$ L4
- $= 0 \rightarrow$ No trojan
- $> 0 \rightarrow$ L5

The TROY project

(Lillo-Box et al., 2018a)

SAMPLE

- Confirmed planets
- Transits + precise RVs
- Hot-Jupiters (m_{planet} > 10 $M_{\oplus}$, P < 5 days)

46 systems

The TROY project

(Lillo-Box et al., 2018a)

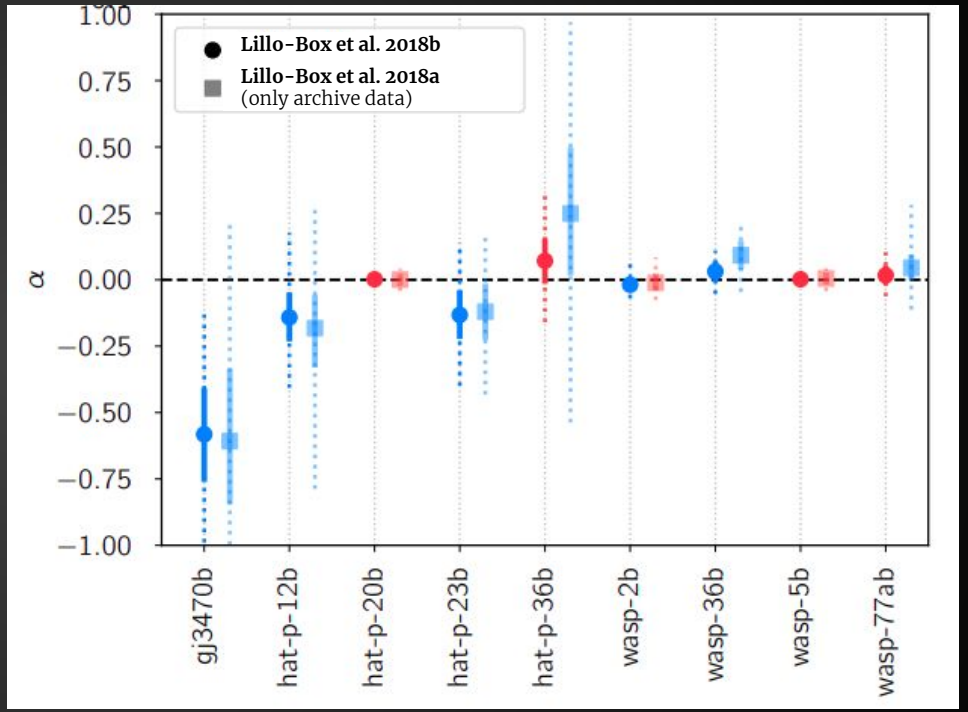
SAMPLE

- Confirmed planets
- Transits + precise RVs
- Hot-Jupiters (m_{planet} > 10 $M_{\oplus}$, P < 5 days)

46 systems

9 candidates ($\alpha \neq 0$ at 1σ)

(Lillo-Box et al., 2018b)



The TROY project

(Lillo-Box et al., 2018a)

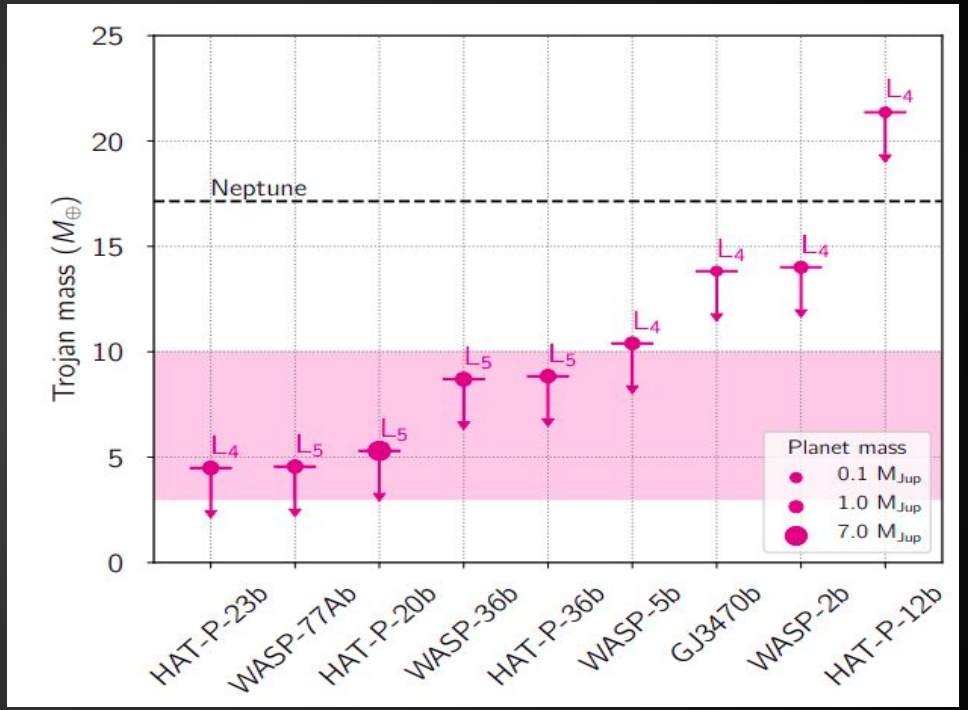
SAMPLE

- Confirmed planets
- Transits + precise RVs
- Hot-Jupiters (m_{planet} > 10 $M_\oplus$, P < 5 days)

46 systems

9 candidates ($\alpha \neq 0$ at 1σ)

(Lillo-Box et al., 2018b)



The TROY project

(Lillo-Box et al., 2018a)

SAMPLE

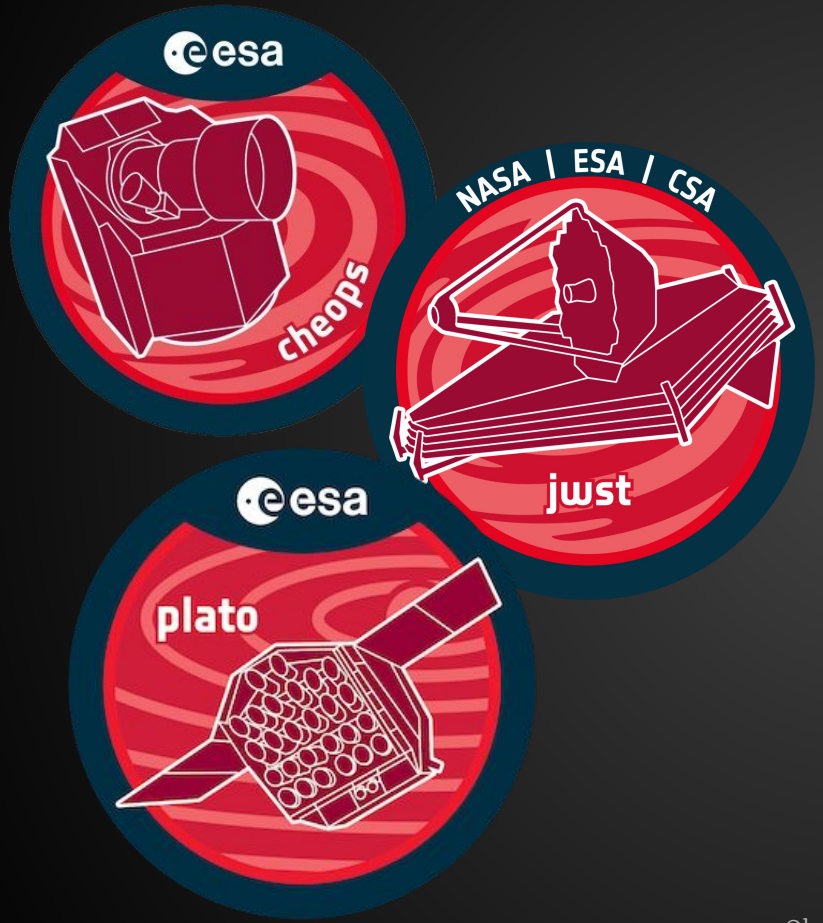
- Confirmed planets
- Transits + precise RVs
- Hot-Jupiters (m_{planet} > 10 $M_{\oplus}$, P < 5 days)

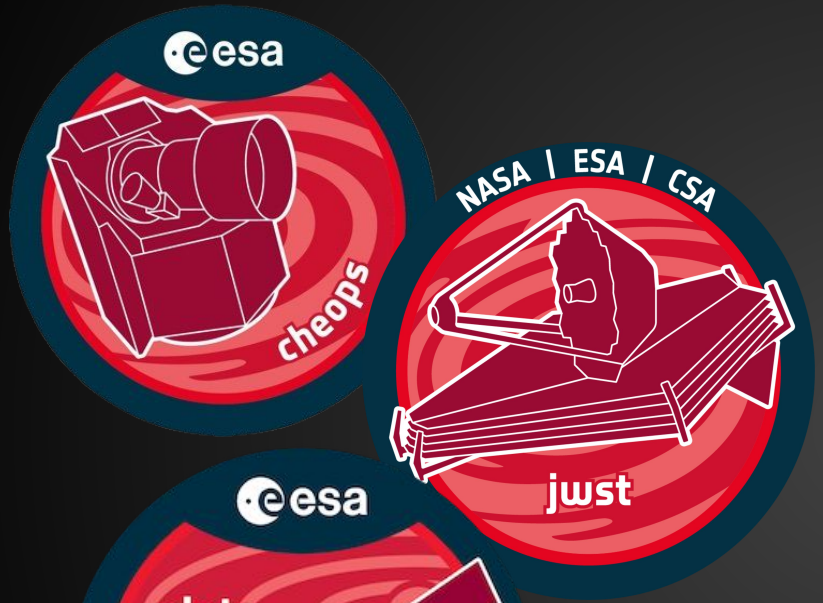
46 systems
9 candidates ($\alpha \neq 0$ at 1σ)

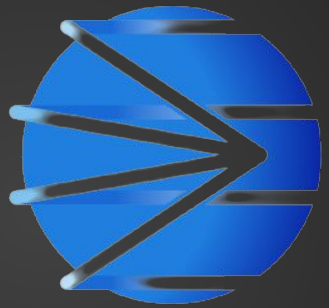
(Balsalobre-Ruza et al., in prep.)

SAMPLE

- Confirmed planets
- Transits + precise RVs
- ~~Hot-Jupiters (m_{planet} > 10 $M_{\oplus}$, P < 5 days)~~
- T_{eff} < 4600 K


esa
cheops
NASA | ESA | CSA
jwst
esa
plato





LIFE

LARGE INTERFEROMETER FOR EXOPLANETS