WHY TO STUDY FORMATION OF PLANETS AROUND SMALL STARS?
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WHY TO STUDY FORMATION OF PLANETS AROUND SMALL STARS?

‣ Small stars are the most common
WHY TO STUDY FORMATION OF PLANETS AROUND SMALL STARS?

- Small stars are the most common
- Rocky planets might be ubiquitous around them
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- The habitable zone around small stars is closer in and their planets easier to be detected
WHY TO STUDY FORMATION OF PLANETS AROUND SMALL STARS?

- Small stars are the most common
- Rocky planets might be ubiquitous around them
- The habitable zone around small stars is closer in and their planets easier to be detected
- The formation of these systems is poorly known
HOW DO PLANETS AROUND SMALL STARS FORM?
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How do planets around small stars form?

- Compact systems, planets with short periods

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HOW DO PLANETS AROUND SMALL STARS FORM?

- Compact systems, planets with short periods
- Most planets are rocky with very little gas
HOW DO PLANETS AROUND SMALL STARS FORM?

- Compact systems, planets with short periods
- Most planets are rocky with very little gas
- Mass ratio close to the one found in satellites systems
MODEL FOR FORMATION OF PLANETS AROUND SMALL STARS

Method

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Population synthesis model developed for studying formation of Galilean Satellites (Miguel & Ida, 2016; Miguel+2019):
MODEL FOR FORMATION OF PLANETS AROUND SMALL STARS

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  - The disk evolves (accretion of embryos & gas drag)
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  - It includes type I and II migration
  - The disk evolves (accretion of embryos & gas drag)
  - Planets can be trapped in regions of zero net torque
  - They can be trapped in resonances
  - They can further evolve through close encounters and collisions after gas dissipation

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Results

MASSES & SEMI-MAJOR AXIS OF THE PLANETS FORMED

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TRAPPIST-1 system
YZ Cet system
GJ3323 system
LHS1140 system
Teegarden system
Proxima Cen b
GJ1214 b
GJ1132 b
Ross128 b
GJ 3512 b

Miguél+2019

M_{planet}/M_{⊕} vs. a [AU]

M_{planet}/M_{⊕} = 0.1, 1, 10, 100

a [AU] = 0.01, 0.1, 1, 10

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Results

MASSES & SEMI-MAJOR AXIS OF THE PLANETS FORMED

~4000 Planetary Systems
After $10^8$ years

Miguel+2019

Graph showing the relationship between $M_{\text{planet}}/M_\oplus$ and $a \ [\text{AU}]$ with $H_2O \%$ as a color scale.

TRAPPIST-1 system, YZ Cet system, GJ3323 system, LHS1140 system, Teegarden system, Proxima Cen b, GJ1214 b, GJ1132 b, Ross128 b, GJ 3512 b

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MASSES & SEMI-MAJOR AXIS OF THE PLANETS FORMED

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DISKS & STELLAR MASSES

Results

TRAPPIST-1 system
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SURFACE CHARACTERISATION WITH ARIEL?
SURFACE CHARACTERISATION WITH ARIEL?

Results

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Hu+2012

Normalized Reflectivity + Offset vs λ [microns]

Lunar Mare
Lunar Highlands
Mercury
Mars
Mars Dark Regions

Fe²⁺, Fe³⁺, H₂O, CO₂, OH
SURFACE CHARACTERISATION WITH ARIEL?

Results

Hu+2012

Graph showing the relationship between $F_p / F_*$ and $\lambda$ for various compositions at different temperatures. The composition types include Metal-rich (1100K), Ultramafic (1117K), Feldspathic (1019K), Basaltic (1077K), Granitoid (1018K), Clay (909K), and Fe-oxidized (1094K) at microns. The graph is labeled Kepler-20 f.
SURFACE CHARACTERISATION WITH ARIEL?

Results

Hu+2012

Kepler-20 f

Kreidberg+2019

LHS 3844b

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Population synthesis model – for the Galilean Satellites—applied to planet formation around small stars (Miguel+2019)

Compact systems with many planets

\( M_* > 0.07 \, M_\odot \) are needed to form planets larger than Mars

and \( M_{\text{disks}} > 0.01 \, M_\odot \), either disks are more massive than thought or large exoplanets form with pebbles?

Planets are mostly rocky & icy, with no gas, because they don’t start gas accretion

These planets might have no atmosphere, but we might be able to characterise their surfaces with ARIEL

Yamila Miguel

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TAKE HOME MESSAGES

- Population synthesis model – for the Galilean Satellites— applied to planet formation around small stars (Miguel+2019)
- Compact systems with many planets
- $M_{\star} > 0.07 M_{\odot}$ are needed to form planets larger than Mars
- and $M_{\text{disks}} > 0.01 M_{\odot}$, either disks are more massive than thought or large exoplanets form with pebbles?
- Planets are mostly rocky & icy, with no gas, because they don’t start gas accretion
- These planets might to characterise their surfaces with ARIEL

Collaborators: Alex Cridland, Chris Ormel, Jonathan Fortney & Shigeru Ida

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