The PLATO mission: Brazil chasing exoplanets

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O BRASIL NO ESPAÇO COM O SATÉLITE PLATO: ENGENHARIA & ASTROBIOLOGIA

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**PLATO** = **P**lanetary **T**ransits and **O**scillations of stars

**ESA**’s *Cosmic Vision 2015 - 2025* medium-class mission

launch in 2026, **SOYUZ** (Kourou)

> 2.000 kg, 1.2 billion Euros

**Orbit:** Sun-Earth **L2** ⇒ 4.5 years
PLATO’s orbit

... In Lagrange’s Sun-Earth L2 point

Why is that?
Because it is a most stable spot in the Solar System
PLATO’S mounting scheme
26 ~ 30 cm telescopes
≈ 3 m equivalent diameter
detection and characterization of Earths
around stars up to V = 11

KEPLER: 105 sq degrees
PLATO: 2232 sq degrees
1,000,000 stars will be observed
Equivalent diameter of a ≈ 3 m dish

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NASA’s KEPLER satellite:

There are in the Milky-Way about

6 BILLION EARTH-LIKE PLANETS

Orbiting Solar-type stars

(Kunimoto & Mathews 2020)

ASTROBIOLOGIA
What will do PLATO?

- search mainly for Earth-like exoplanets orbiting nearby stars
- Determine accurate physical properties of the host stars through seismology
- planetary parameters will be known with unprecedented precision:
  - 2% in $R$
  - 4-10% in $M$
  - 10% in age
And how will **PLATO** detect exoplanets?

- by the "transit method":

When *transiting* in front of a star, the planet makes a small eclipse.

The eclipse’s depth is proportional to the planet/star surface ratio.
Current status of planet detection

Red dots = planets with M and R determined. Blue dots = RV detections with Msini limits.

(PLATO mission.com)
Super Earth exoplanets (1 < M_{planet} ≤ 10 M_{Earth} or R_{planet} ≤ 3 R_{Earth}) for different host star masses with respect to the position of the Habitable Zone (in green). Black dashed line: current max distance of super Earths with RV and transit measurements. Thin line: most distant planet with transits and TTV. Orange dashed line: distant goal of PLATO for fully characterized (transit + RV) super Earths.
Detectable exoplanets as a function of $V$ mag of host stars
Gray shaded band = prime detection range of PLATO 2.0 ($4<V<11$) for Earth-like planets.
Limit for giant planets $V=16$ (https://sci.esa.int/web/plato)
PLATO & planetary science:

◆ Planets around solar-type stars + intermediate mass stars, subgiant, giants and post-RGB stars ⬤ ⬤ ⬤ ⬤ unprecedently good statistics for formation and evolution of planetary systems

◆ Planet atmospheres: albedos, metallicity, molecular composition, clouds ⬤ ⬤ ⬤ ⬤ identification of best targets for deep spectroscopy

◆ Detection of rings, moons, Trojan, exocomets

◆ First large-scale catalogue of bulk characterized planets with accurate parameters
Mean density vs. Mass diagram

Dashed lines indicate density-mass relationships: green = Jupiter-like; violet = iron; pink = silicate; light blue = water ice. Solar system planets are shown and blue dots are their large moons. Red dots = exoplanet gas giants; orange dots = low-mass exoplanets (Noack et al. 2017)
Predicted Sizes of Different Kinds

Earth Analog

1 Earth mass

5 Earth masses

10,000 miles

https://www.researchgate.net
PLATO can give answers to other questions:

◆ What is the frequency & distribution of rocky planets?

◆ What is the mass limit of gaseous giant cores?

◆ At what distance from the star and when the gas accretion stops?

◆ How the properties of planetary systems depend on the stellar spectrum, its metallicity, chemical composition and age?
Overview of past and future missions relevant for exoplanet characterization (Noack et al. 2017)
The quest for exoplanet masses ("follow-up")

_needed to define the kind of exoplanet we are dealing with: the rocky ones are the more interesting for ASTROBIOLOGY

_needed very high resolution spectrograph needed

Telescopes to which Brazil has access:

ESO’s 3.6 m La Silla telescope: NIRPS spectrograph

Hawaii-Japan-Brazil PLANETS 1.85 m high-tech Haleakala telescope: Echelle spectrograph
Complementary science (1 million stars)

- Binaries: characterization & discovery of low mass companions
- Massive stars, low & intermediate red giants: internal structure and evolution
- Structure & origin of SdB stars
- WDs: seismology in the space era
- Angular moment studies through gravity modes, important for a lot of stellar phenomena: gyrochronology, magnetic activity cycles, stellar dynamos, surface activity, rotation...
Brazilian science with PLATO’s data:

- Stellar rotation & stellar spots
- Stellar seismology of pulsating stars
- T Tauri stars
- Exoplanets: detection, characterization, follow up...
And what Brazilian engineering will do for PLATO? (CoRoT’s heritage)

🌟 Atitude control system + jitter correction + photometric masks (software)
(Polytechnic School, São Paulo University)

🌟 Electronic simulator of the satellite’s imaging system + instrument control unit + hardware data compression (hardware + software)
(Mauá Institute of Technology).
Front cover of *Astronomy & Astrophysics* (July 2019), showing a figure of the paper by Brazilian engineers about the work done with imagery of the PLATO satellite (Marchiori et al. 2019). The entire sky can be seen in galactic coordinates and the observation fields of PLATO (blue), KEPLER (red and green), TESS (yellow ellipses) and CoRoT (pink) are shown for comparison. PLATO observations will cover almost 50% of the sky.
Line-of-sight estimation and control

Aykroyd, Duleba & Fialho, 2020
Stellar sensors using satellite’s fast cameras

These are quite complex software engineering operations. The solutions were accomplished by Brazilian engineers.
Financing the Brazilian participation in **PLATO**:

**FAPESP**’s Thematic project,

About R$ 7 milhões (~ US$ 1.4 Mi) in 4 years.
(equipment, scholarships, travel expenses...)

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Thank you