UNIVERSITY OF TARTU
Tartu Observatory
1632

ARIEL MISSION IN ESTONIA

From stars to exoplanets

Anna Aret

Mihkel Kama, Tõnis Eenmäe, Colin Folsom, Indrek Kolka, Laurits Leedjärv, Heleri Ramler

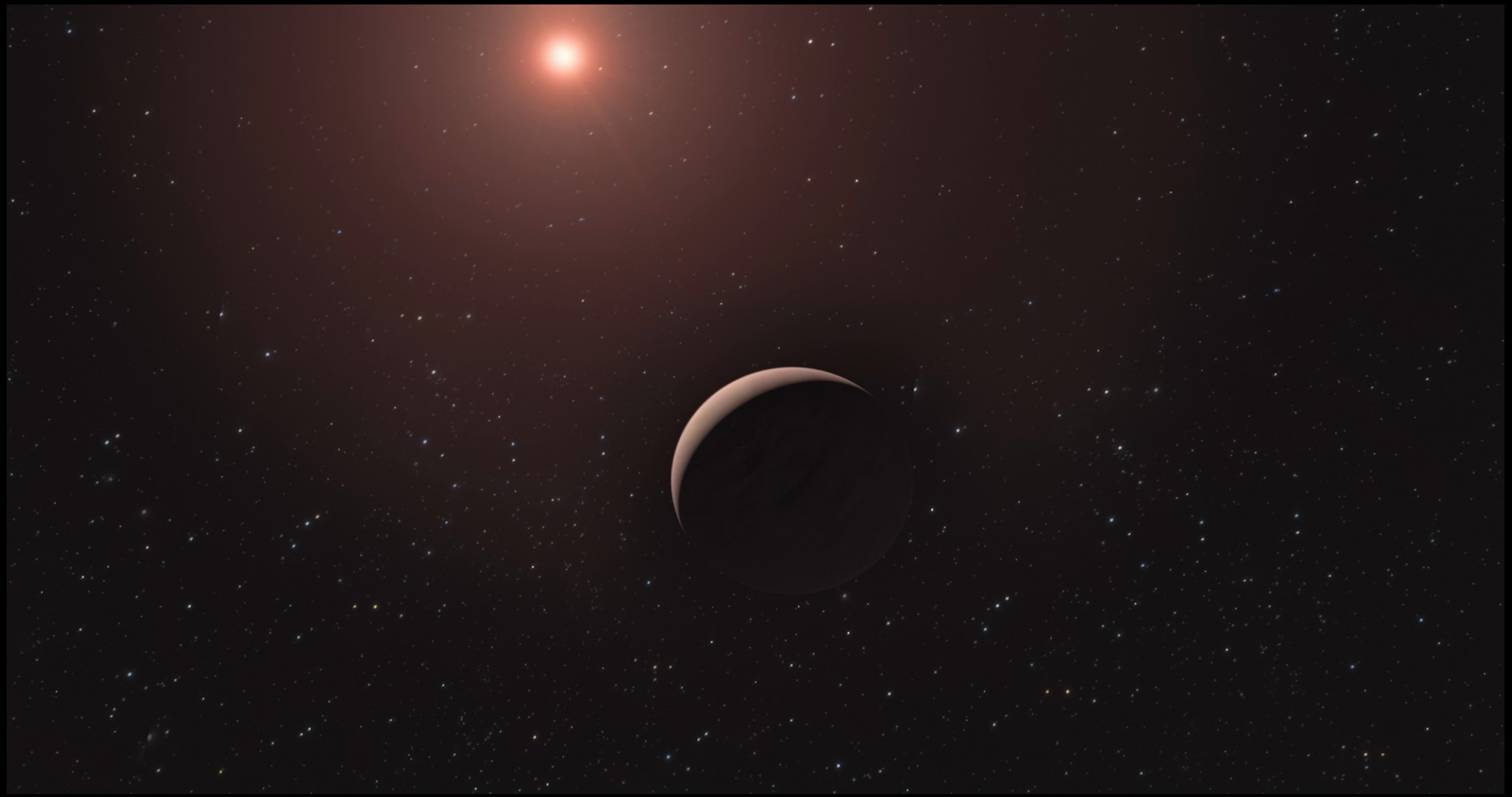
Sandipan Borthakur, Vitalii Checha, Anni Kasikov, Alexandra Lehtmets, Kertu Metsoja, Veronika Mitrokhina

UT Tartu Observatory

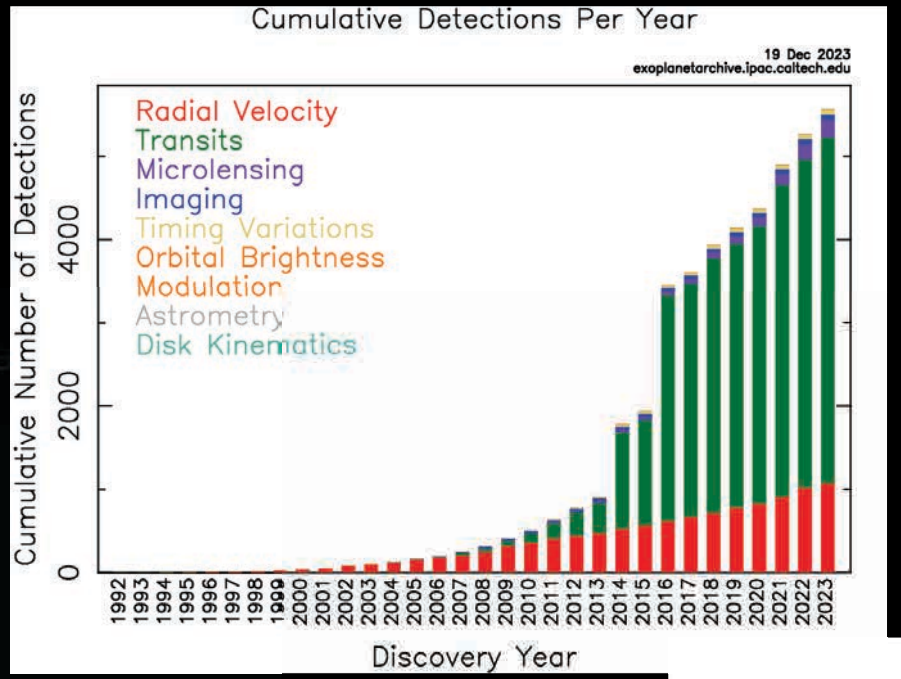
Image credit: Léa Changeat

11/01/2024

An exoplanet is a planet that's orbiting around the star that's not our Sun



Credit: ESO/M. Kornmesser



5 566
Confirmed planets
18.12.2023

Image credit: NASA Exoplanet Archive

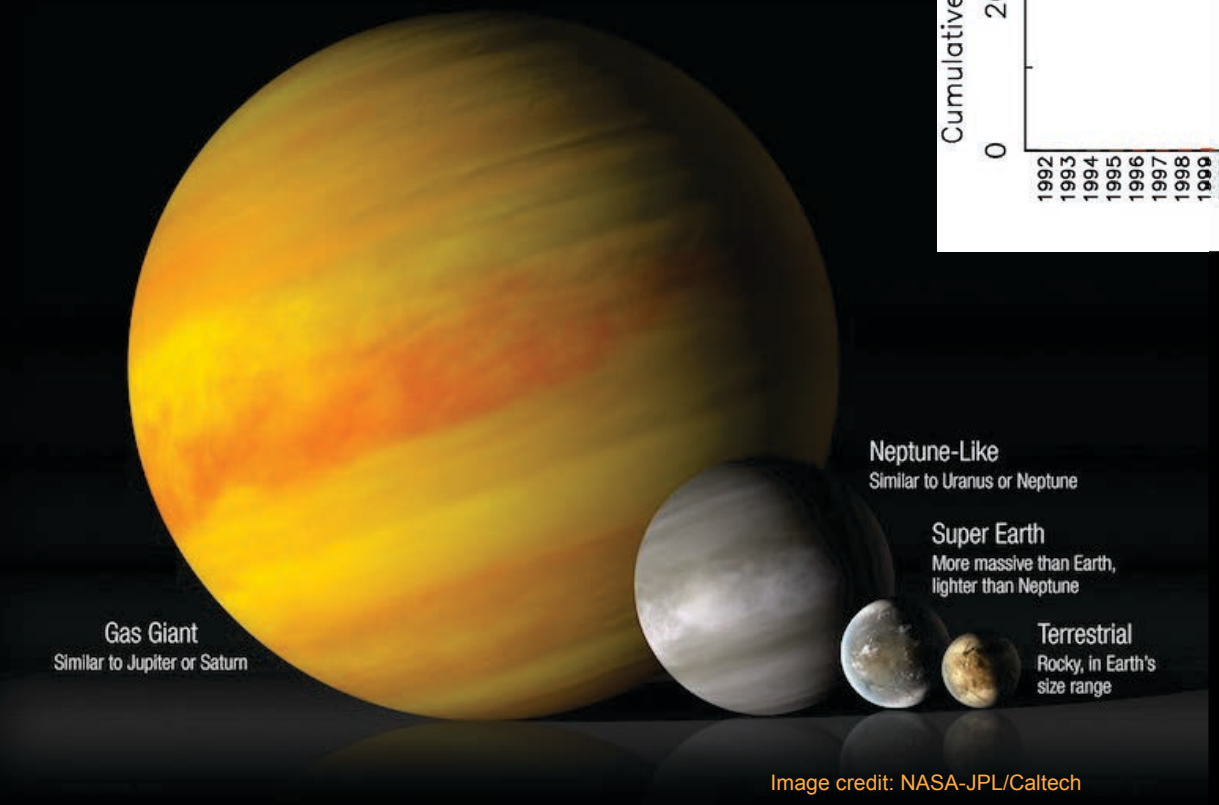
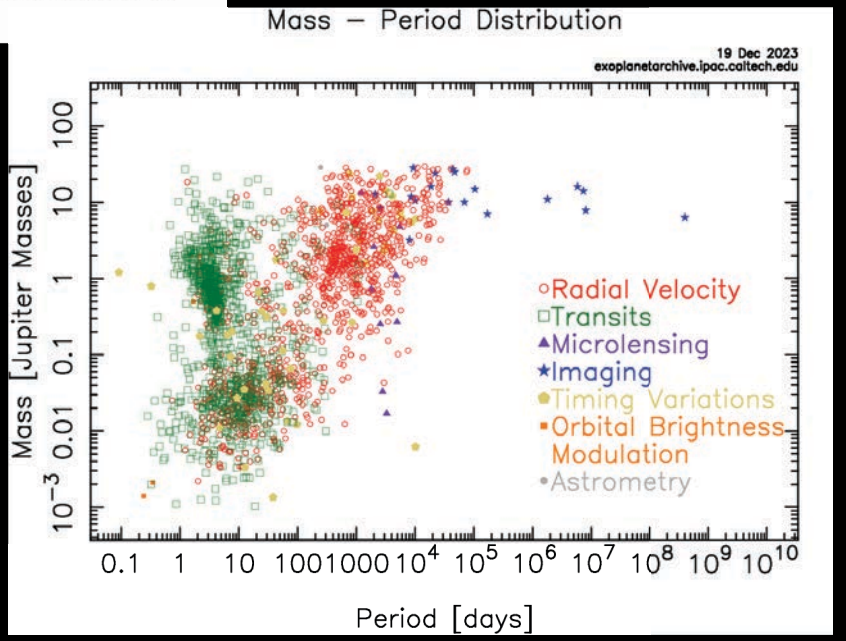
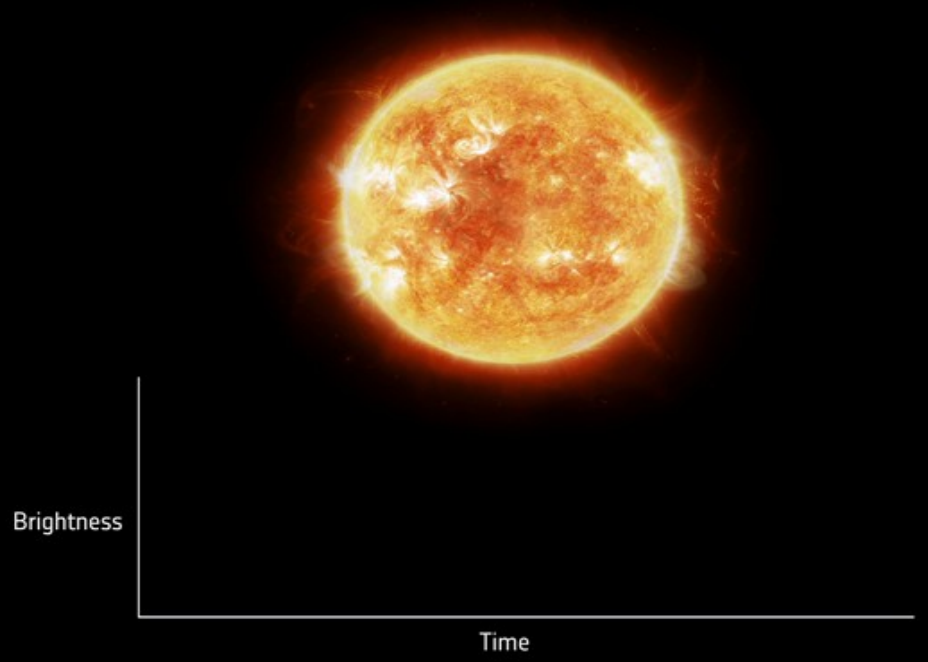


Image credit: NASA-JPL/Caltech



Monitoring exoplanets with the transit method



Credit: ESA

The change in the star's brightness is less than one percent
A planet the size of Earth would cause a 0.008% change in the brightness of the Sun

ARIEL SPACE MISSION

European Space Agency M4 Mission

Key Science Questions

- What are exoplanets made of?
- How do planets and planetary systems form?
- How do planets and their atmospheres evolve over time?

Primary goal

- Large-scale survey of a diverse sample of about 1000 exoplanets

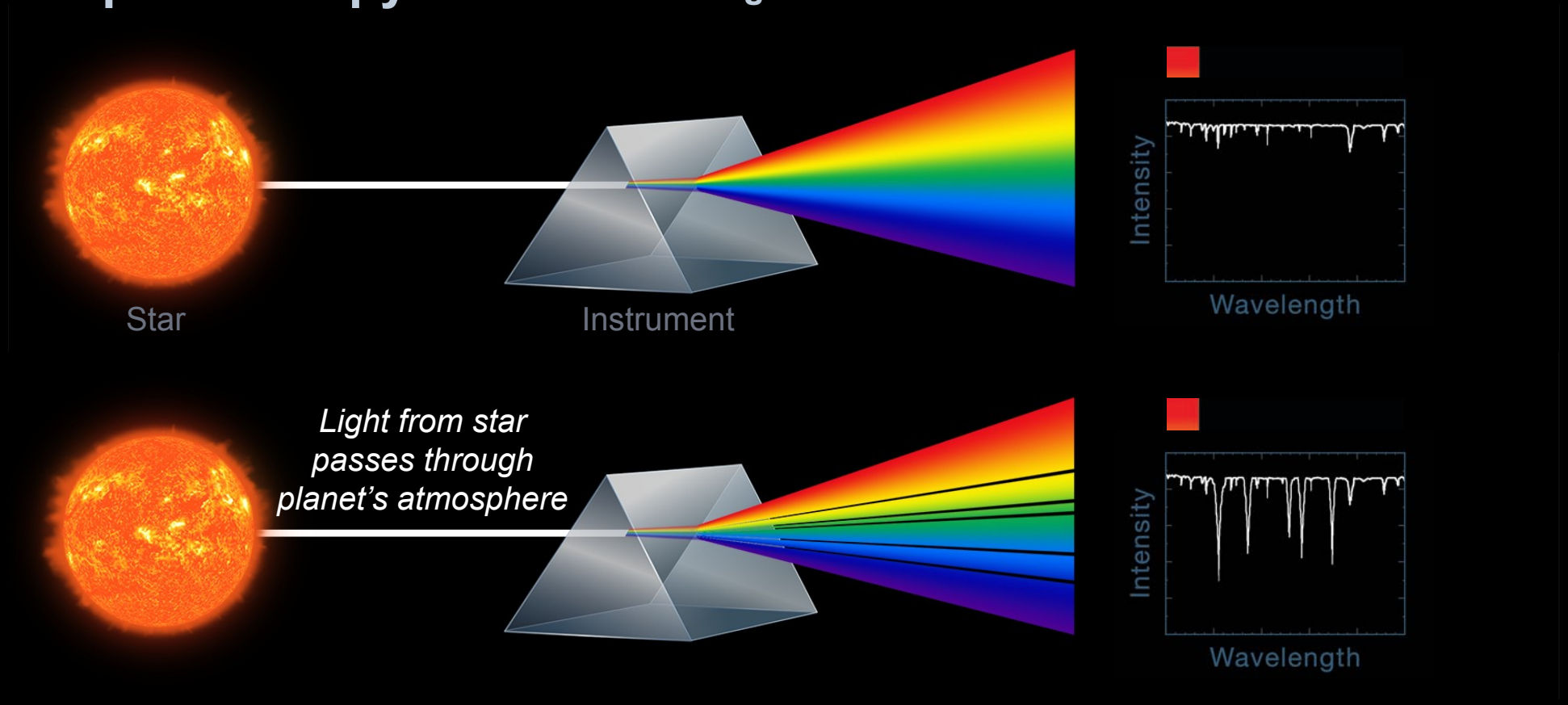
Image credit: Léa Changeat

ARIEL SPACE MISSION

European Space Agency M4 Mission

Exoplanet Communications

Spectroscopy – Detection of Biosignatures



1/10/24

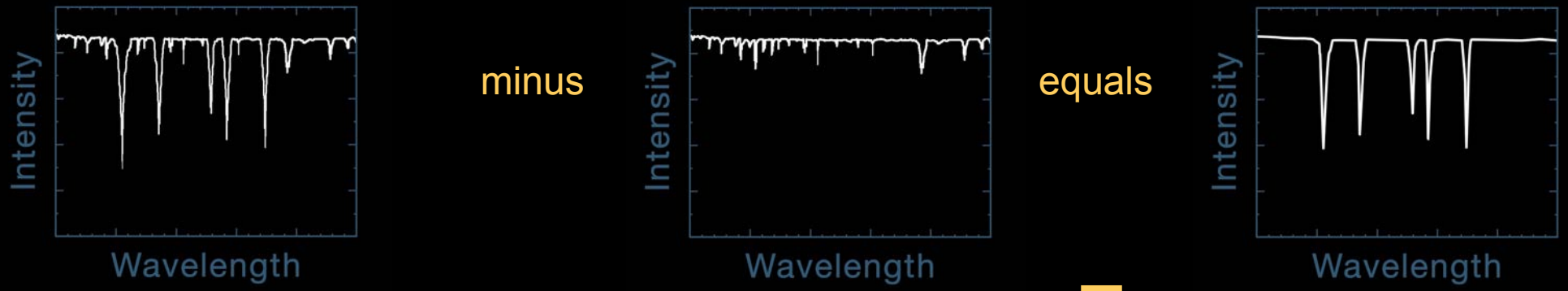
6

ARIEL SPACE MISSION

European Space Agency M4 Mission

Exoplanet Communications

Spectroscopy – Detection of Biosignatures



Light from star & planet

−

Light from star only

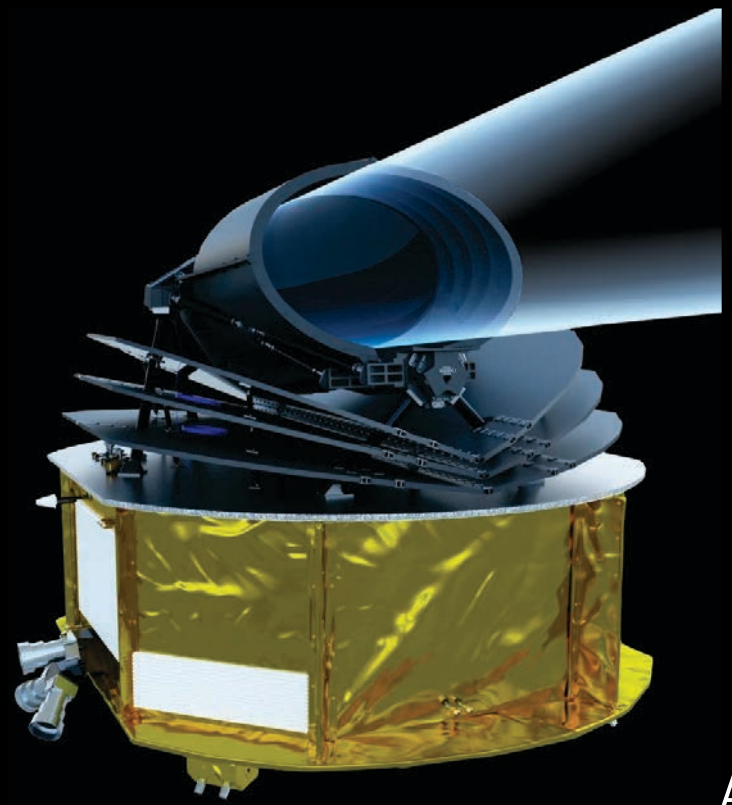
=

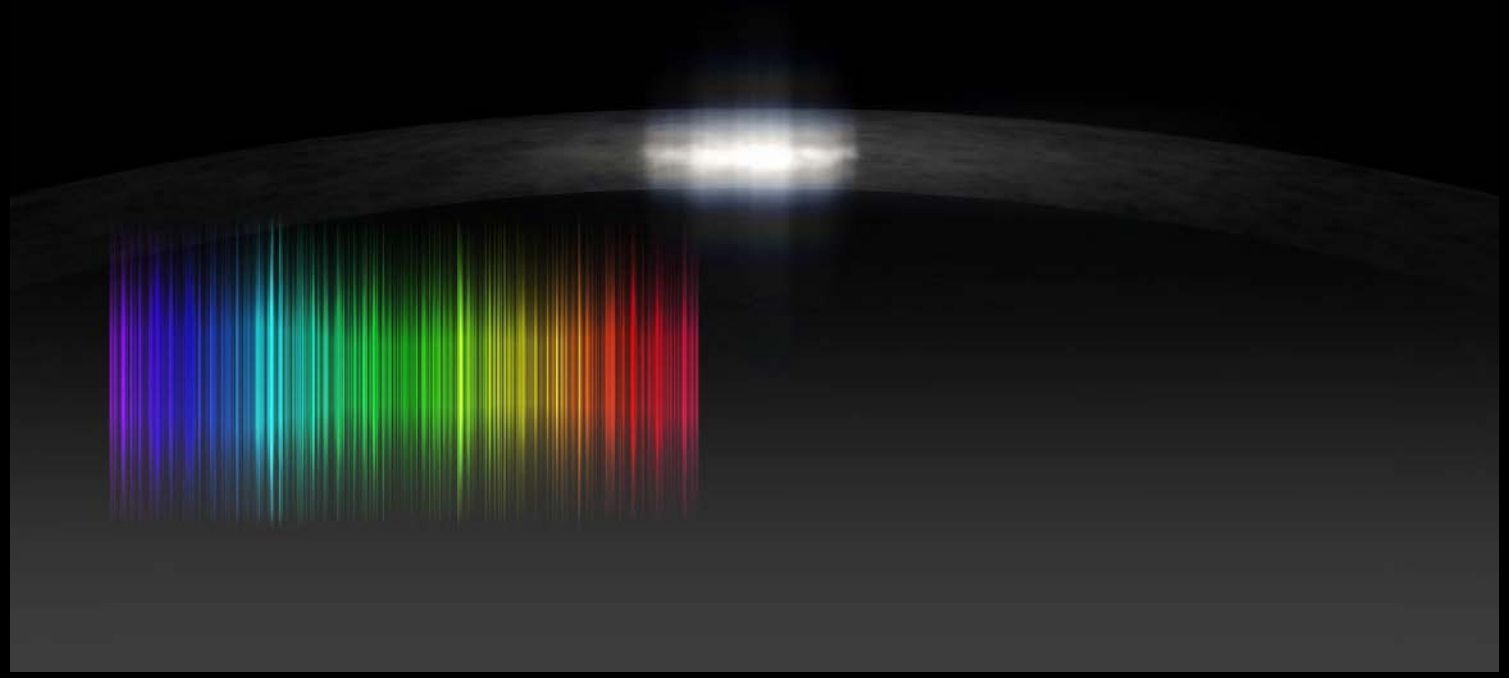
Light from planet only

exoplanets.nasa.gov

ARIEL SPACE MISSION

European Space Agency M4 Mission



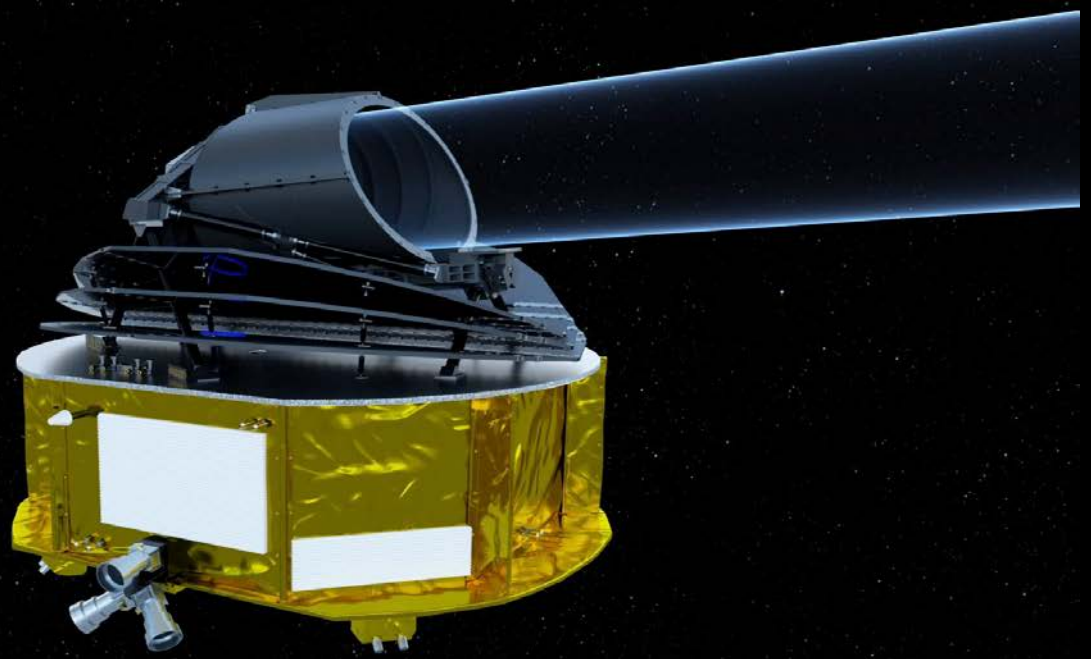


Credit: ESA/STFC RAL Space/UCL/UK Space Agency/ ATG Medialab

Ariel detecting light from a distant star

ARIEL SPACE MISSION

European Space Agency M4 Mission



Payload

Off-axis Cassegrain telescope:
elliptical primary mirror 1.1 x 0.7m

Instrumentation

An infrared spectrometer AIRS:

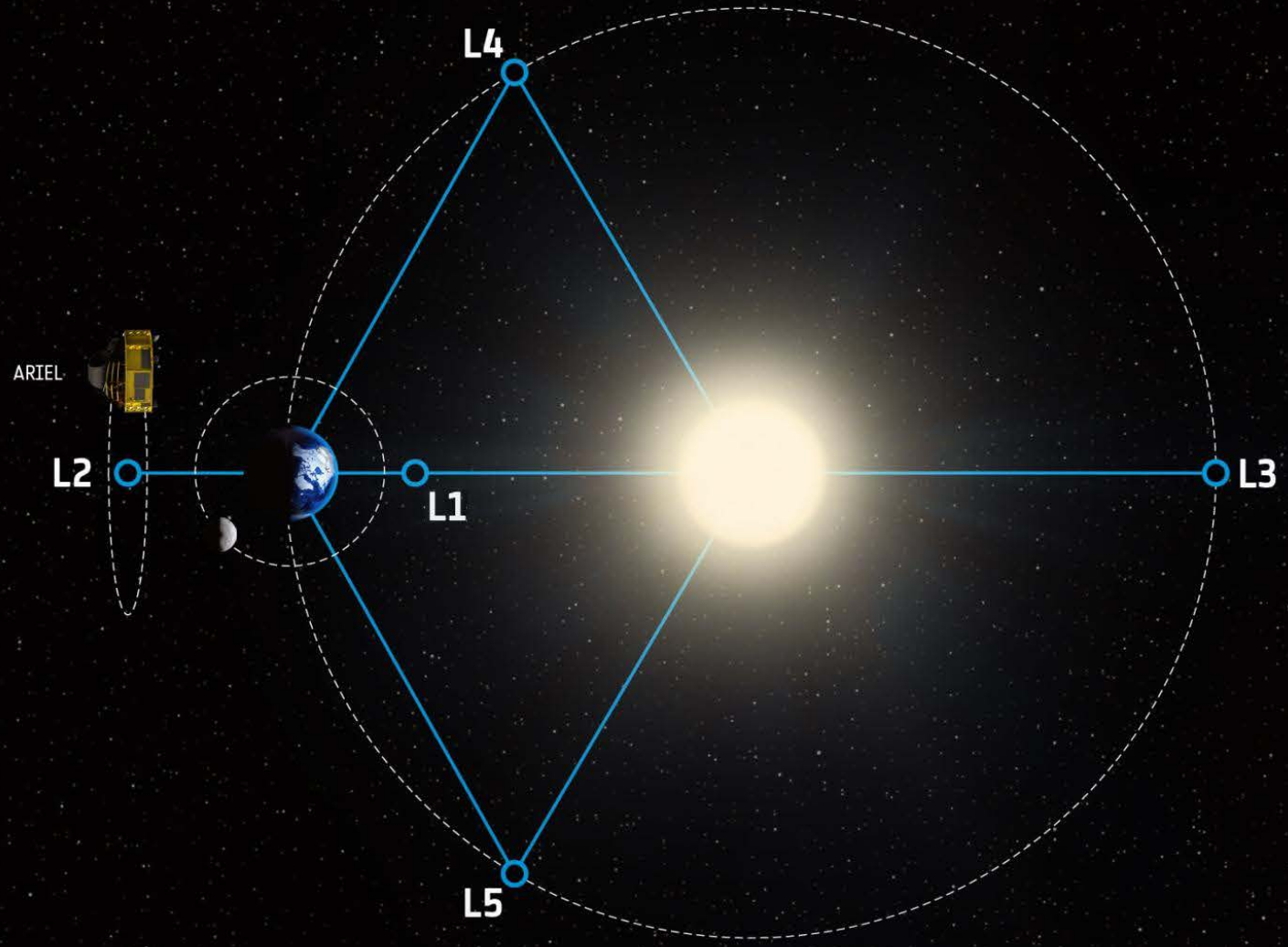
- two medium-resolution channels 1.95-3.9 μm and 3.9-7.8 μm
- one low-resolution channel 1.25-1.95 μm

A Fine Guidance System (FGS) with 3 photometric channels:

- 0.50-0.55, 0.8-1.0, 1.0-1.2 μm

ARIEL SPACE MISSION

European Space Agency M4 Mission



Launch date: 2029

Destination
halo orbit around Sun-Earth Lagrange point L2

Launch vehicle:
Ariane 6. Launch shared with Comet Interceptor

Lifetime:
Nominal 4 year operational timeline,
with a potential extended science operations

Ariel Mission Consortium

Principal Investigator
Giovanna Tinetti (UCL)

Consortium Project Manager
Paul Eccleston (RAL Space)

Consortium co-PI board

Estonia joined in 2019

WP 1: Management & PLM* System Level

WP 9: Science ground segment:
participation in and leadership of
in various science working groups

Science Working Groups

22 WGs working on different scientific topics

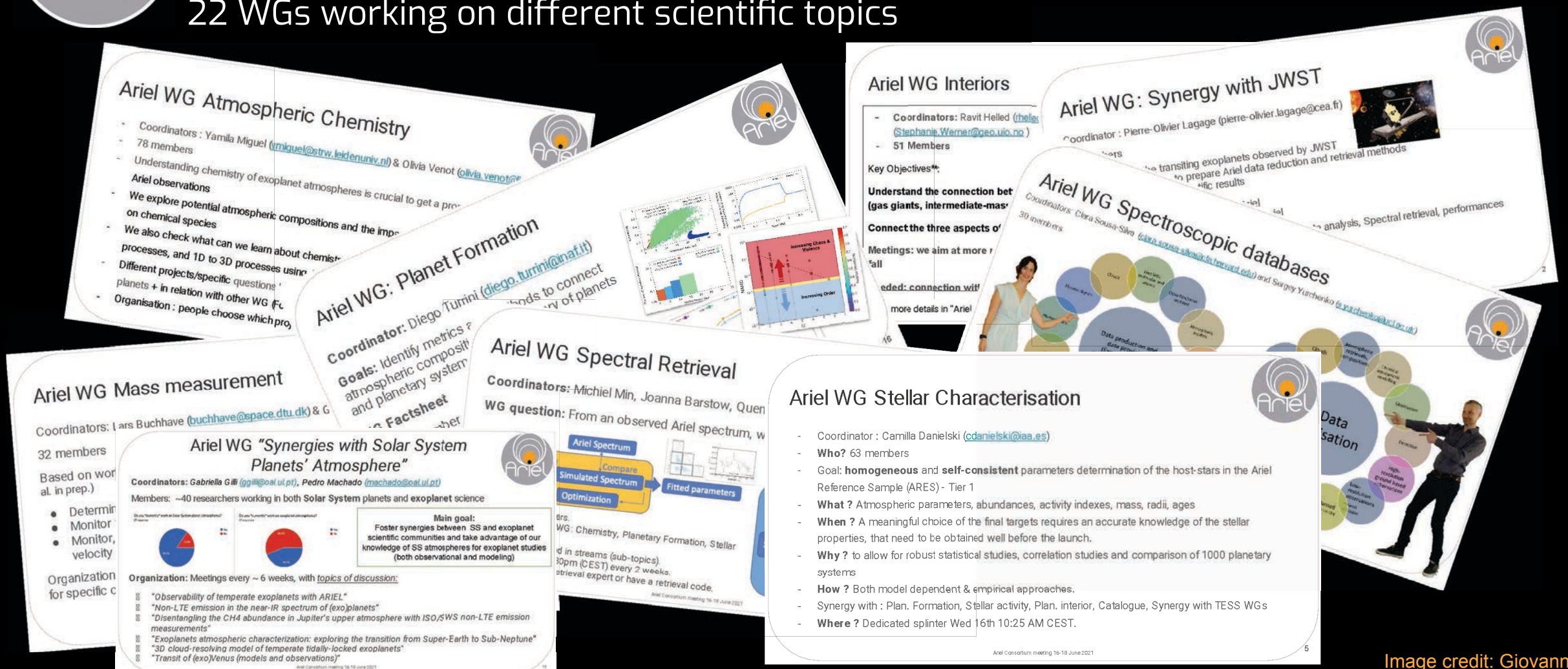


Image credit: Giovanna Tinetti

Stellar Characterisation WG

Goal :
homogeneous and self-consistent parameters determination of the host stars in the Ariel Reference Sample (ARES):

atmospheric parameters, abundances,
activity indexes, mass, radii, ages

Method : analysis of spectroscopic and photometric observations
Both model dependent & empirical approaches

Ephemerides WG

Goal :
Provide updated ephemerides (transit times) for the Ariel targets for precise scheduling of the Ariel observations

Method : photometry of exoplanet host stars

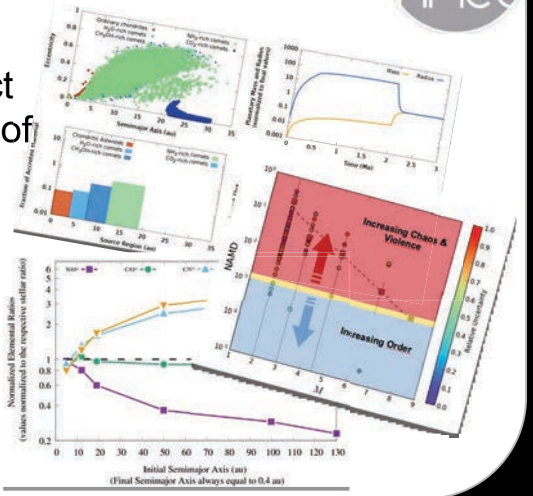
Project ExoClock : www.exoclock.space
Integrated platform to organise the follow-up effort,
with contributions from professional and amateur observatories
and from space-based telescopes.

Planet Formation WG

Goal :
Identify metrics and methods to connect atmospheric composition to the history of planets and planetary systems.

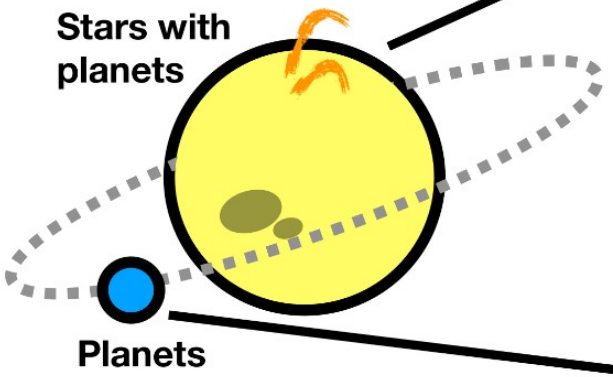
Themes: from star formation to
planetary evolution

Coordinator: Diego Turrini (INAF)



Stellar Physics @ Tartu Observatory
University of Tartu

Stars with proto-planetary disks



Stars with planets

Planets

Tartu Obs.

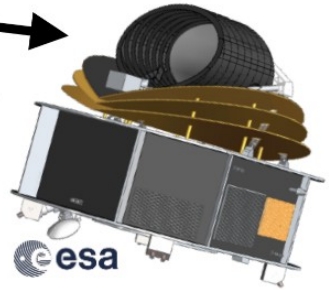
Local data
- Optical stellar spectra
- Optical photometry
- Time-series monitoring

- Guaranteed access
- New echelle spectrograph & photopolarimeter
- High Northern sky coverage

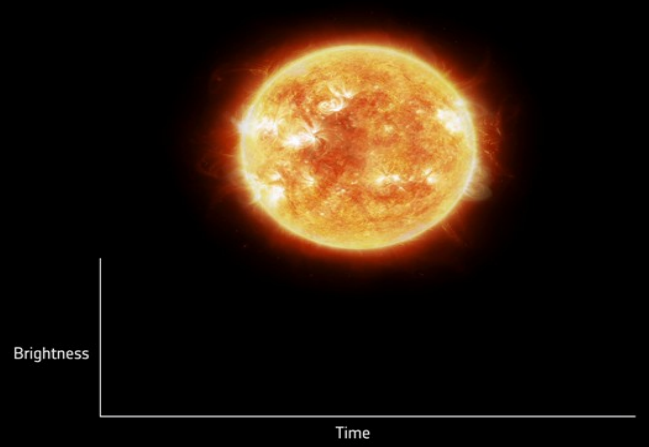
Team strengths
- Stellar astrophysics
- Observations & processing
- Planet-forming disks
- Exoplanetary science

Supplementary data
- ESO and other big facilities

ARIEL



ARIEL science consortium



Credit: ESA

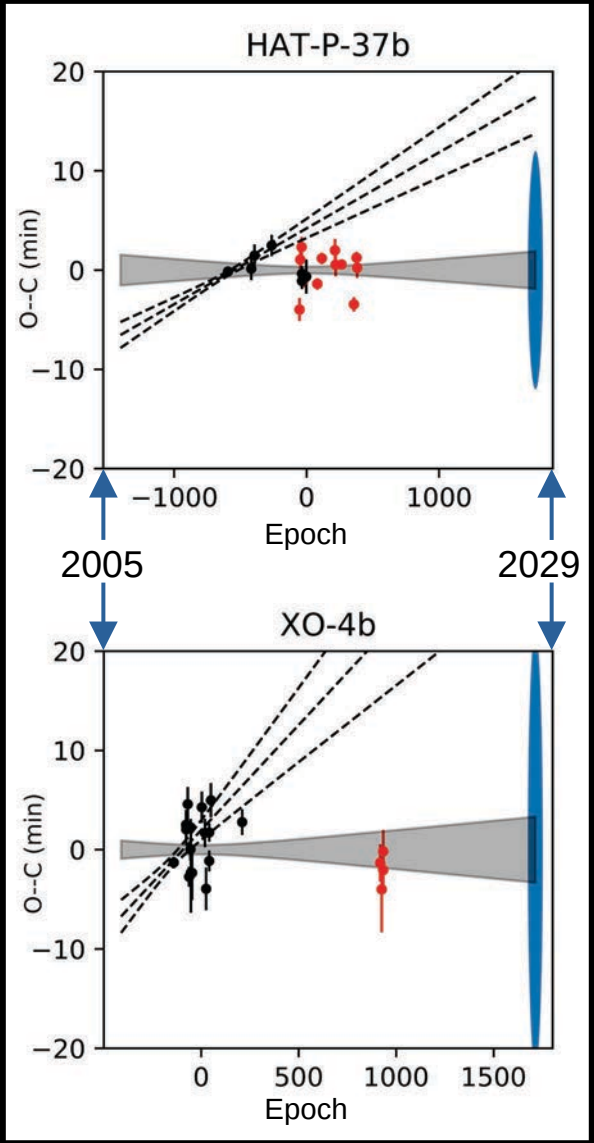
Ephemerides WG

Goal :
Provide updated ephemerides (transit times) for the Ariel targets for precise scheduling of the Ariel observations

Method : photometry of exoplanet host stars

Project ExoClock : www.exoclock.space
Integrated platform to organise the follow-up effort,
with contributions from professional and amateur observatories
and from space-based telescopes.

Refined ephemerides
by the ExoClock network



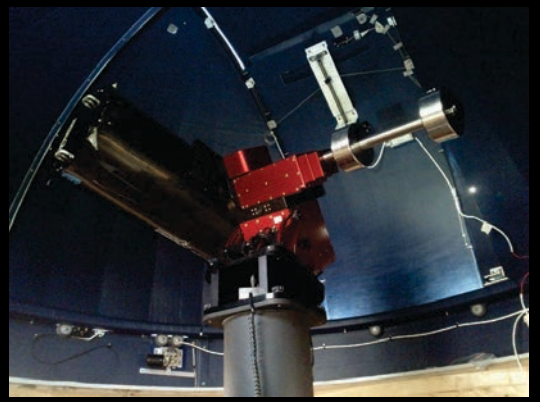
Initial: dashed lines
Updated: shaded area

Uncertainty by 2029: blue

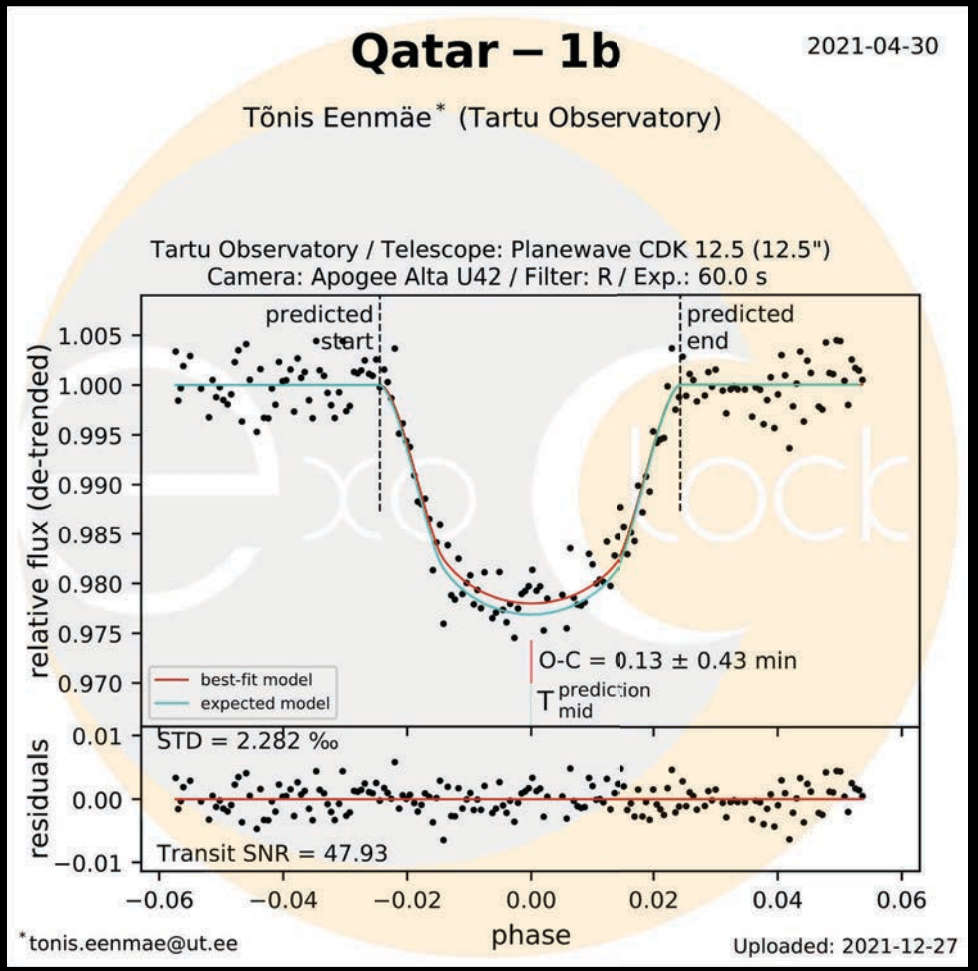
Credit: Kokori et al 2022

0.6-meter Zeiss 600

0.31-meter RAITS
semi-robotic



Observations
at UT Tartu observatory



Ephemerides WG

Goal :
Provide updated ephemerides (transit times) for the Ariel targets for precise scheduling of the Ariel observations

Method : photometry of exoplanet host stars

Project ExoClock : www.exoclock.space
Integrated platform to organise the follow-up effort,
with contributions from professional and amateur observatories
and from space-based telescopes.

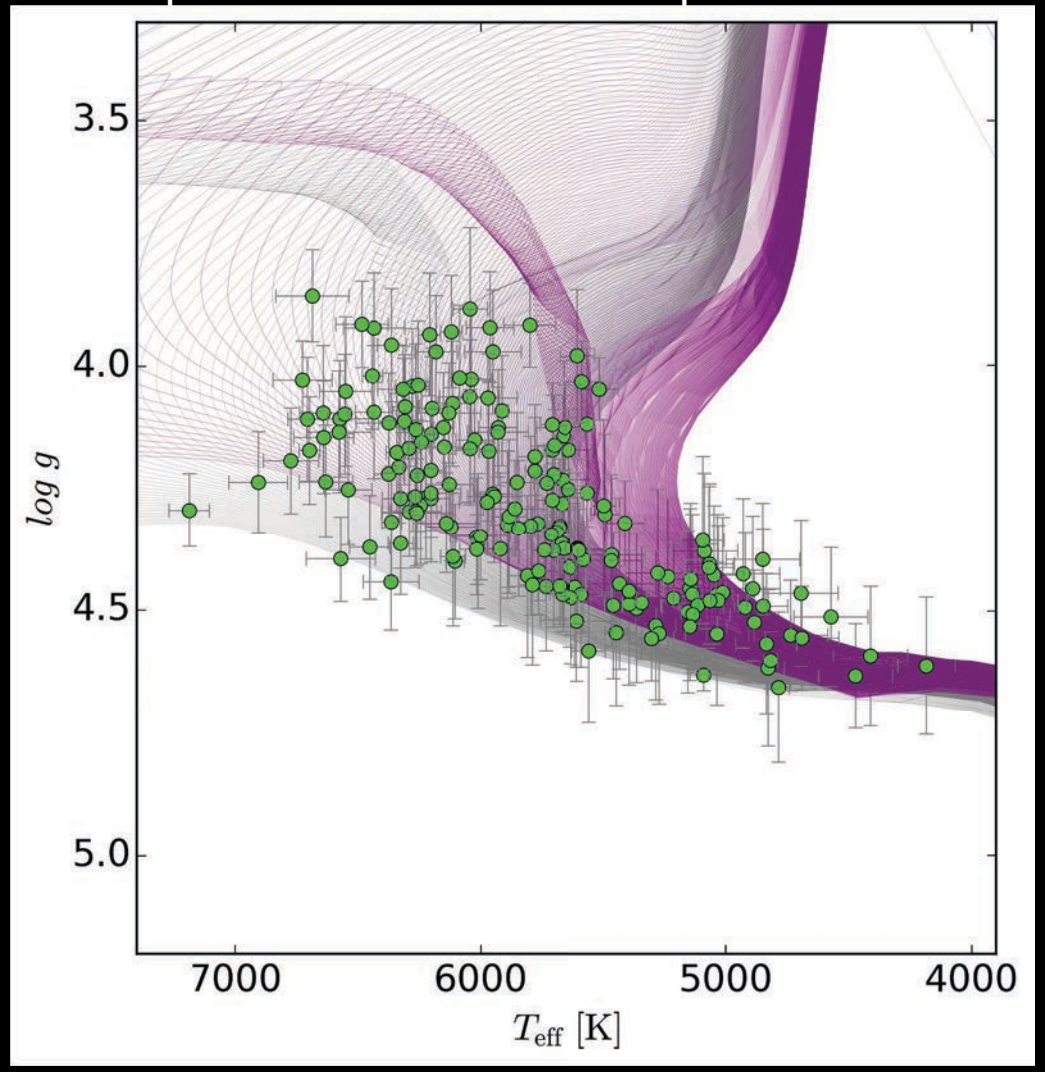
Stellar Characterisation WG

Goal :
homogeneous and self-consistent parameters determination of the host stars in the Ariel Reference Sample (ARES):

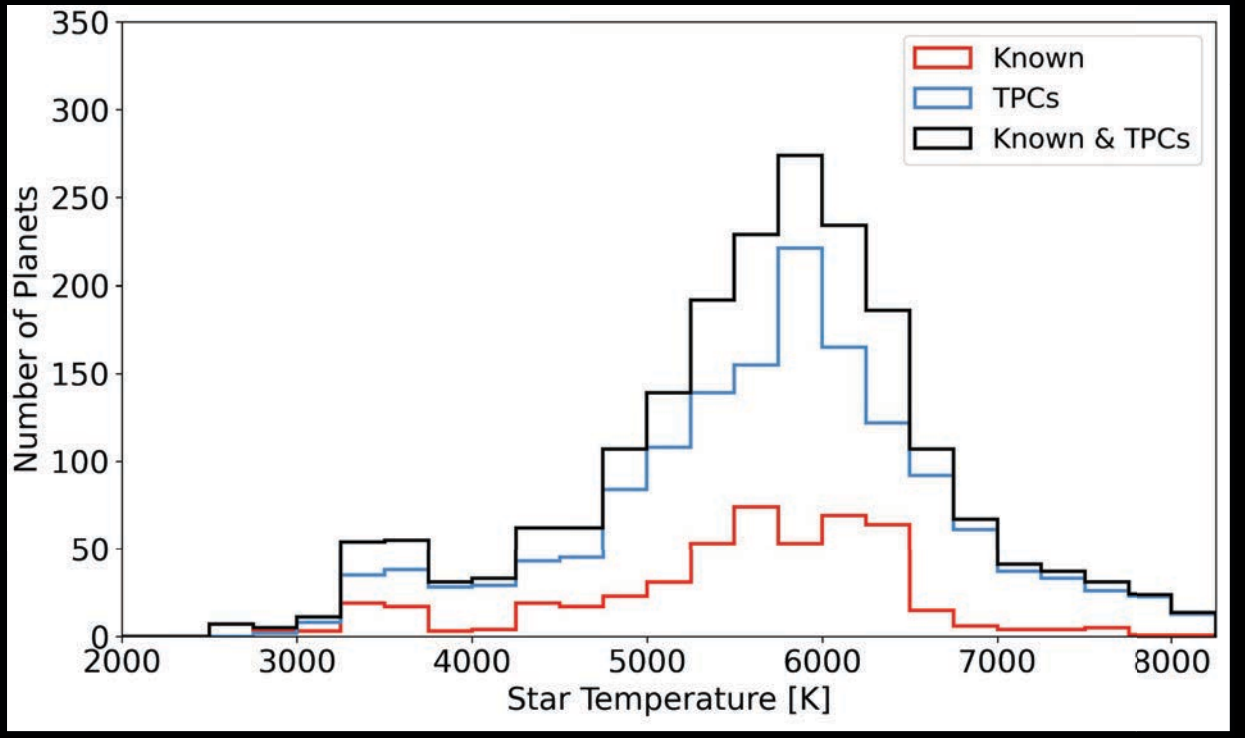
atmospheric parameters, abundances,
activity indexes, mass, radii, ages

Method : analysis of spectroscopic and photometric observations
Both model dependent & empirical approaches

Stellar parameters of 187 FGK planet host stars



Magrini et al 2022

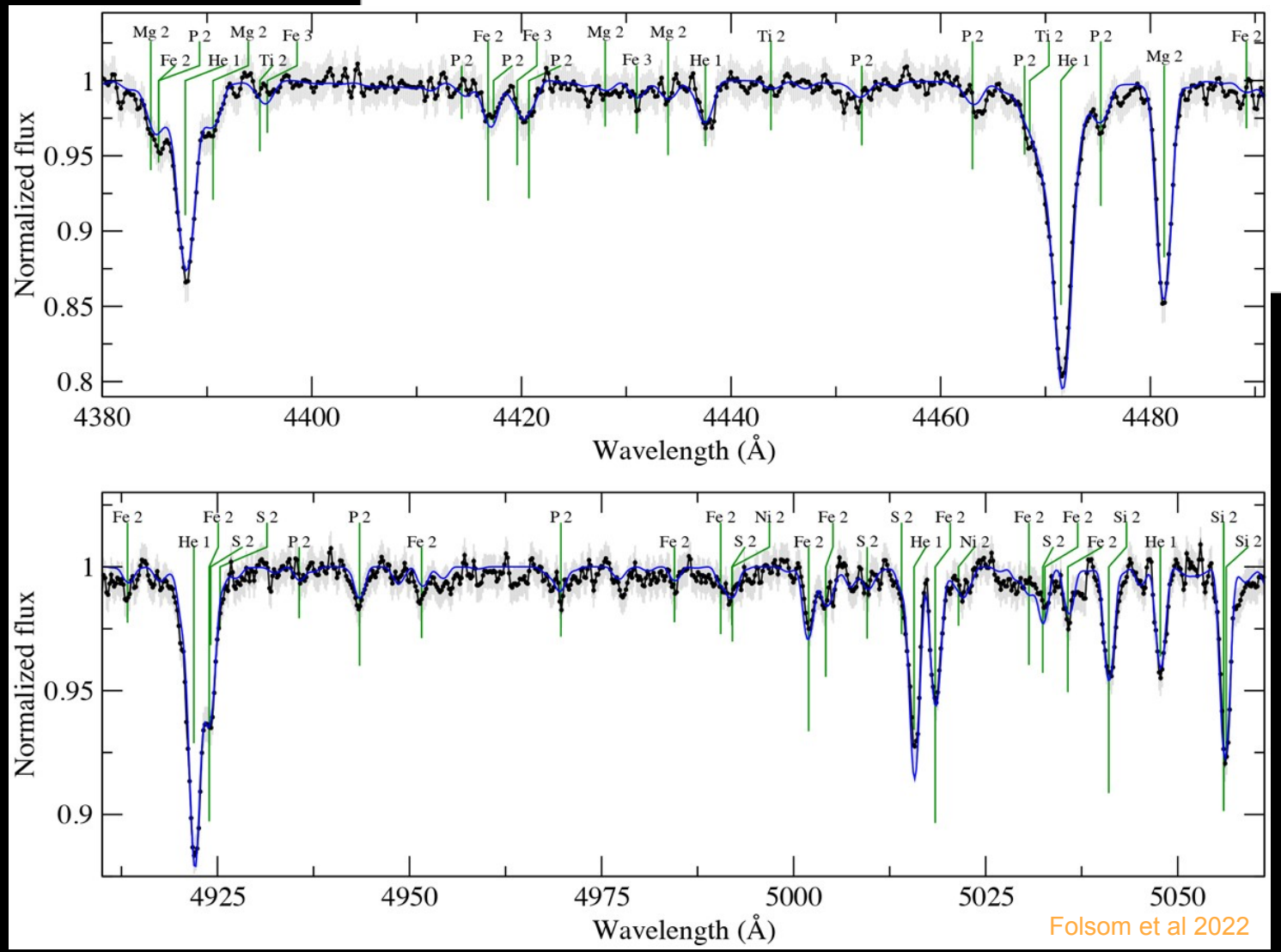


Edwards & Tinetti 2022

Stellar parameters and chemical composition

Observed spectrum: black dots
TO 1.5-m telescope

Synthetic spectrum: blue solid line
ZEEMAN spectra synthesis code

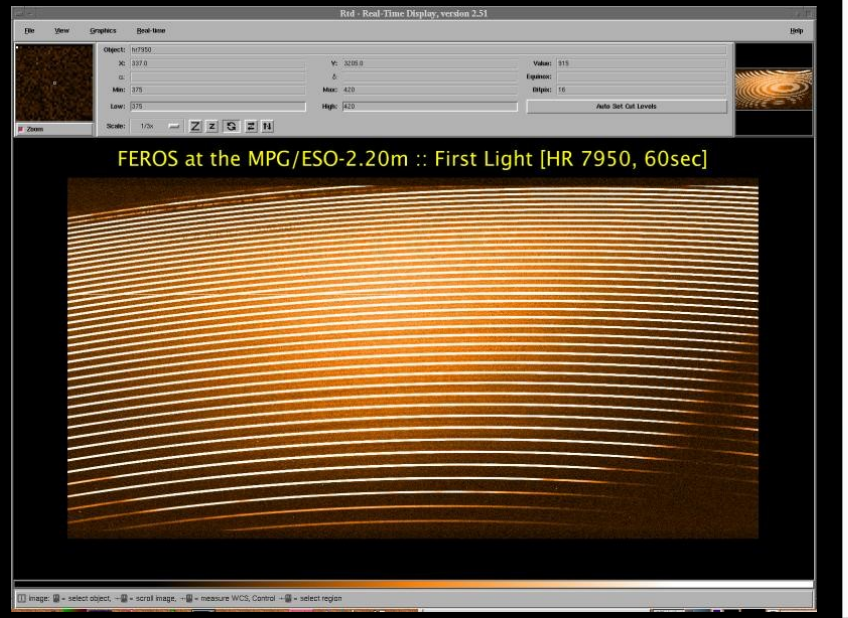


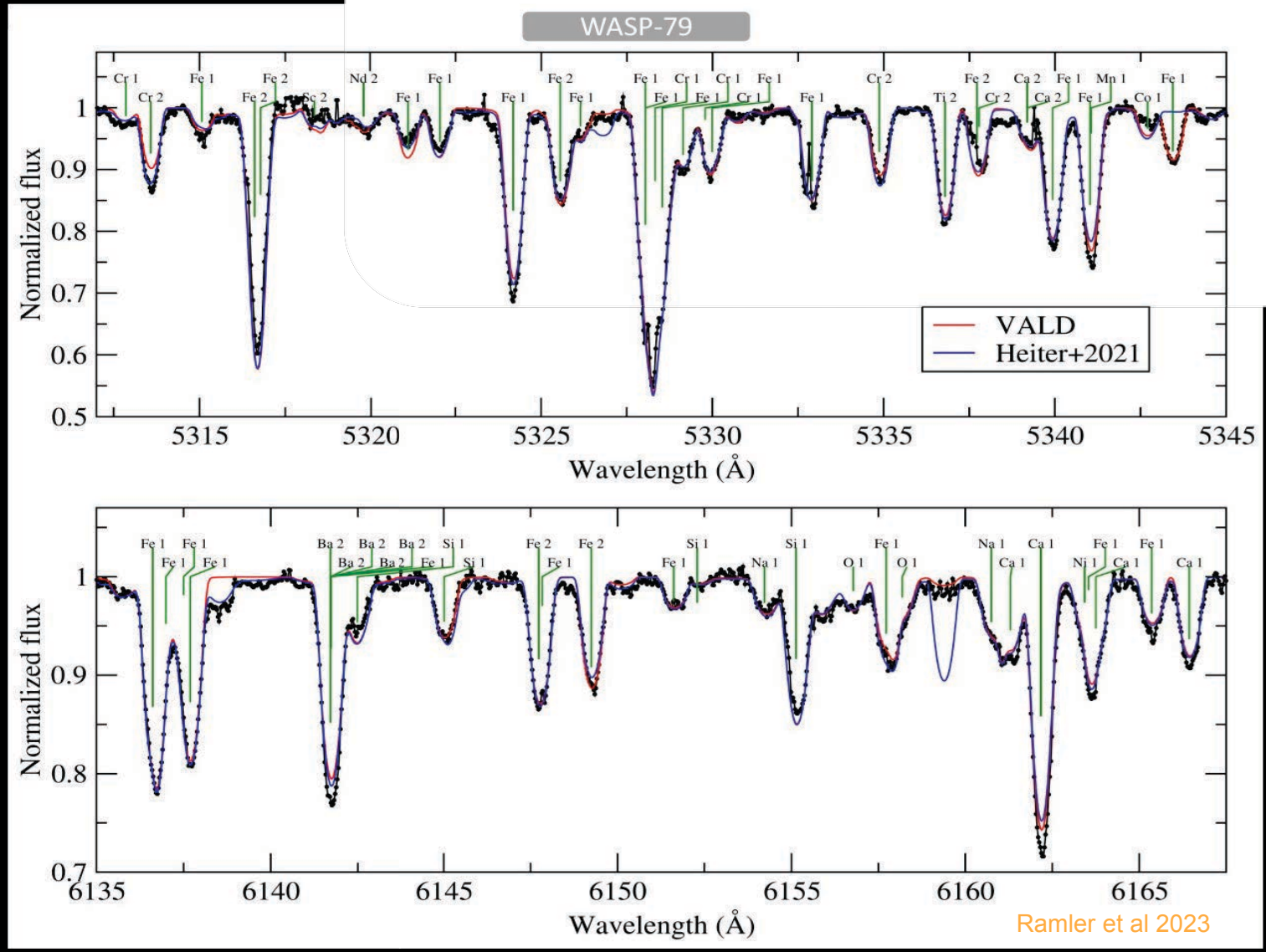
Folsom et al 2022

Stellar parameters and chemical composition

Observed spectrum: black dots
ESO FEROS spectrograph

Synthetic spectrum: blue solid line
ZEEMAN spectra synthesis code





Modelling birth and death

Evaporating gas giant

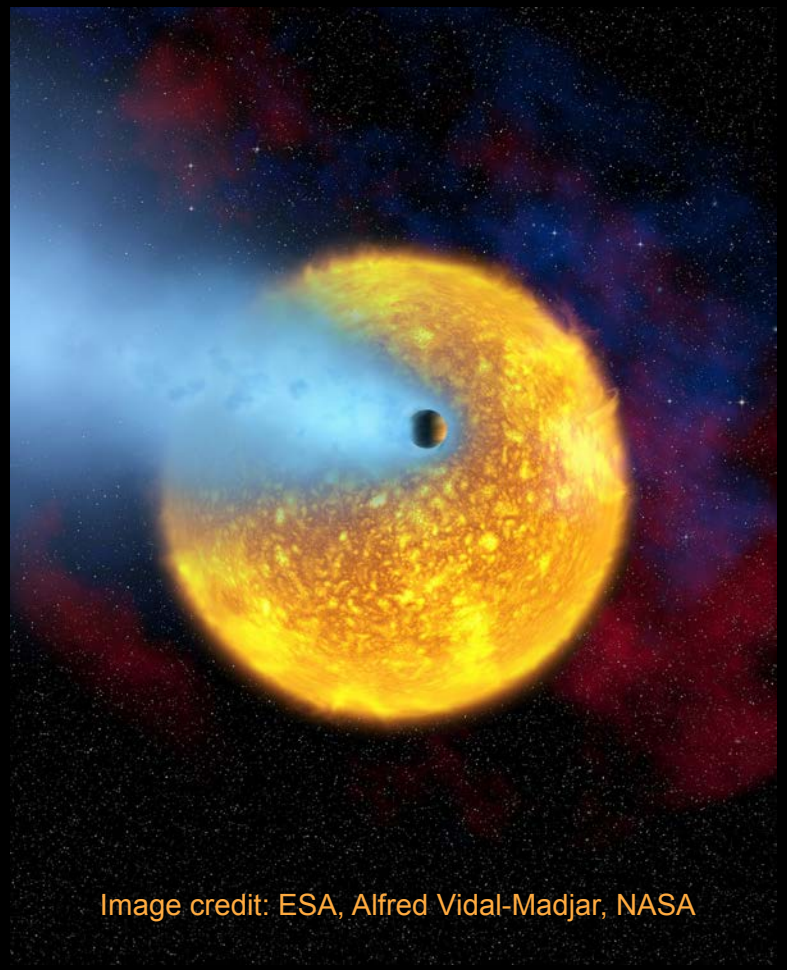
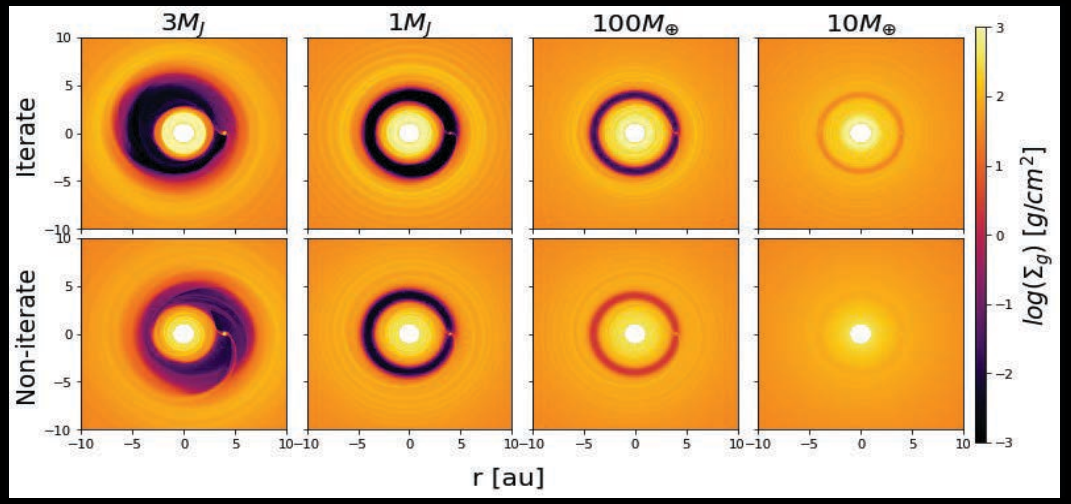


Image credit: ESA, Alfred Vidal-Madjar, NASA

Planet-induced gaps in protoplanetary disks



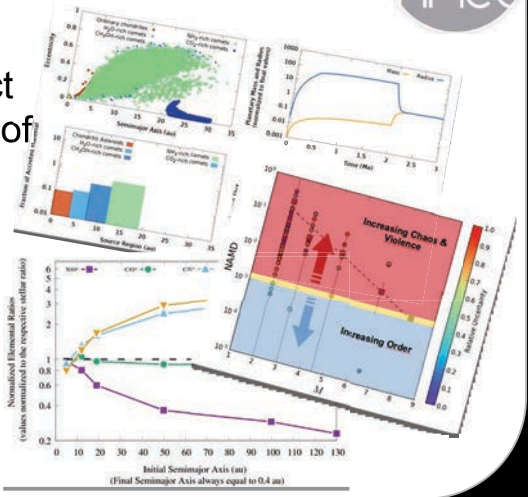
Chen, Kama, Pinilla, et al 2023

Planet Formation WG

Goal :
Identify metrics and methods to connect atmospheric composition to the history of planets and planetary systems.

Themes: from star formation to planetary evolution

Coordinator: Diego Turrini (INAF)



EXOHOST

Spectral Characterisation of Exoplanet Hosts and Other Stars

Horizon Europe Twinning project 2023–2025

Main science objective

Study properties of exoplanet and protoplanetary disk host stars

- Chemical composition holds clues to planet formation

  Study relations between formation processes and diverse outcomes of star-planet systems

- Precision of exoplanet measurements depend on host star properties

  Contribute to the ESA Ariel Mission Consortium

EXOHOST Consortium

UNIVERSITY OF TARTU Tartu Observatory 1632

UCL

UPPSALA UNIVERSITET

ÖAW AUSTRIAN ACADEMY OF SCIENCES INSTITUT FÜR WELTRAUMFORSCHUNG IWF

Funded by the European Union

UKRI UK Research and Innovation

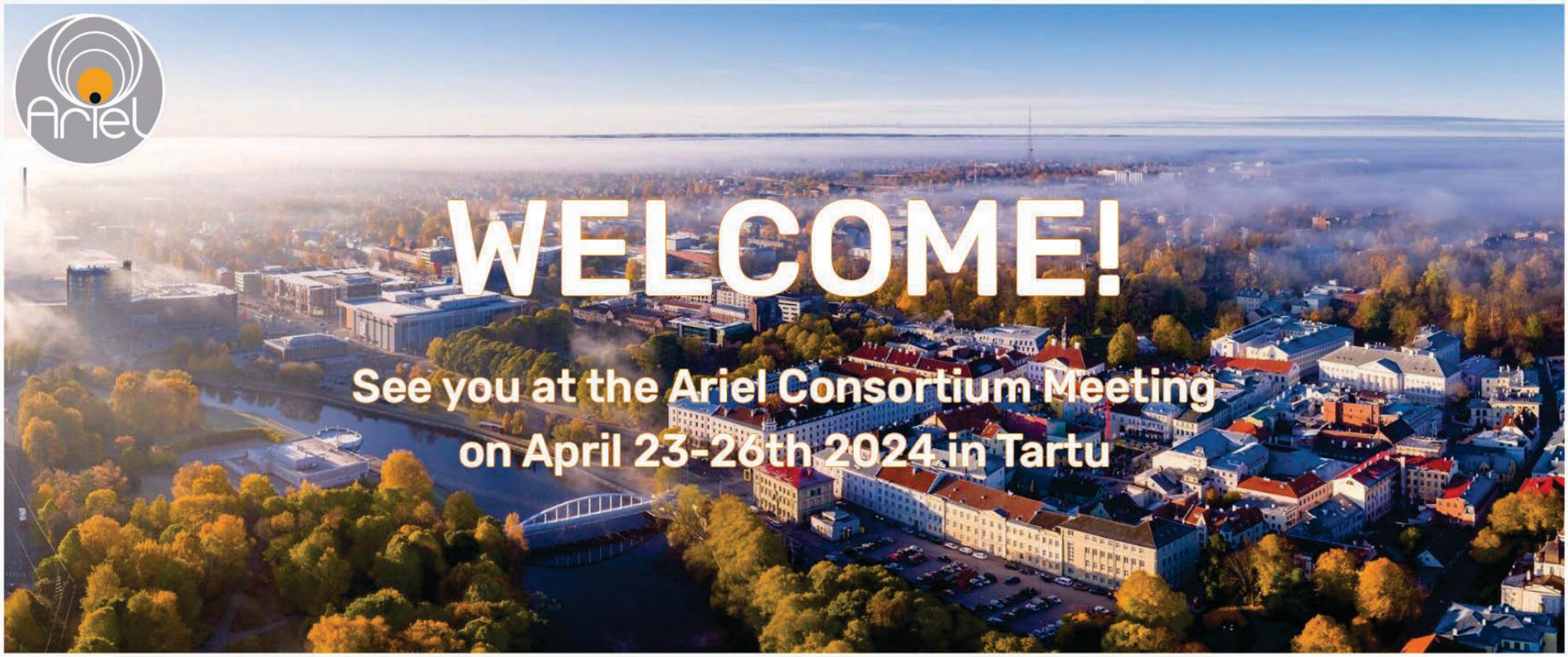


Image credit: Tarmo Haud

The 2024 spring Ariel Consortium Meeting will be hosted by the University of Tartu, Tartu Observatory

For any queries, please contact us at: arieltartu2024@ut.ee