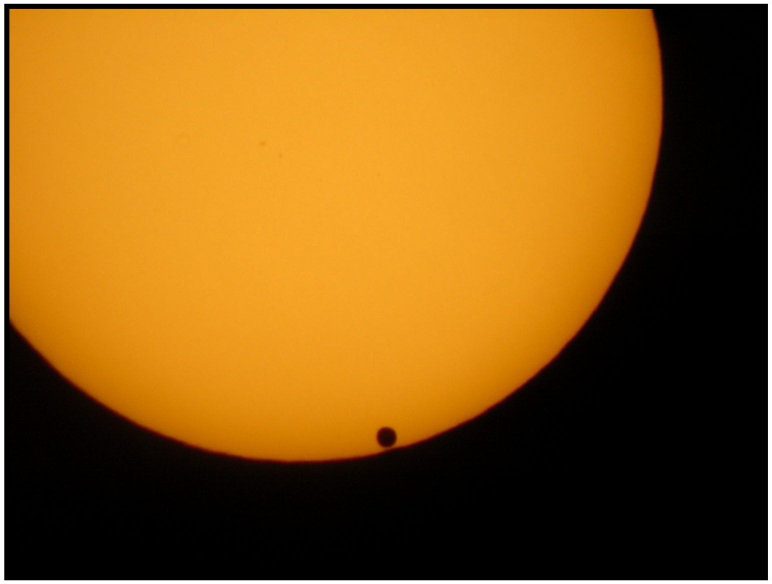
Detection and characterization of transiting planets with the robotic telescope TRAPPIST



Michaël Gillon (Université de Liège, Belgium)
michael.gillon@ulg.ac.be

FNRS – LA LIBERTÉ DE CHERCHER

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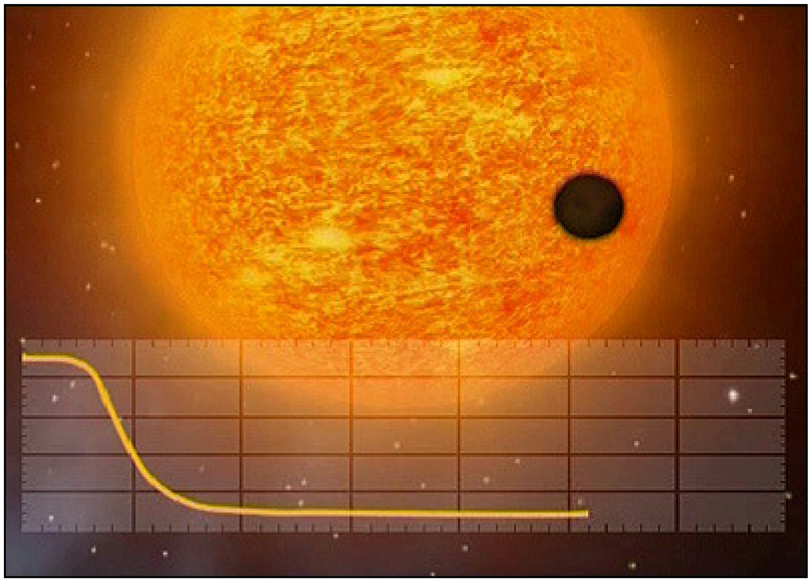
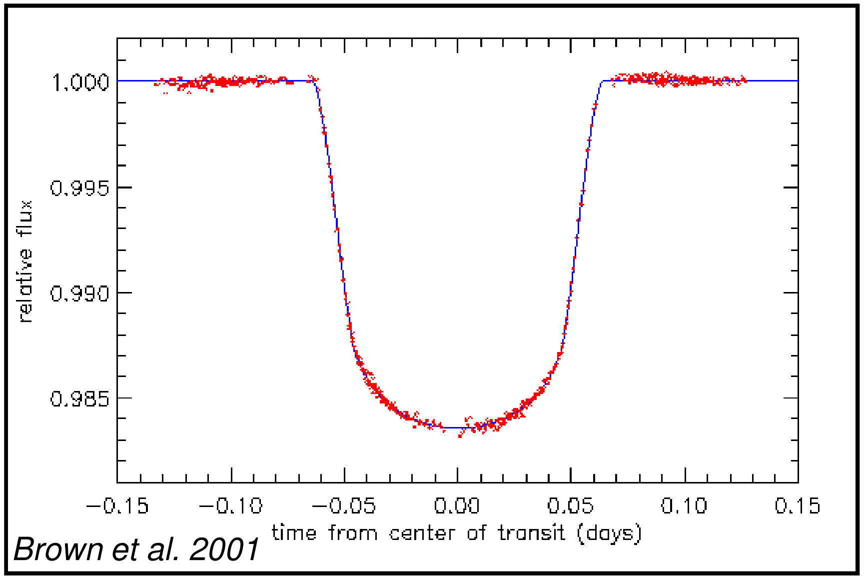
Transits: observing the shadow of exoplanets





Brown et al. 2001

Amplitude ~ $(R_p/R_*)^2$

~1% for Jupiter in front of the Sun

~0.1% for Neptune

<0.01% for Earth

Probability ~ R_*/a

up to 30% for the shortest orbits

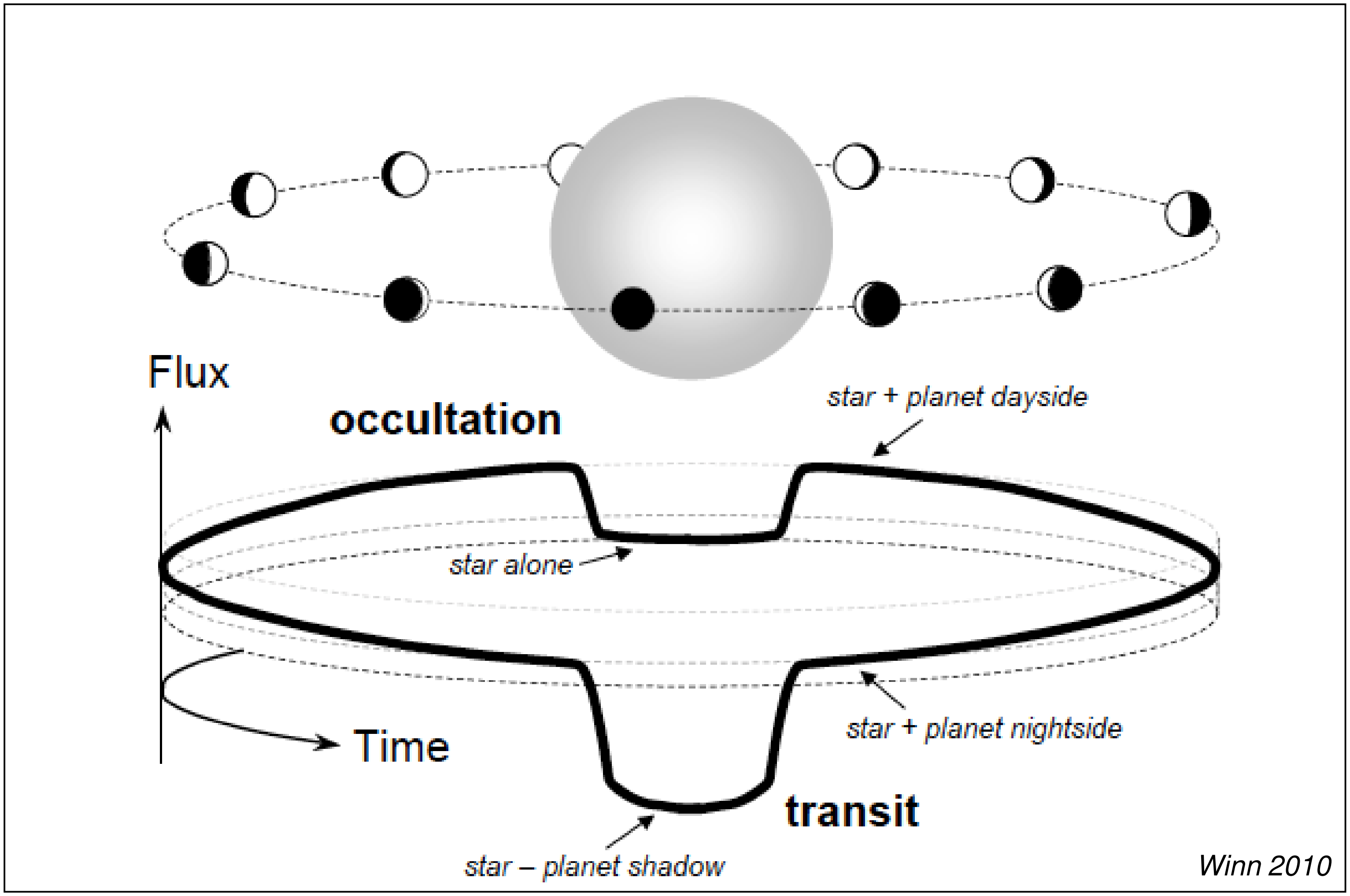
~0.5% for Earth+Sun

What do we learn from transits?

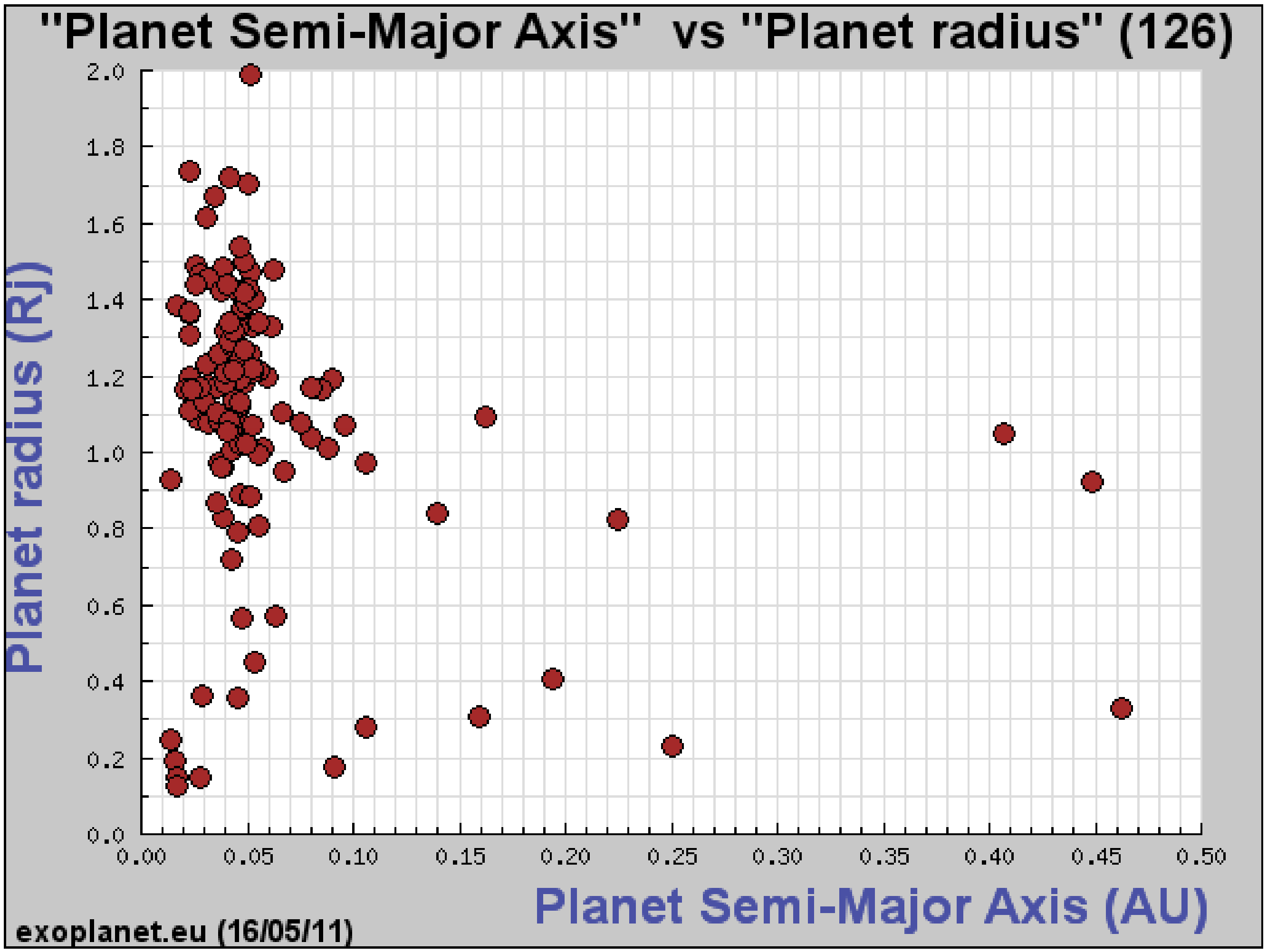
- Radius ratio R_p/R_*
- Orbital period P
- Inclination *i*
- a/R_* + P -> stellar density ρ_*
- If stellar parameters, e.g. T_{eff} & [Fe/H] -> M_*, R_* and R_p
- If radial velocities : M_p, *e* and ω
- Radial velocities during transit: projected spin-orbit angle β
- $dF/F(\lambda)$ -> limb transmission spectrum
- Occultation(λ) -> dayside emission spectrum
- Timing and/or duration variations: precession, 2nd planet, moon, etc.
- Moon, rings
- Stellar limb-darkening, spots

Thorough characterization: orbit, structure, interactions & atr

Exoplanetary eclipses: transit and occultation



Transiting planets known yesterday

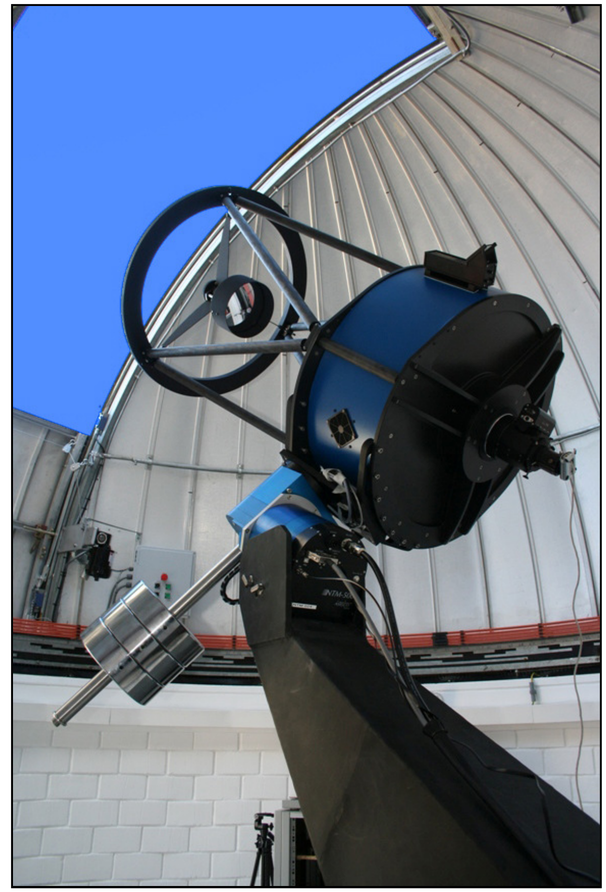


The TRAPPIST project

- Search for the transits of the RV low-mass planets (Neptunes & super-Earths)
- High-precision photometry of known transiting planets, to improve their characterization and search for timing variations
- Follow-up of the planet candidates found by the WASP and CoRoT transit surveys
- Near-IR thermal emission measurements for the most irradiated transiting planets
- Photometric variability of planet host stars, notably to help discriminating orbital & activity RV signals.

➔robotic telescope dedicated to high-precision differential photometry (<1 mmag/2 min), in one of the best sites of Southern hemisphere.

TRAPPIST: TRAnsiting Planets and PlanetesImals Small Telescope



- Aperture = 60cm, F/8, Ritchey-Chretien
- Fully robotic
- High-quality CCD camera
- 75% dedicated to exoplanet photometry
- ESO La Silla Observatory, Chile
- Funding: FNRS (80%) – SNSF (20%)

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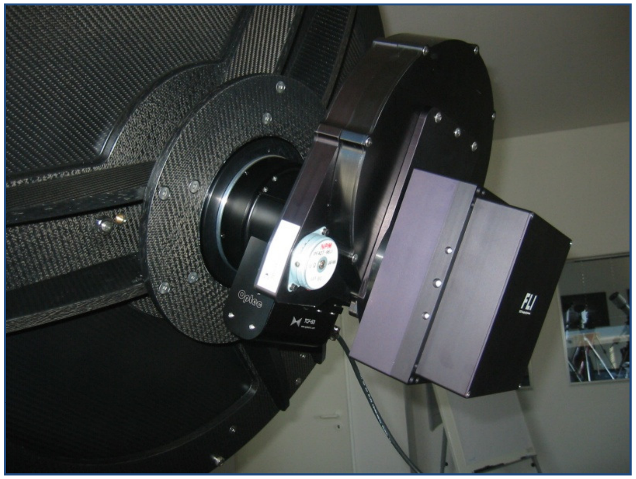
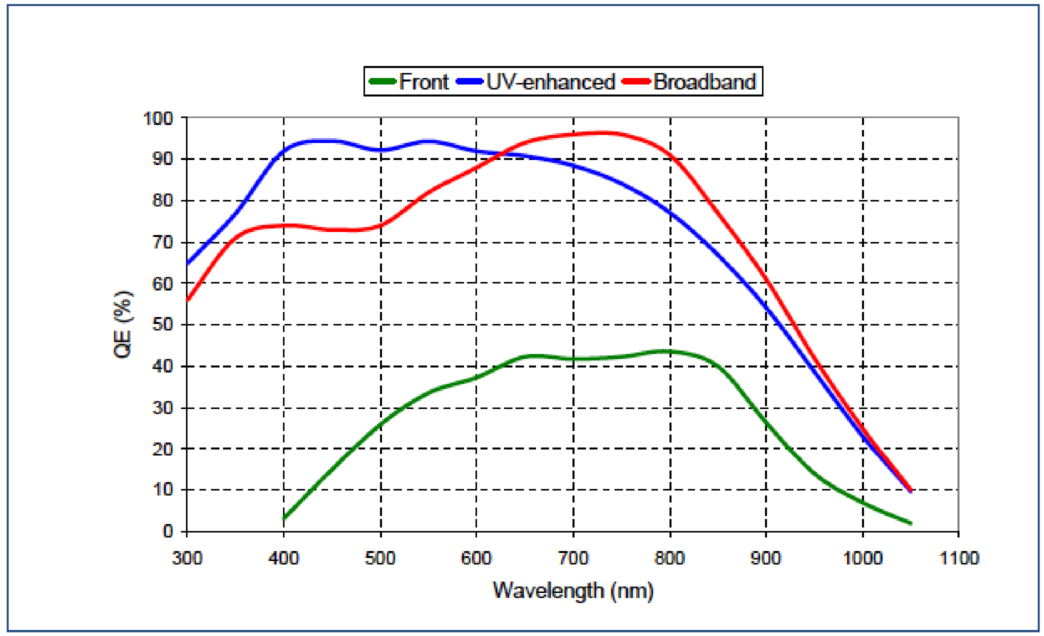
OBSERVATOIRE DE GENÈVE FONDÉ EN 1772

TRAPPIST CCD camera

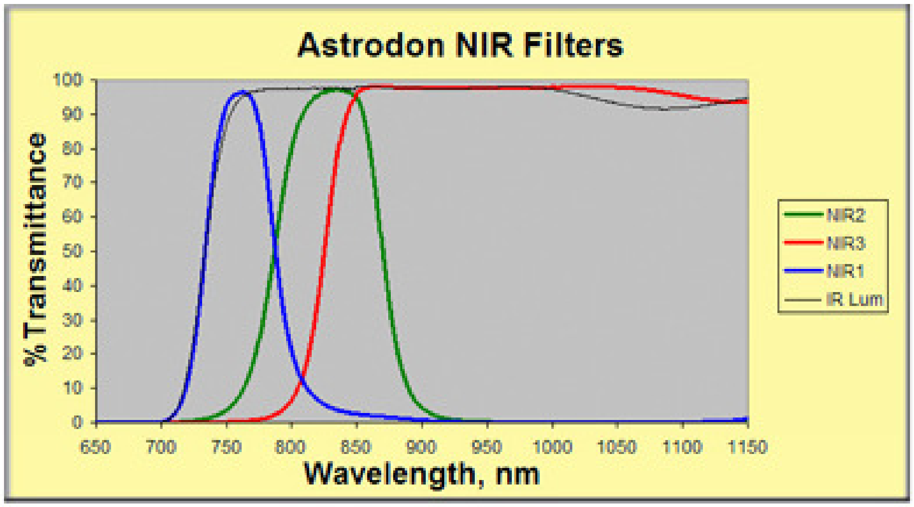




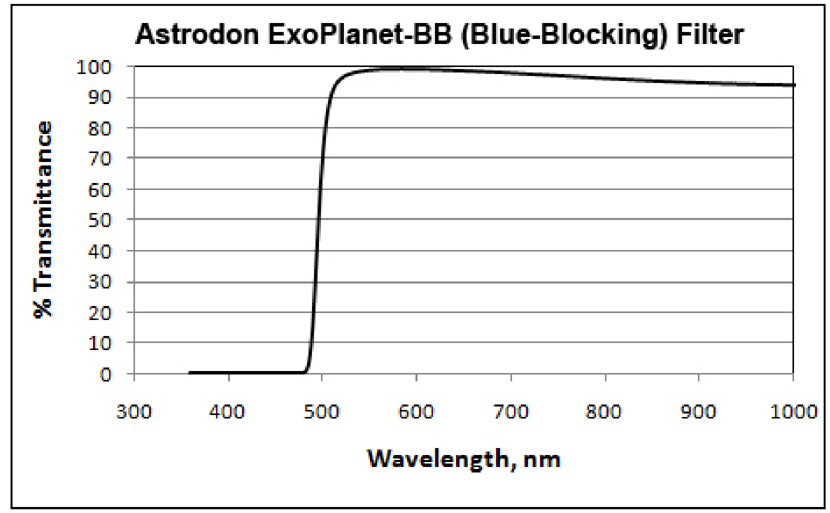
Camera: FLI Proline
CCD Fairchild U3041
2k x 2k, pixel scale = 0.65″, FOV=22′ x 22′
Read-out + overhead ~6s

Filter wheel: Dual Apogee FW 2x7
5″ square
B, V, Rc, Ic, I+z, z′ + 6 NASA comet filters

TRAPPIST "I+z" and "BB" filters



I+z

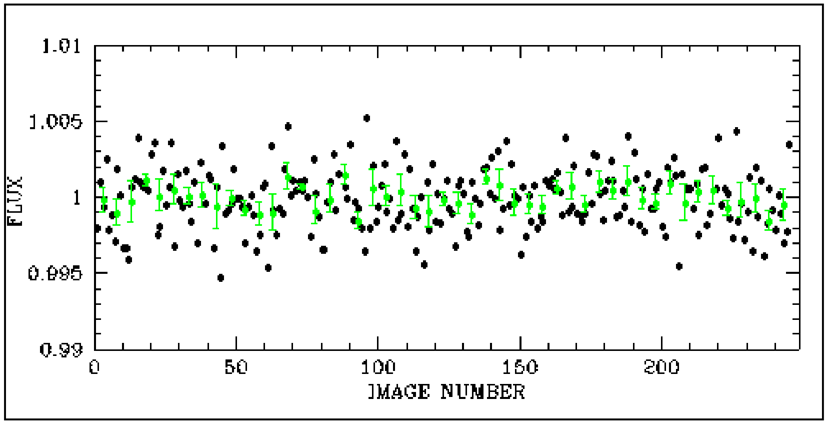


BB + TRAPPISTCAM = wide I filter

<u>Why?</u>

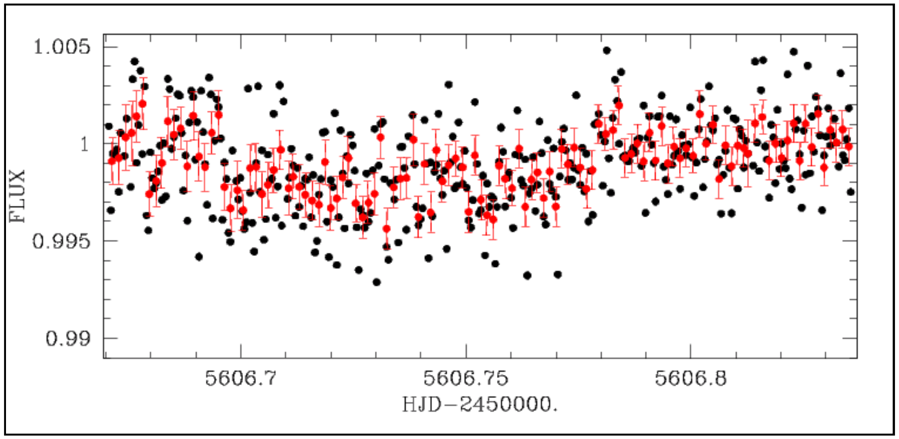
More photons
Less limb-darkening + LD does not change much between I and z
Less color effect in the lightcurves
Smaller moon pollution

The photometric precision of TRAPPIST



I+z filter J=10
rms ~ 800ppm / 2 min

700 to 1500 ppm/2 min for our typical targets

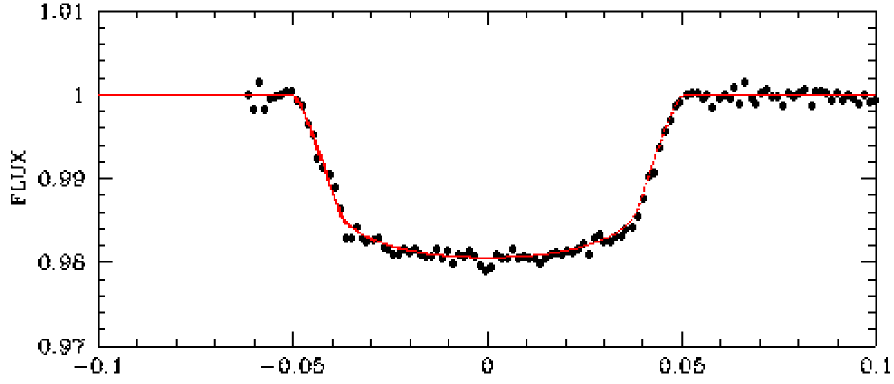


Precise enough to detect
a 2 mmag eclipse

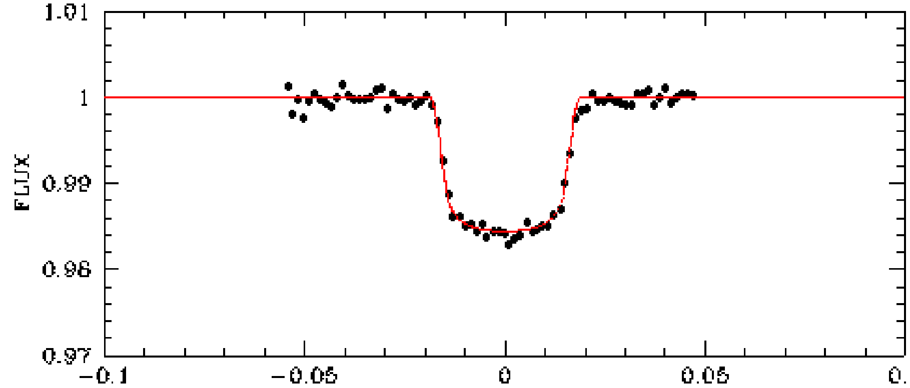
2 mmag = Neptune in front of a K-dwarf

TRAPPIST is dedicated: a galore of transits!

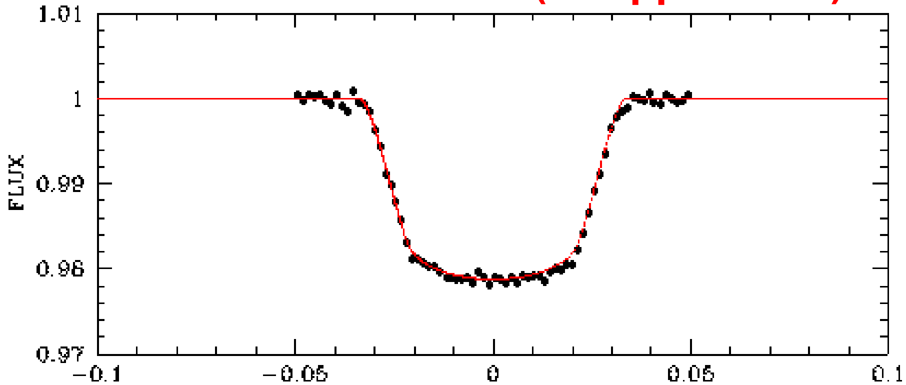
WASP-23b: 3 transits (650 ppm/2min)



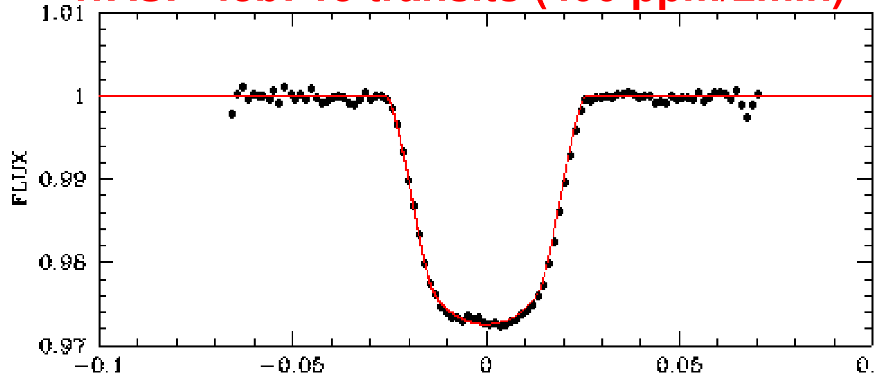
GJ1214b: 3 transits (600 ppm/2min)



WASP-19b: 7 transits (500 ppm/2min)



WASP-43b: 15 transits (400 ppm/2min)



We reach the sub-mmag/min regime with a few transits

Full potential will be reached when a few technical problems will be fixed: dome, focus, small software issues, fast read-out mode, etc.

First TRAPPIST exoplanet results

- Participation to the detection of 13 CoRoT & WASP planets:
  - CoRoT-17b (Szismadia et al. submitted)
  - CoRoT-19b (Guenther et al., submitted)
  - WASP-23b (Triaud et al., 2011)
  - WASP-35b (Enoch et al., 2011)
  - WASP-36b(Smith et al., submitted)
  - WASP-42b (in prep.)
  - WASP-43b (Hellier et al., 2011)
  - WASP-45b (Anderson et al., 2011)
  - WASP-46b (Anderson et al., 2011)
  - WASP-49b (in prep.)
  - WASP-50b (Gillon et al., submitted)
  - WASP-54b (in prep.)
  - WASP-55b (in prep.)

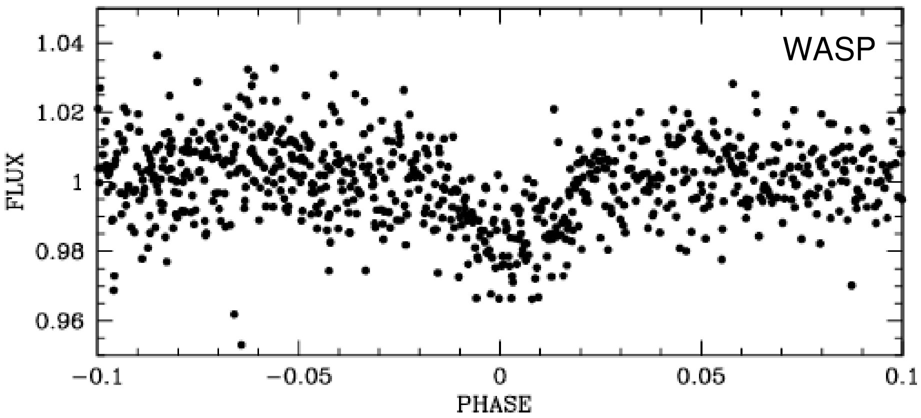
and rejections of many more planetary candidates

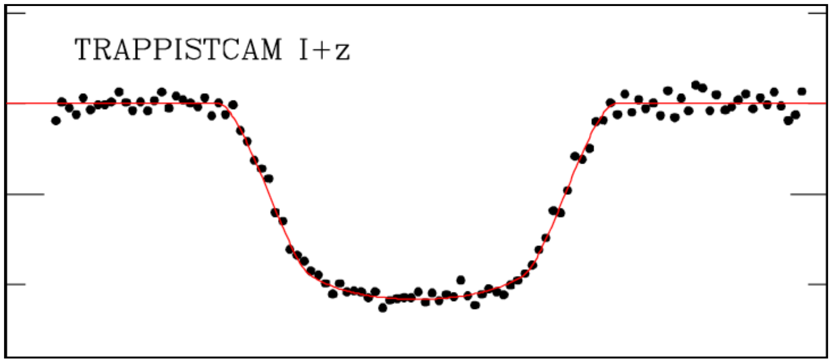
- High-precision transit & occultation photometry for >30 transiting planets (under analysis, 2 papers in prep.)

- Transit search for 2 RV planets (paper in prep.)

- Variability follow-up for 5 planet host stars, undergoing

WASP-50: a new hint for planet-star interactions





Evolution modeling, log A(Li) ➔ several Gyrs

P_{rot} = 16.3±0.5 d, log R'_{HK}=-4.67 ➔ <1 Gyr

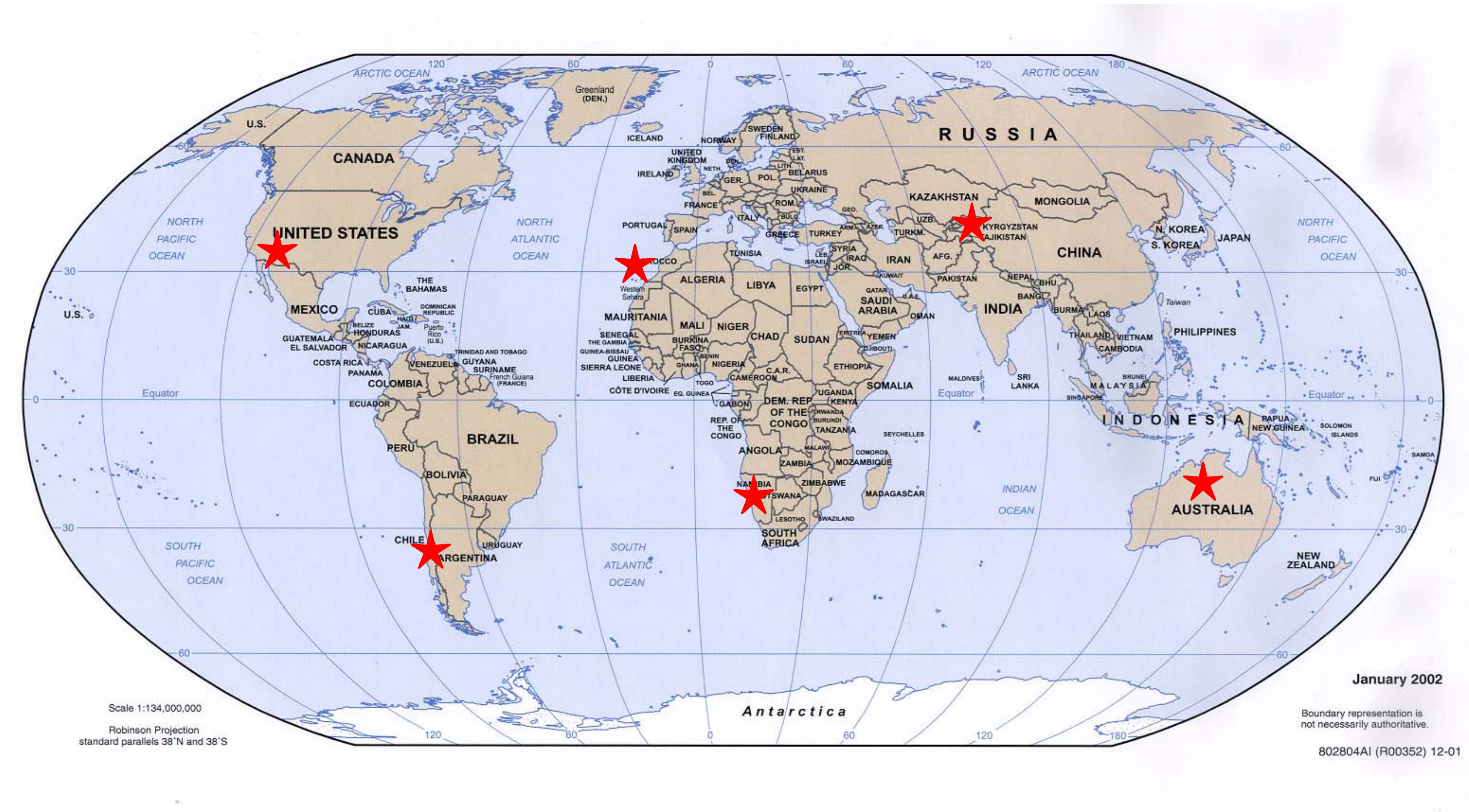
WASP-50 strengthens an excess of activity/rotation induced by hot Jupiters (Pont 2009)

WASP-50 strengthens the correlation logR'HK – planet density (Hartman 2010)

High stellar obliquity much more observed for hot stars (Winn et al. 2010)

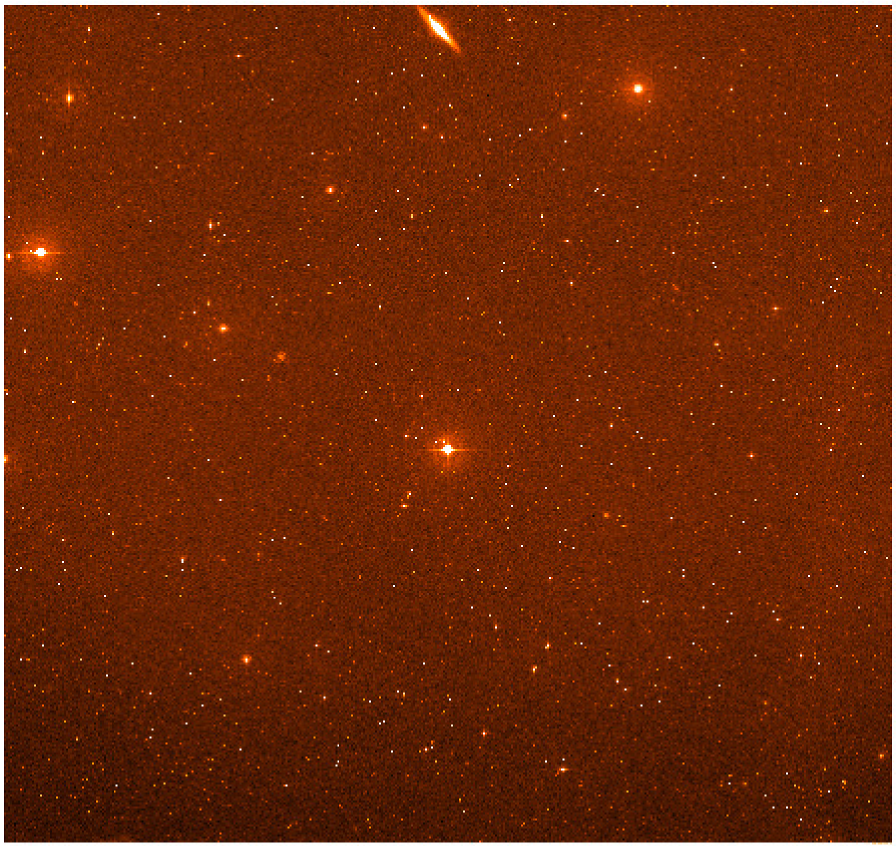
Strong planet magnetic field favors core-envelope decoupling of cold stars?

Next: a TRAPPIST network?



Much better phase coverage

Next: Mini-TRAPPIST?

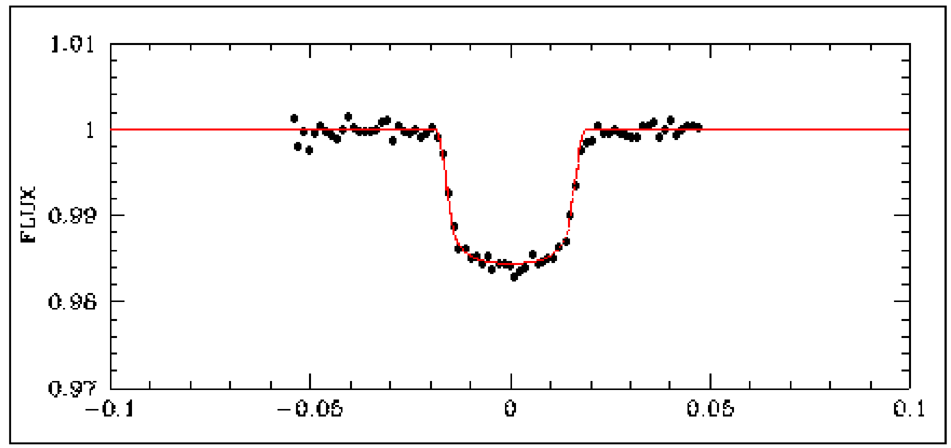


51 Cnc, 2° x 2° FOV
Bright stars need large FOVs!

25 cm, F/4
Apogee U16 4k x 4k 9microns
1.9”/pixel, 2.1° x 2.1°
~1.5 kEuros
Expected precision (I=5)
500 – 1600 ppm / 5 min
depending of airmass
(scintillation)

Next: TRAPPIST-IR?

Searching for transits of terrestrial planets around ultracool dwarfs



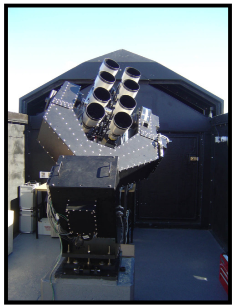
Habitable planets amenable for atmospheric studies
Unexplored parameter space
Requires 1m class telescope(s) with IR detector

Thank you for your attention!

Transit search projects

From the ground

Surveys



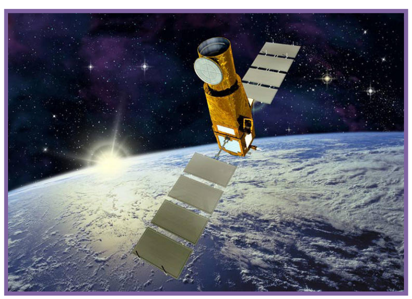
WASP, HAT, TrES, XO, Mearth…

RV planets monitori

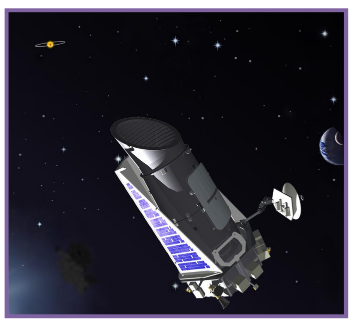
Pro & amateurs..

From space

Surveys

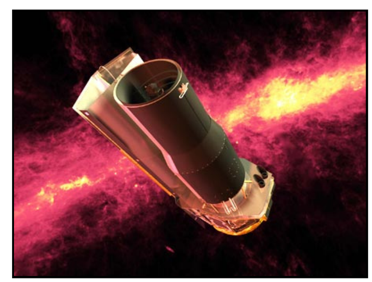


CoRoT



Kepler

RV planets monitor



Spitzer

MOST