The many reasons to search for circumbinary planets

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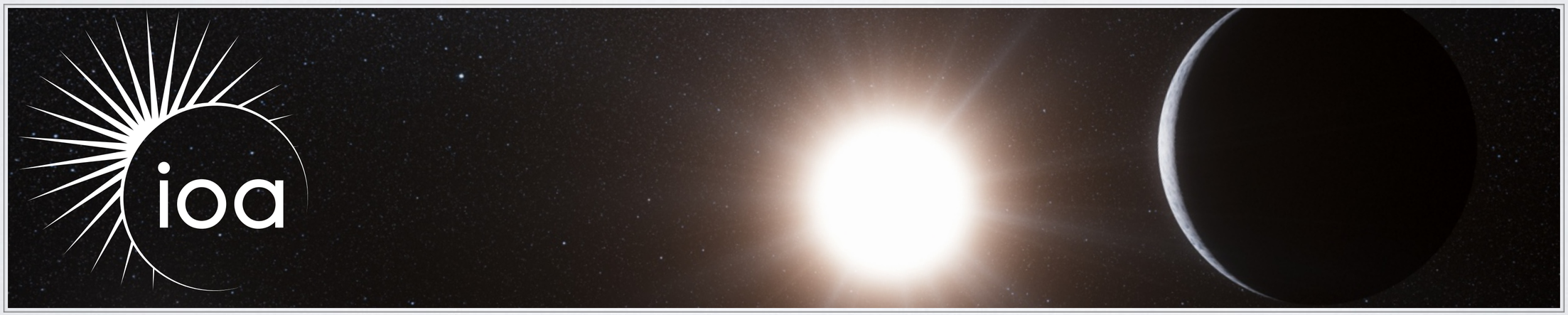


www.amaurytriaud.net

circumbinary planets

the tally

RV: HD202206c? (Correia et al. 2005)
ETV: CM Dra? (Deeg et al. 2008)

Kepler (transit): 9 systems (11 planets)
Kepler (ETV): 3 systems?

direct imaging: 3 systems?
post-common envelope (ETV): 5 systems (6 planets)?

circumbinary planets

why bother

boosted probabilities of transit

study planetary formation

investigate planetary migration

observe how atmospheres react to change

the most accurately measured planets

learn about stellar formation

confront stellar evolution models

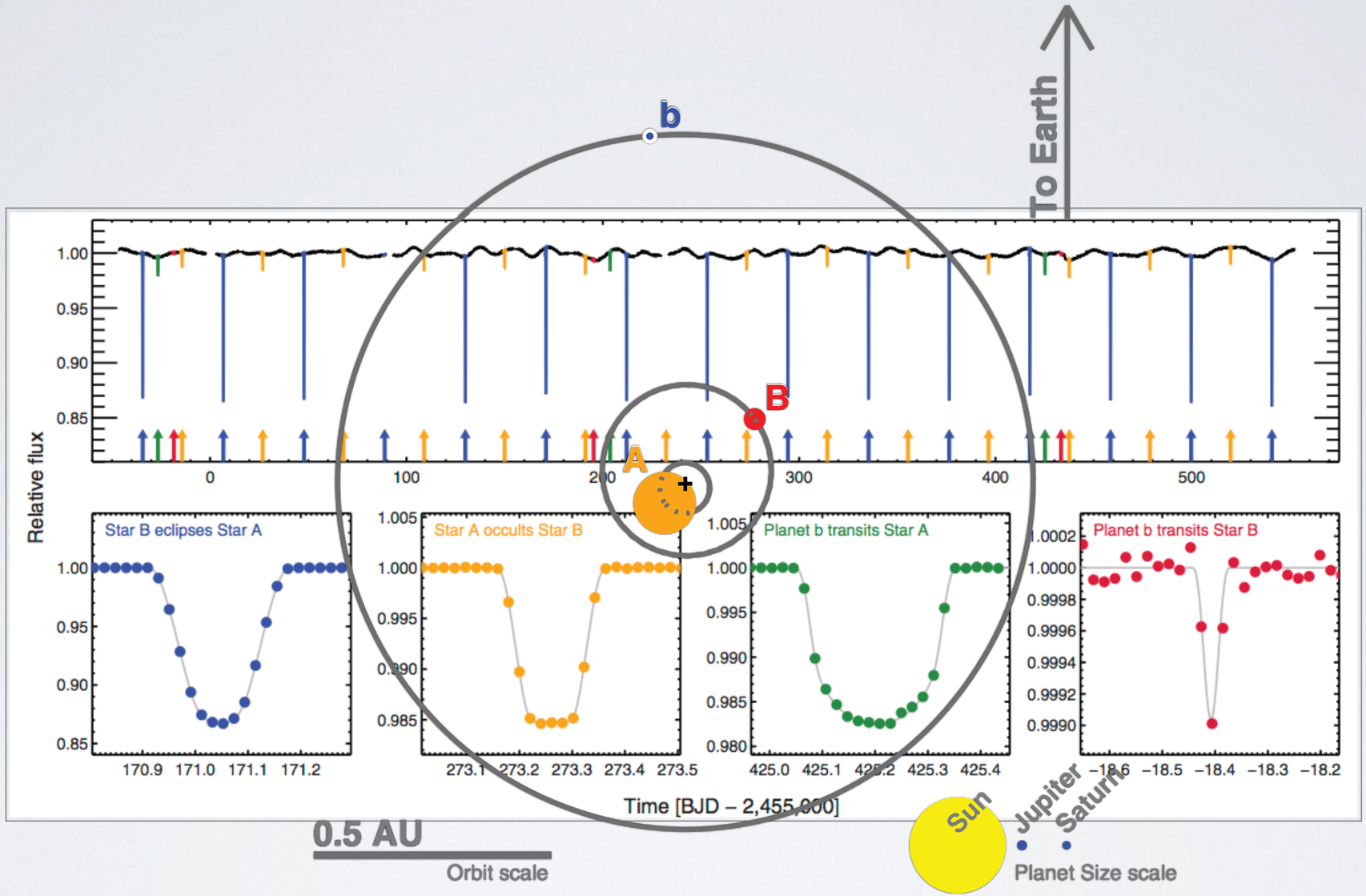
the transit technique

the transit technique is very limited to short periods
(hot Jupiter ~ 10% - Earth ~ 0.4%)

we do not have any a priori on the inclination of the planet
(need to survey many stars)

planet masses and radii depend on the assumed/modelled
mass and radius for the host star

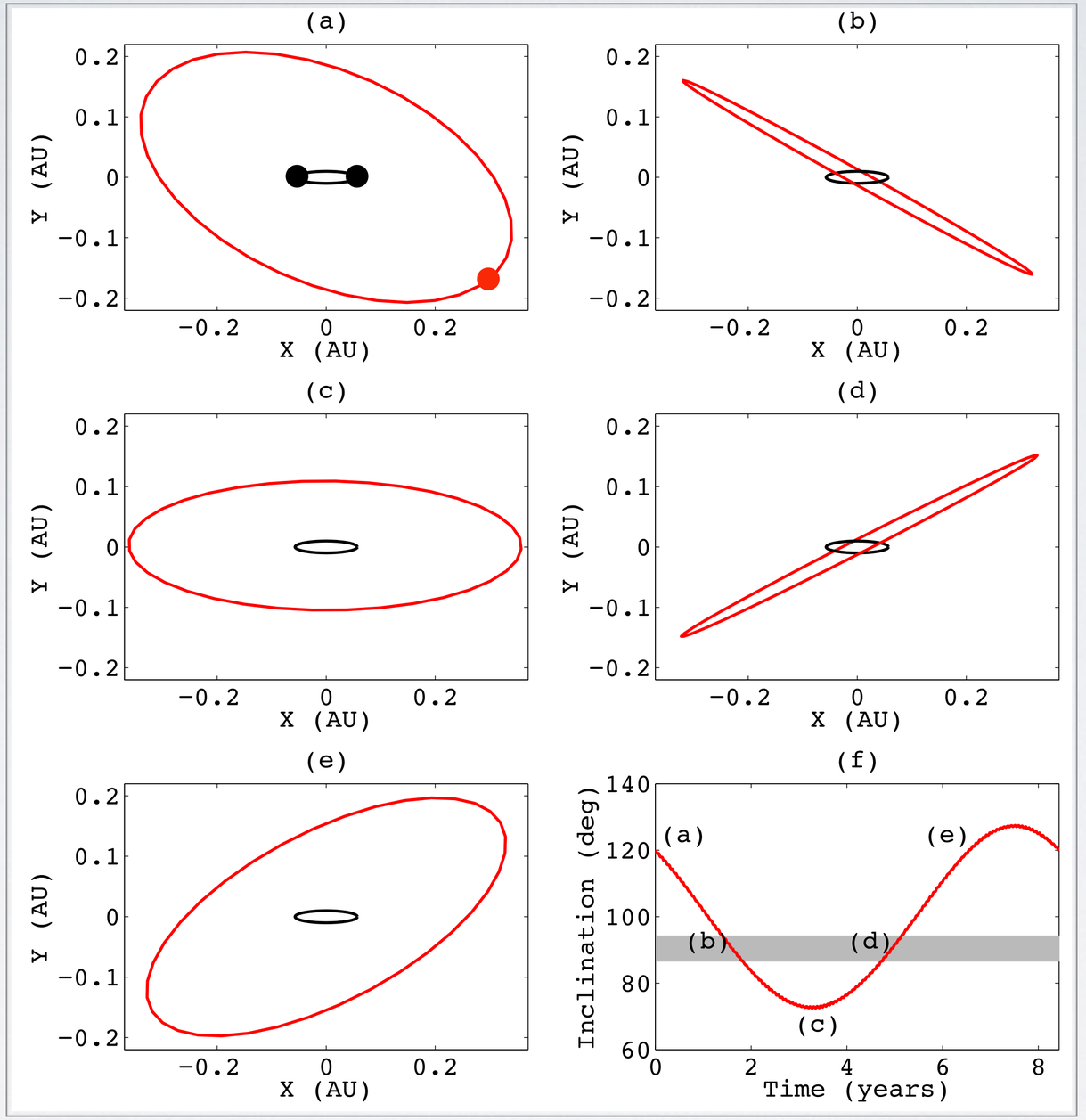
circumbinary planets



Kepler-16b

Doyle et al. 2012

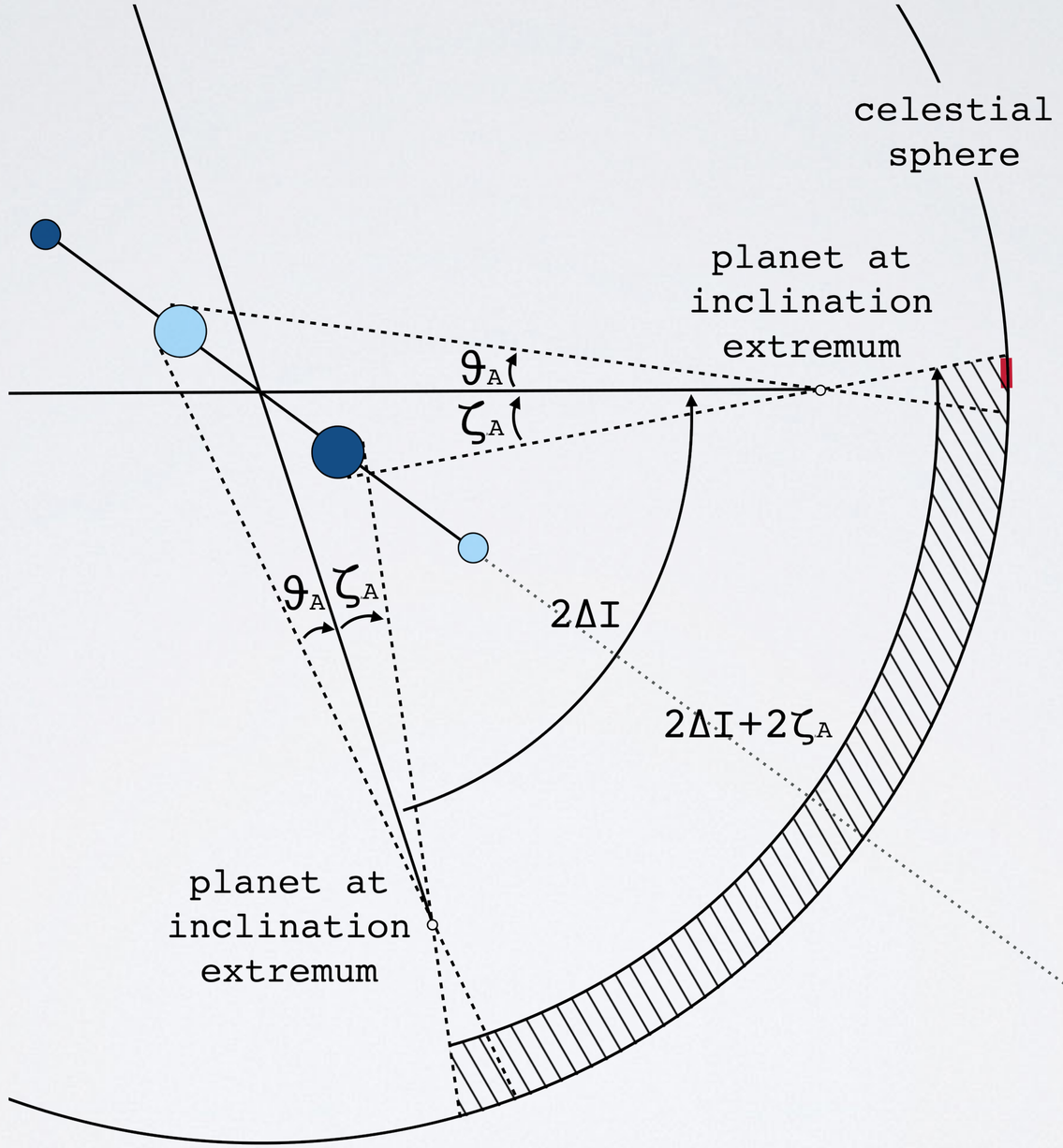
it takes three to tango

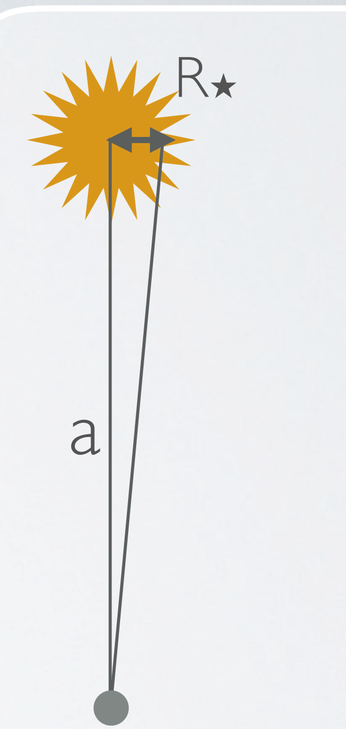


precession brings planets into transitability

Martin & Triaud (2014)

a changed probability of transit





P ≈ sin ΔI

Martin & Triaud (2015a)

two interesting consequences:

the probability of transit becomes independent of the orbital distance

a serious advantage to characterise temperate planets

▲▲

> 90% of all planets orbiting **eclipsing binaries** will one day transit

transit 100% secure if mutual inclination > 0.6°

Martin & Triaud (2014,2015a)

advantages of circumbinary planets

the transit technique is very limited to short periods
(hot Jupiter ~ 10% - Earth ~ 0.4%)
no longer, we are now independent of orbital distance

we do not have any a priori on the inclination of the planet
(need to survey many stars)
does not matter, in eclipsing binaries, the planet will transit

planet masses and radii depend on the assumed/modelled
mass and radius for the host star
eclipsing binaries are the only stars we can measure the
mass and radius, without evolution models

circumbinary planets appear plentiful

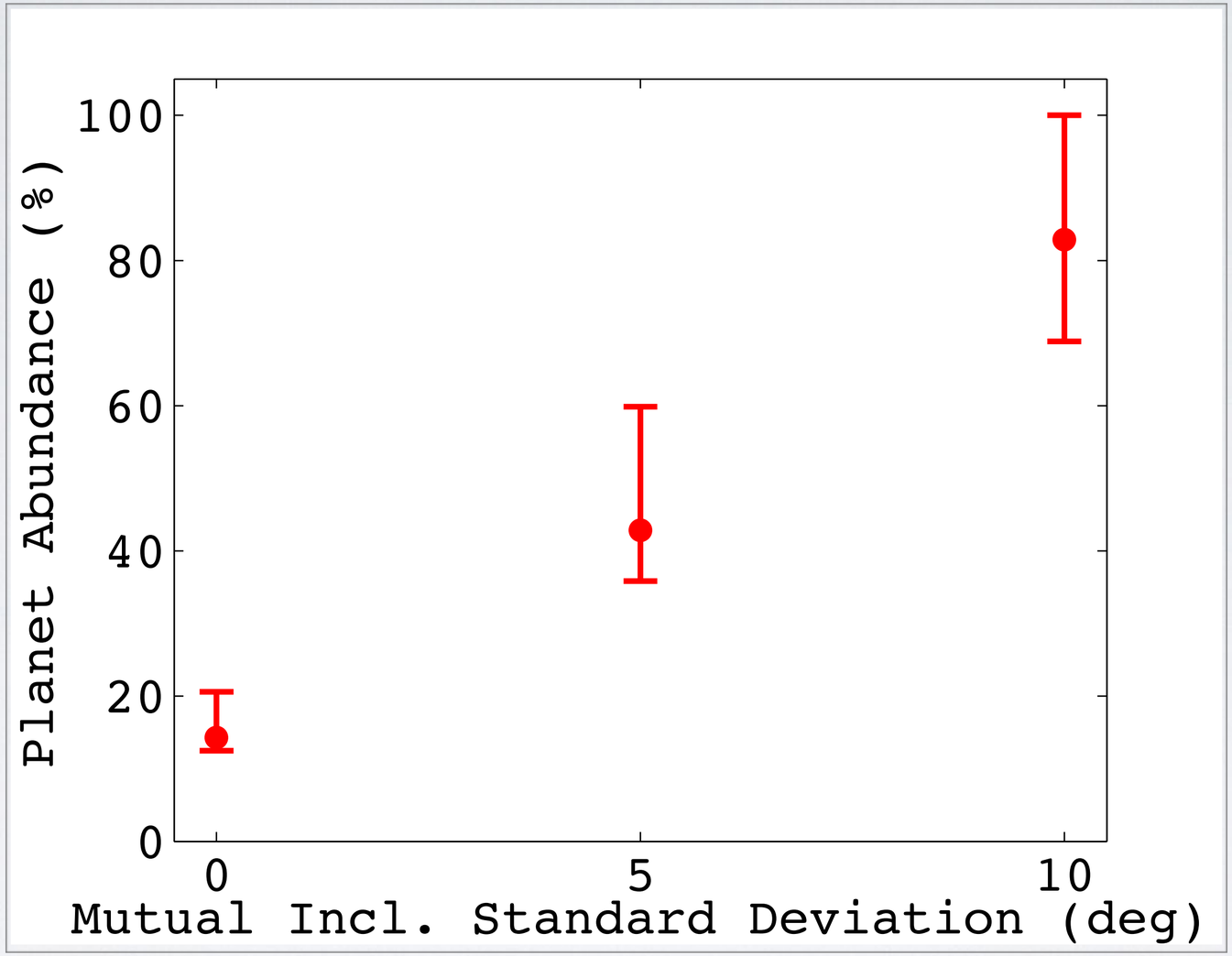
Kepler discoveries consistent with > 9%
of binaries (with P< 120 days) having gas giants
(Martin & Triaud 2014, Armstrong et al. 2014)

period distribution different from single star hosts

lack of planets in binaries < 5 days (Martin et al. 2015)

adjust to ~ 13% of binaries have circumbinary gas giants

only a minimum rate could be computed with Kepler



adjusted from Armstrong et al. (2014)

a different environment for planet formation

a gravitational dipole stirs the circumbinary disc
planetesimal accretion is stifled within 50 binary separation (Meschiari 2012)

planet formation, and orbital evolution history
are reflected in the planets physical parameters:

mass distribution

occurence rate

metallicity distribution

orbital inclination

eccentricity distribution

period distribution

all we know so far edges from single stars. Let's change the scenery!

circumbinary planets & atmospheres

Transits can last 10s of hours (even days)
can get two transits per orbit
and transit two stars => check systematics

at each transit we have a different orbital configuration
the planet receives a varying level of irradiation
changes of 10s Kelvin will happen

=> we can study how atmospheres react to changing conditions

BEBOP

Binaries Escorted by Orbiting Planets

goals

show circumbinary planets can be found using RVs

measure an upper bound on the occurrence rate

derive a mean mutual inclination

verify the metallicity, period and mass distributions

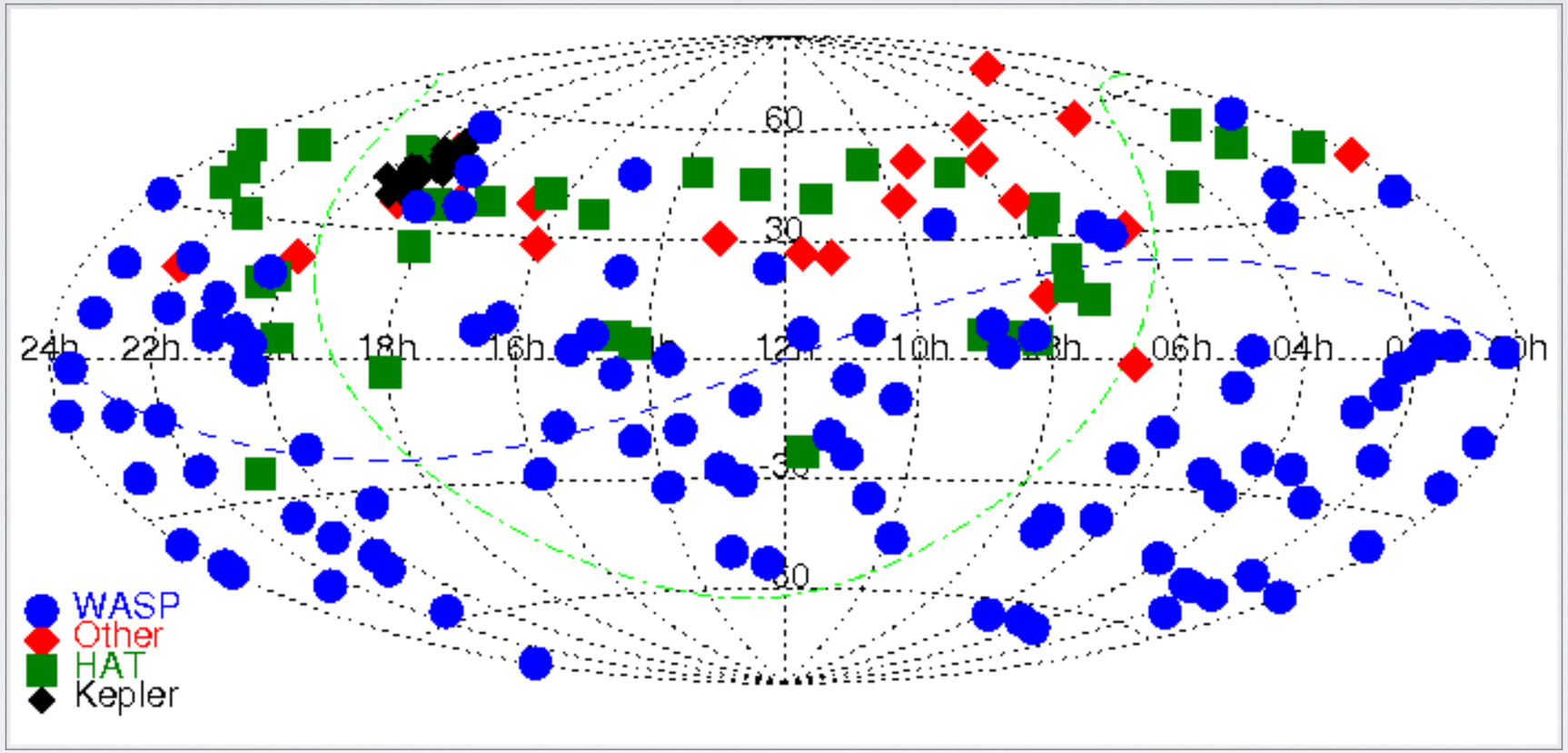
95% of the planets will transit, find them

study changing and temperate atmospheres

WASP

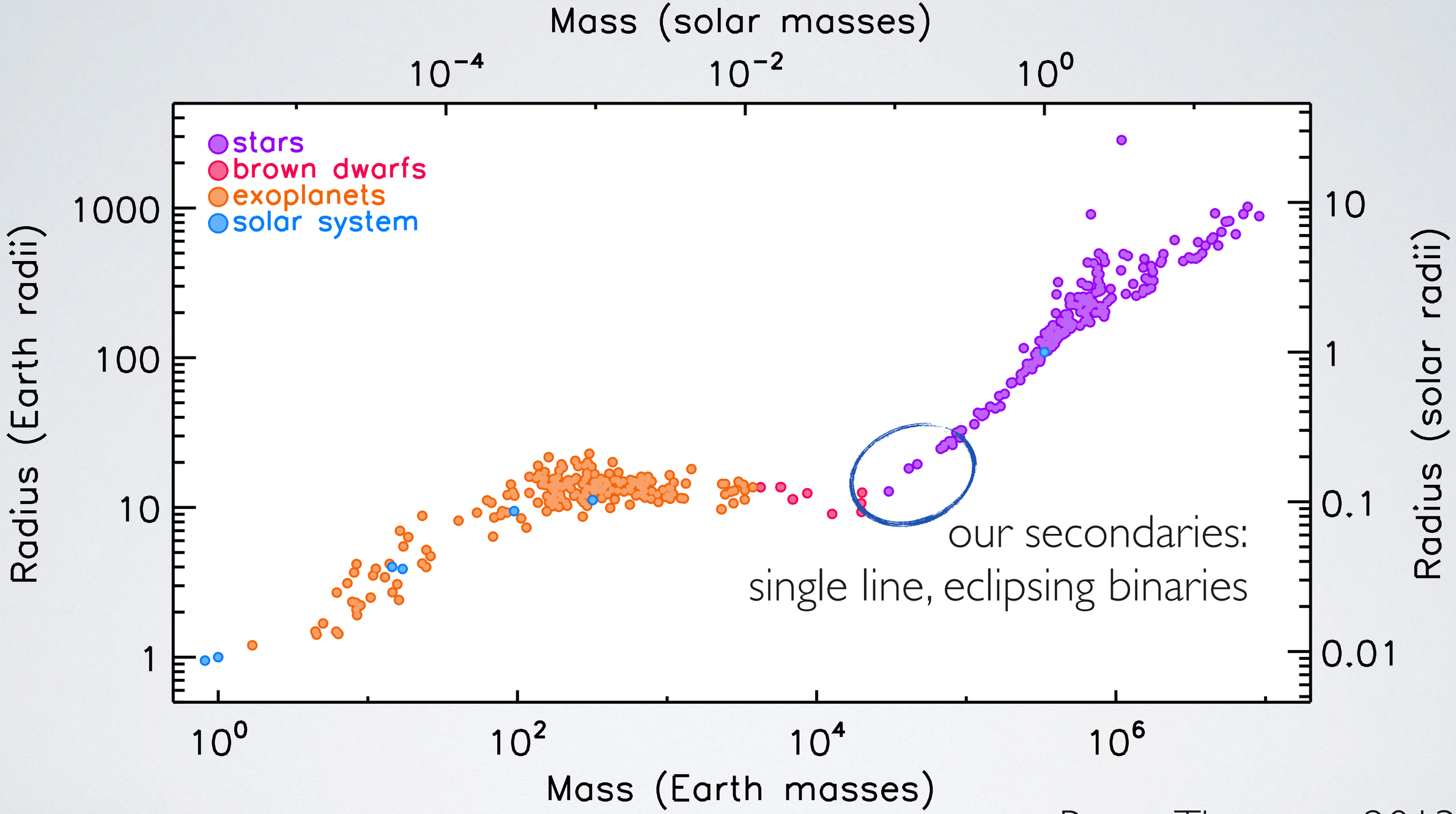
Wide Angle Search for Planets

www.wasp-planets.eu



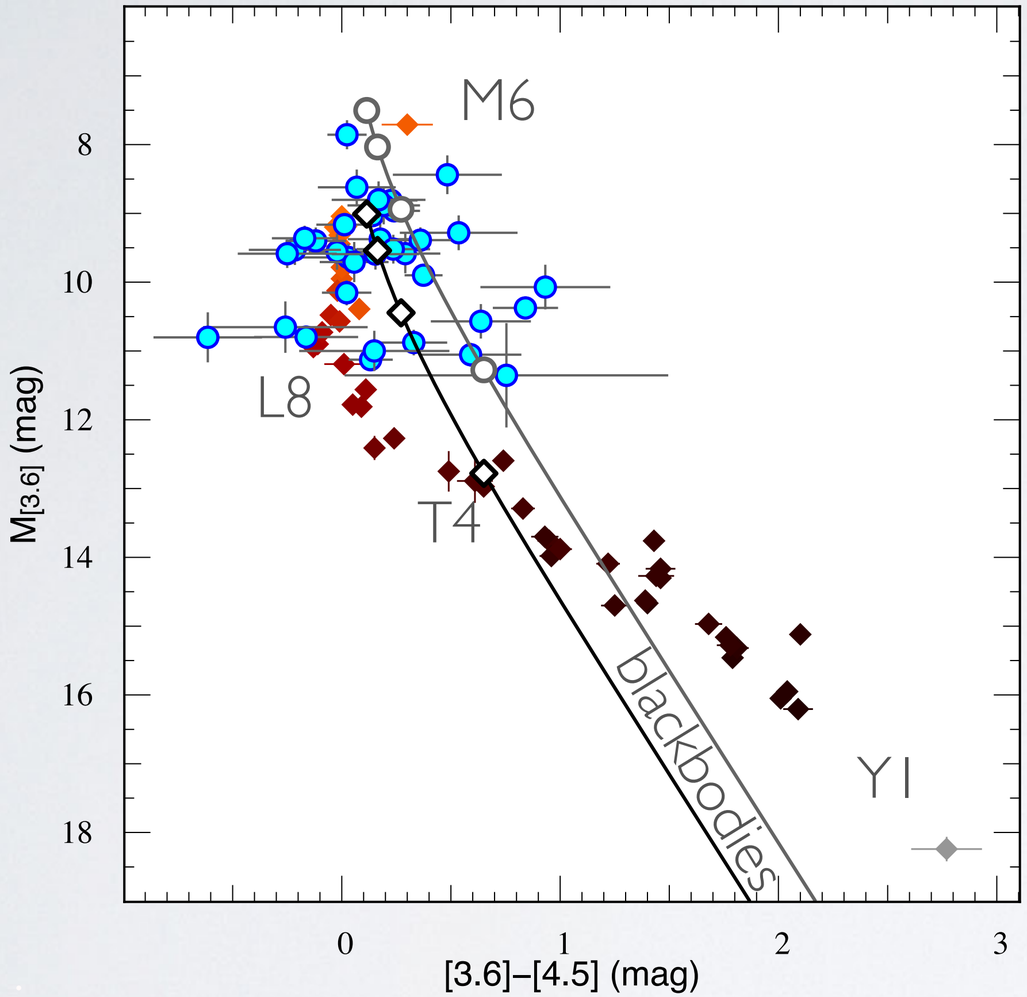
123 transiting planets | 2 brown dwarfs | 214 low mass eclipsing binaries

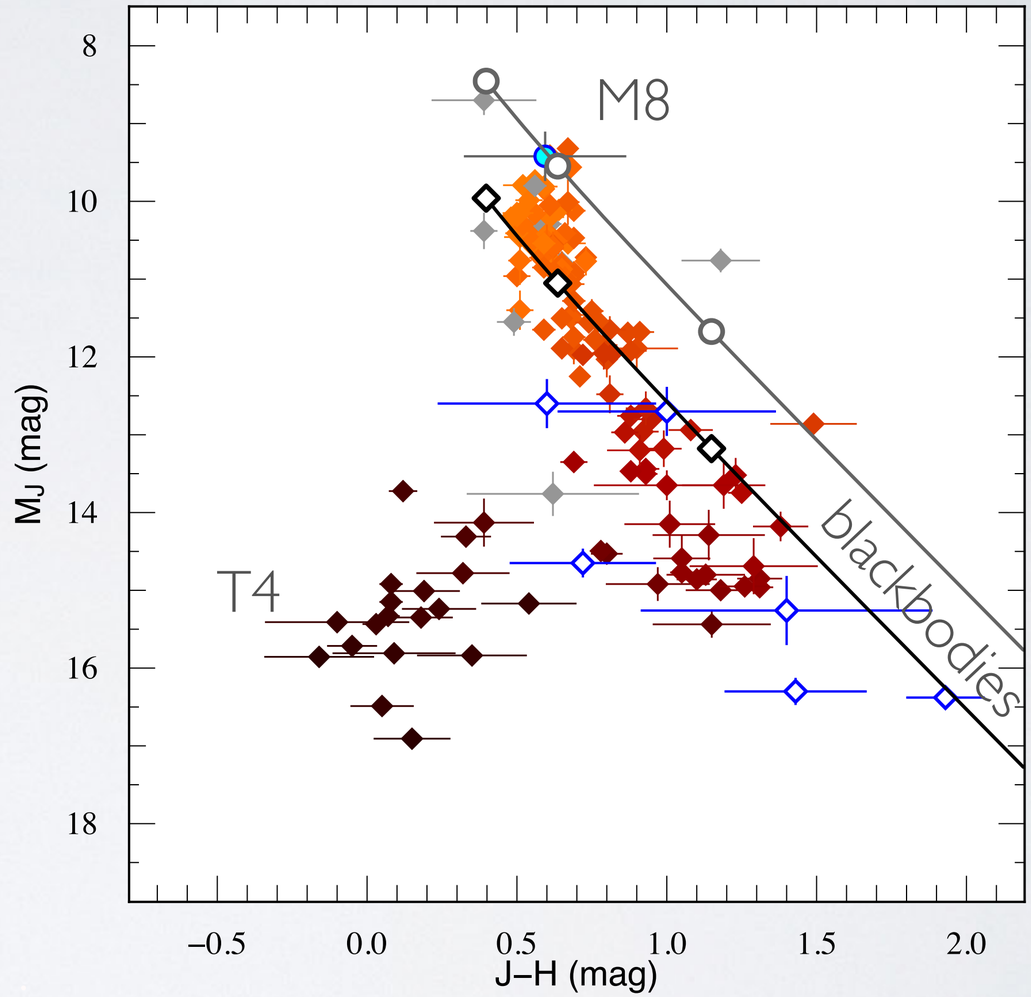
secondary stars as small as hot Jupiters



Berta-Thomson 2013

secondary stars as faint as hot Jupiters





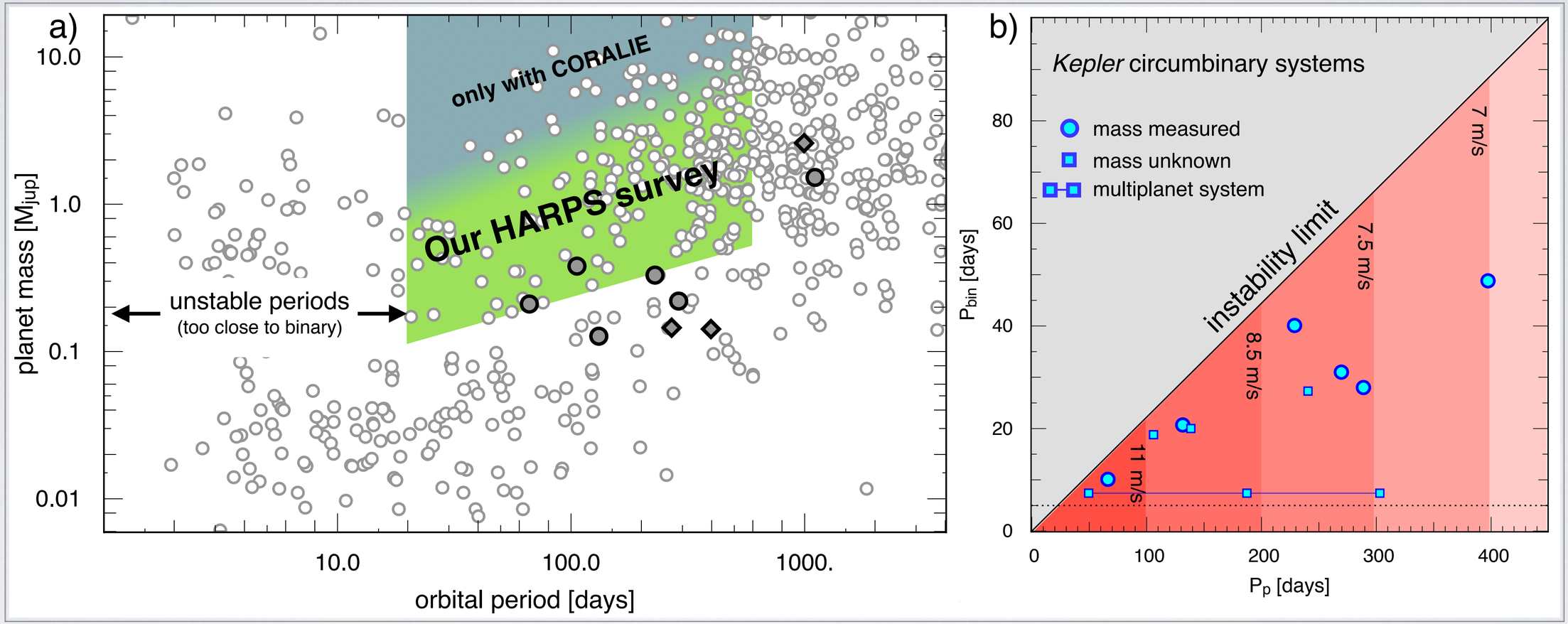
$L \propto R^2 T^4$

Triaud et al. 2014

BEBOP

60 bright and nearby, low-mass, eclipsing binaries from WASP

on HARPS: reach < Saturn's mass for 50% of the sample

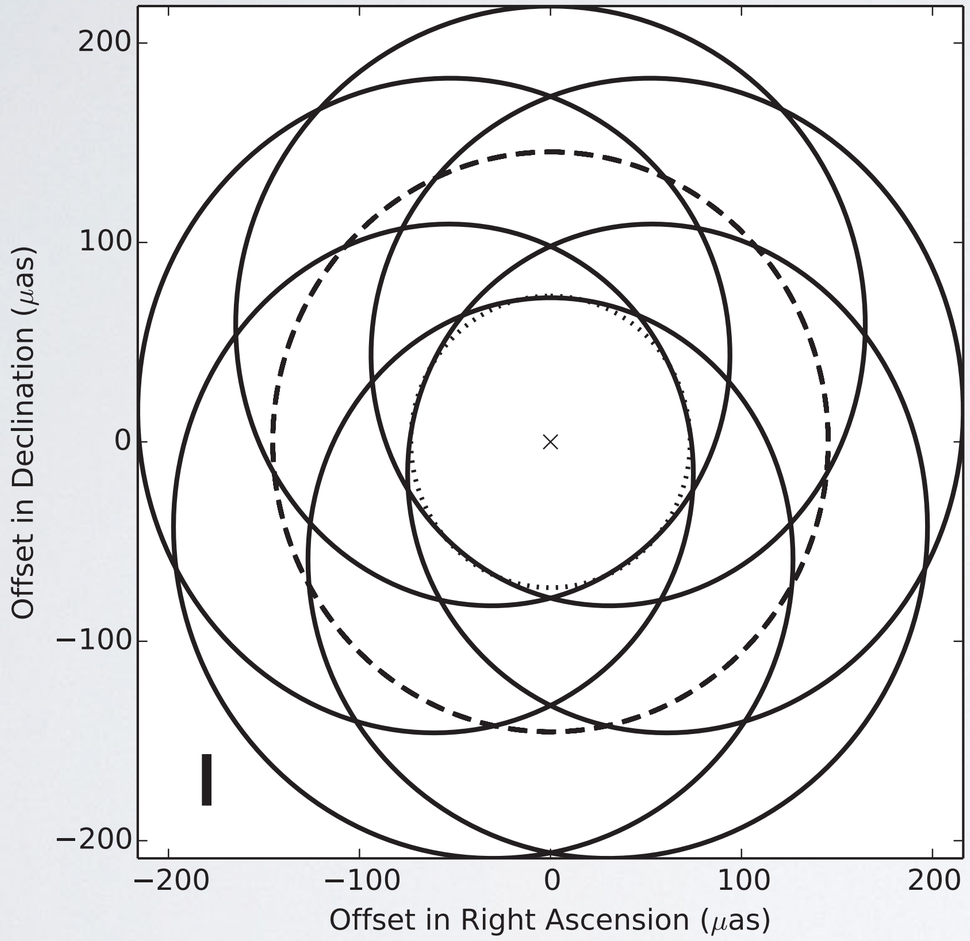


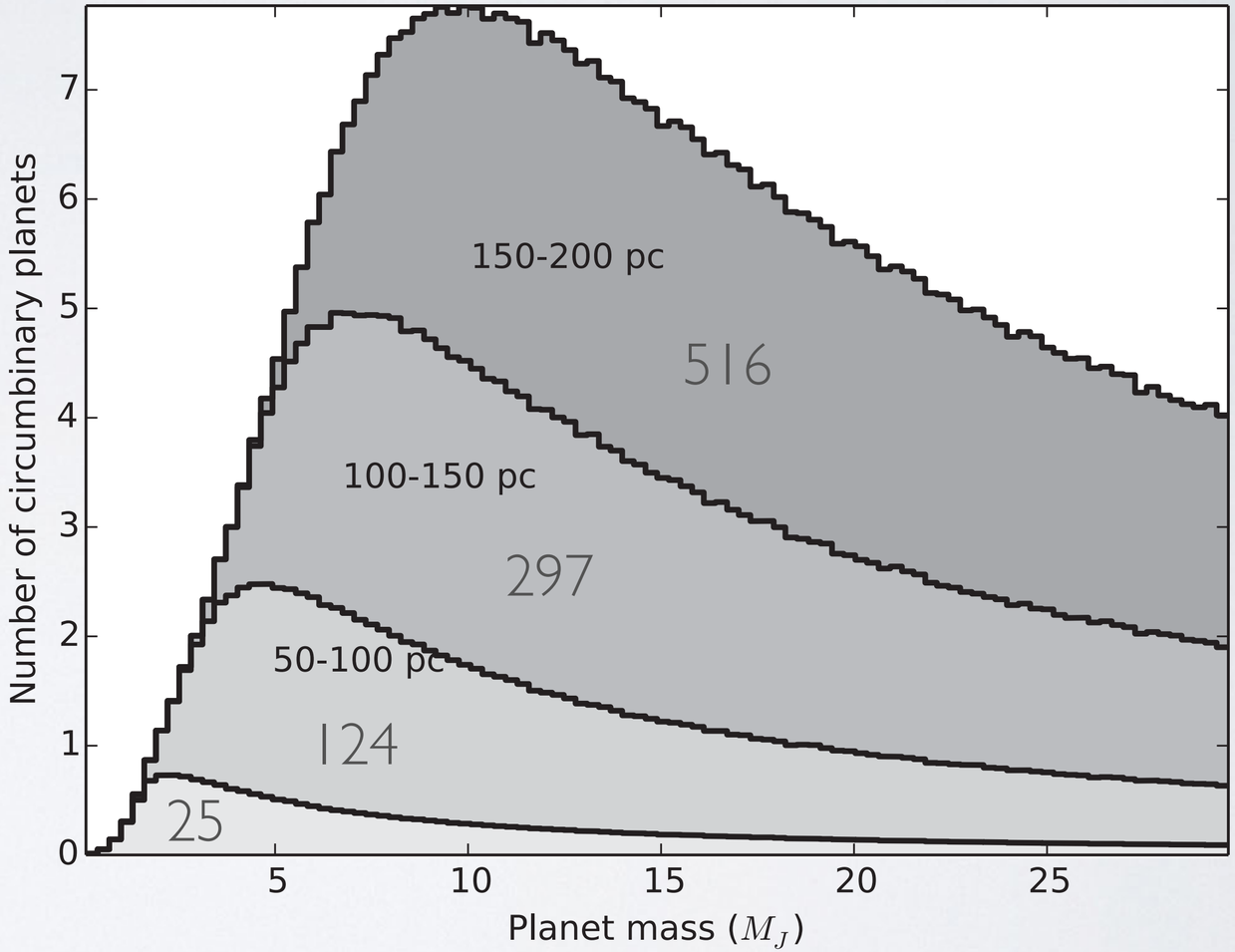
only 3 transiting gas-giants with P > 30 d with Jmag < 12
we expect between 7 and 22

GAIA

hundreds of circumbinary gas giants!

mutual inclinations measured with 10° precision





Sahlmann, Triaud & Martin (2015)

circumbinary planets

soon more to play with

boosted probabilities of transit

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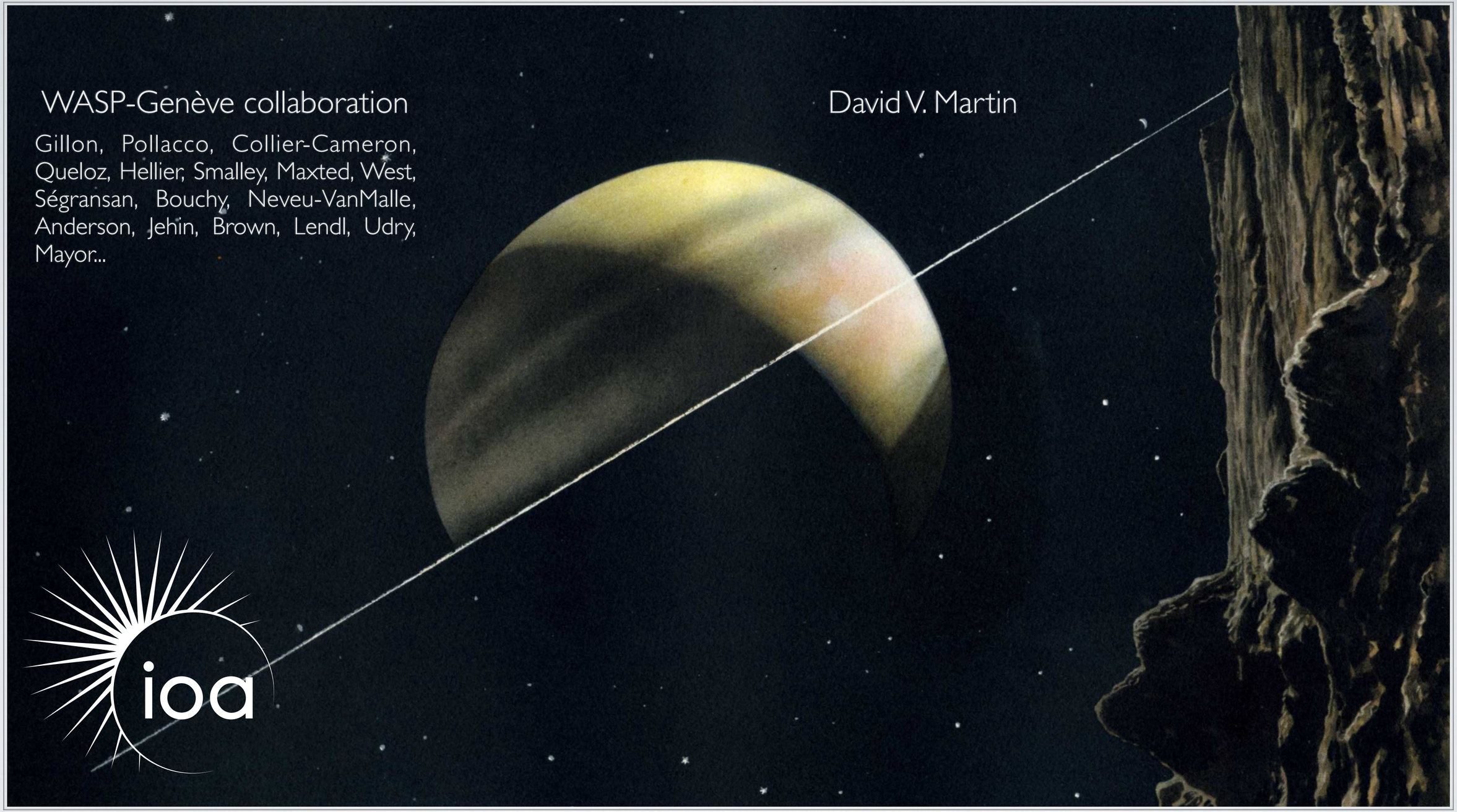
WASP-Genève collaboration

Gillon, Pollacco, Collier-Cameron, Queloz, Hellier, Smalley, Maxted, West, Ségransan, Bouchy, Neveu-VanMalle, Anderson, Jehin, Brown, Lendl, Udry, Mayor...

David V. Martin



L. Rudaux, 1937