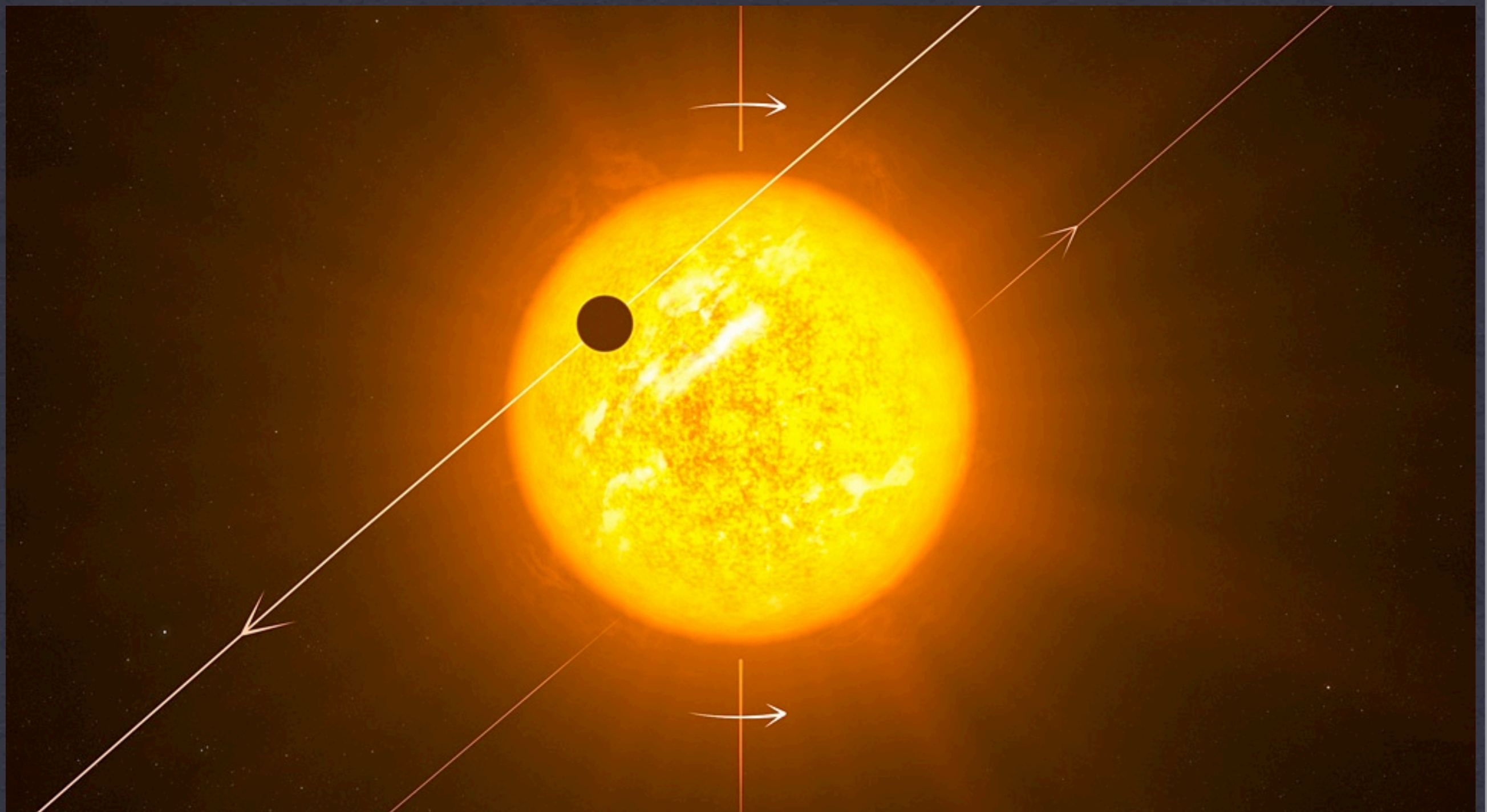


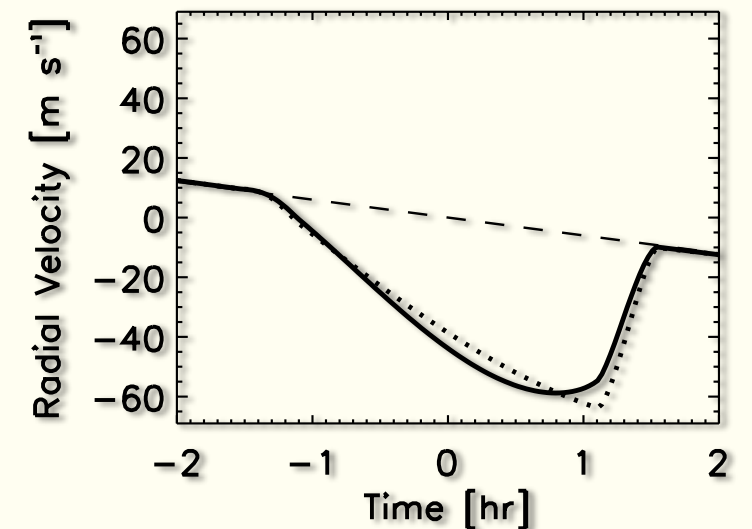
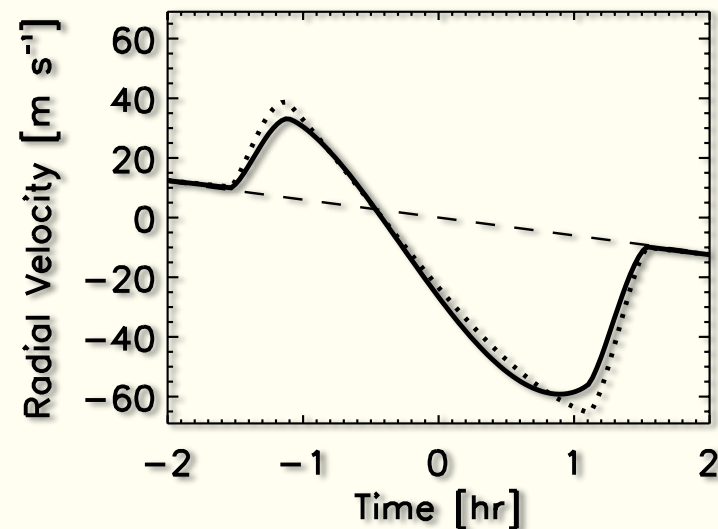
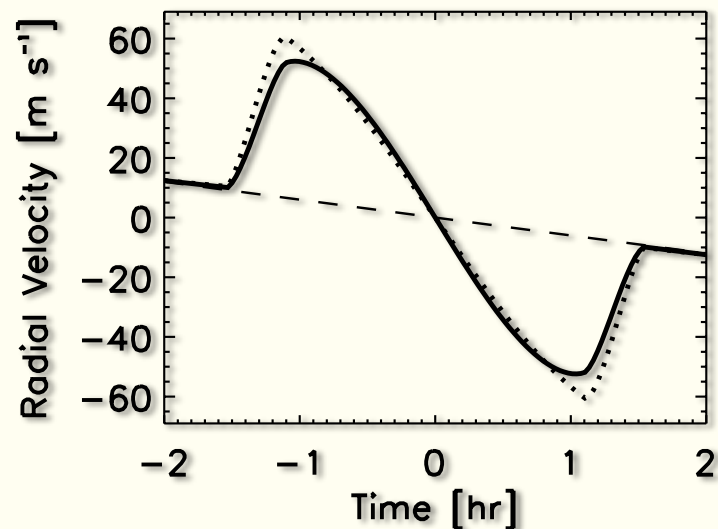
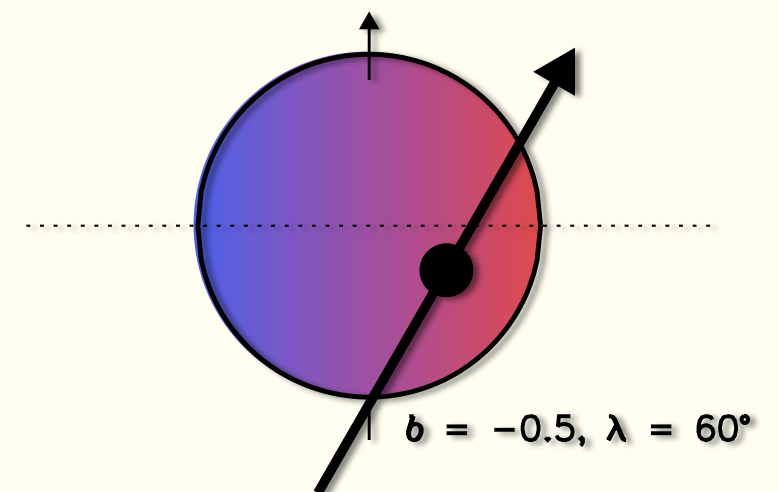
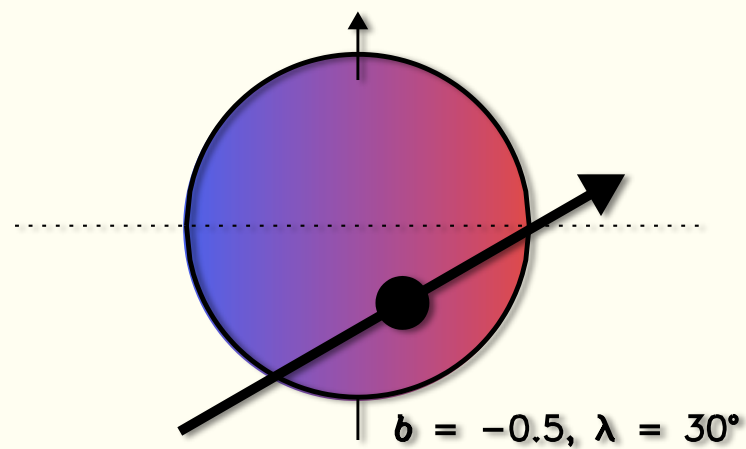
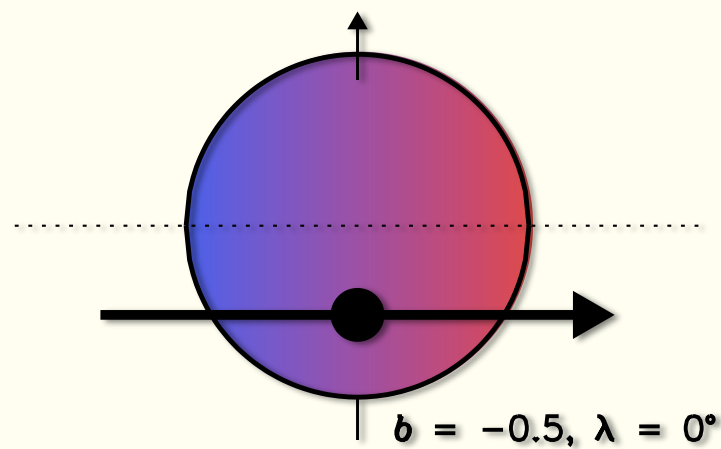


The Rossiter-McLaughlin effect: a tool to understand planetary systems

VITACURA - 06/03/12

AMAURY H.M.J. TRIAUD

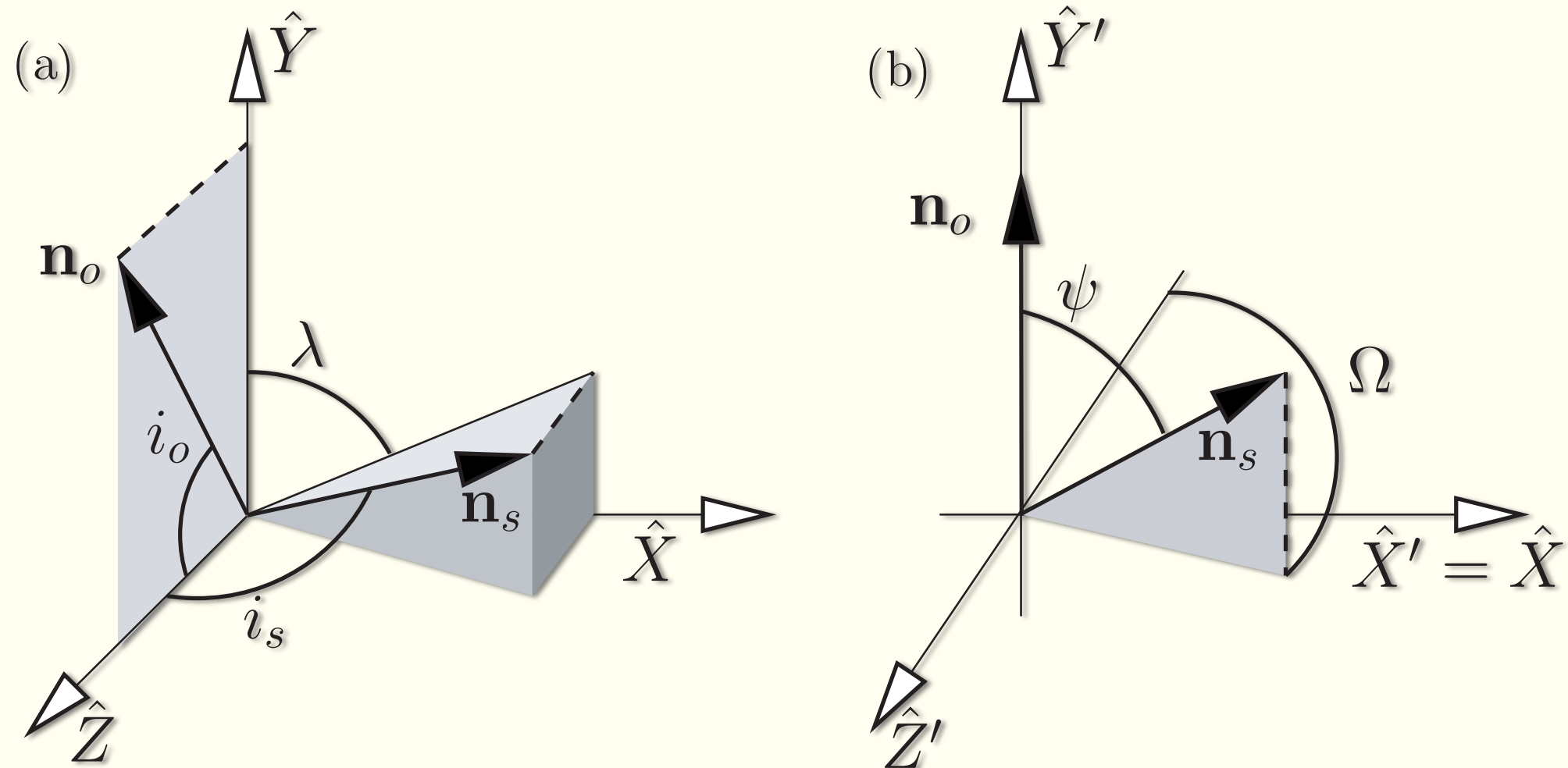




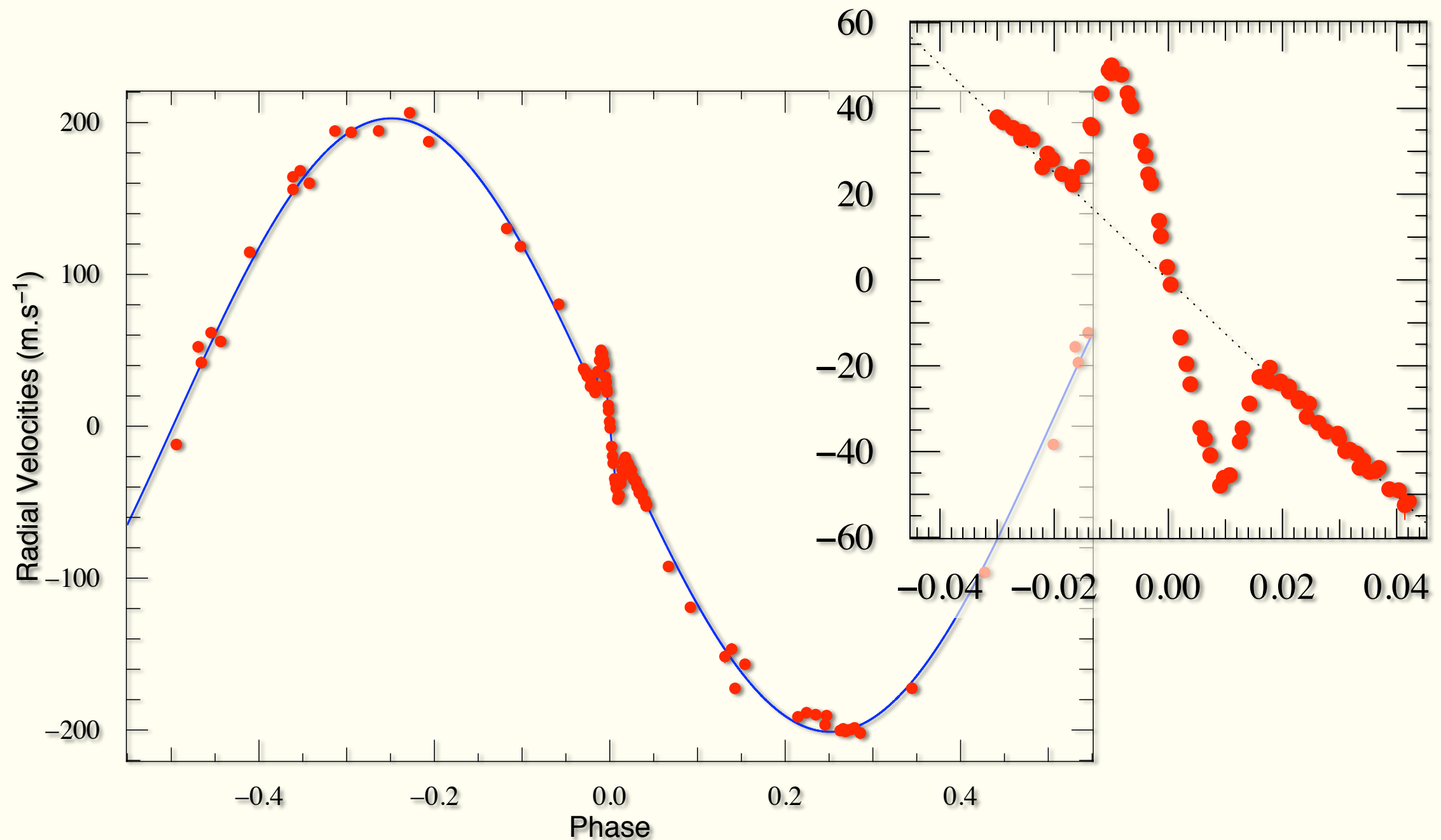
The Rossiter-McLaughlin effect
 In function of the spin/orbit angle, the shape changes
 we only measure the projected spin/orbit angle

$$\beta = -\lambda$$

GAUDI & WINN 2007



What is what.
 $\beta = -\lambda$ & $l = i_s$

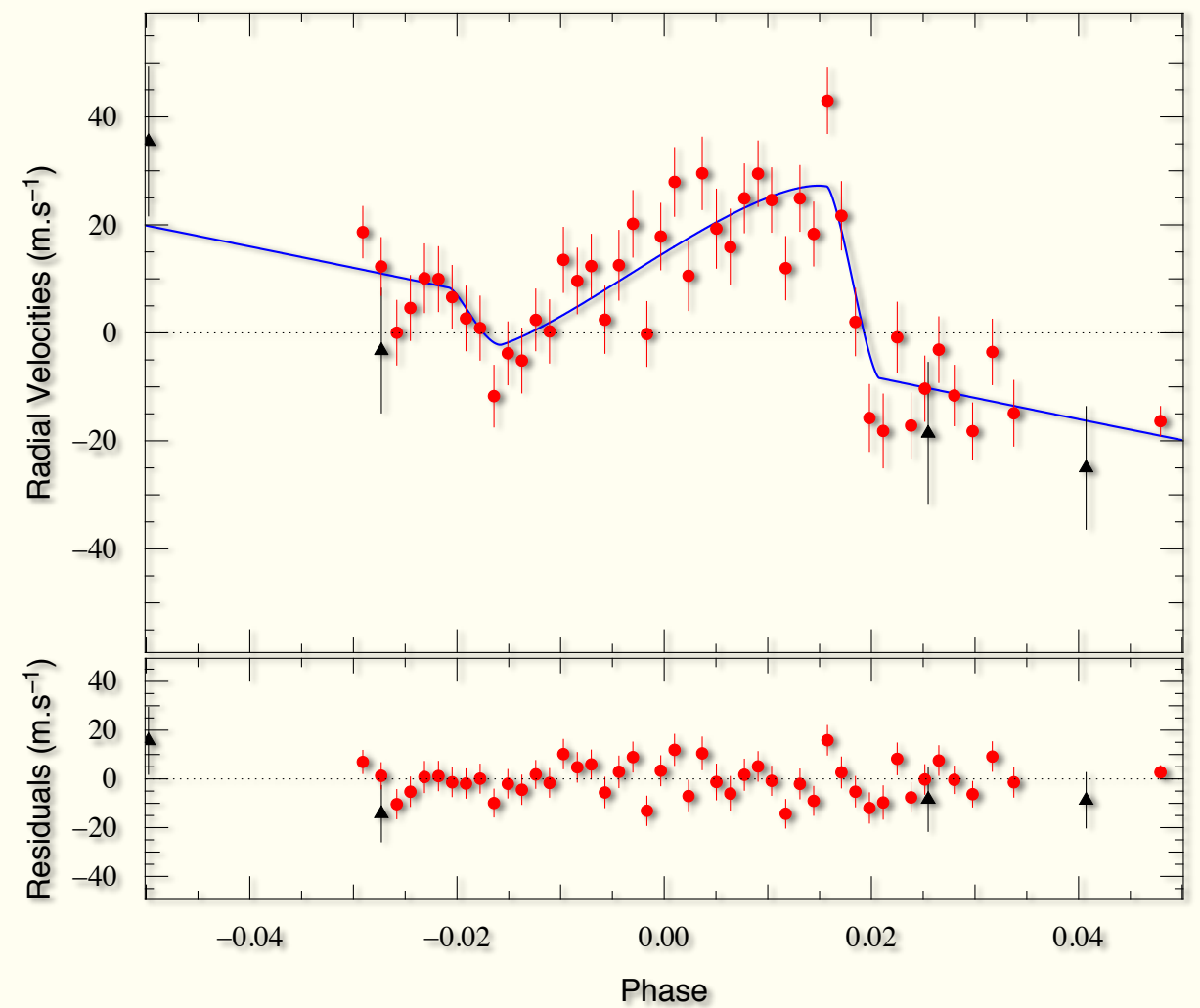
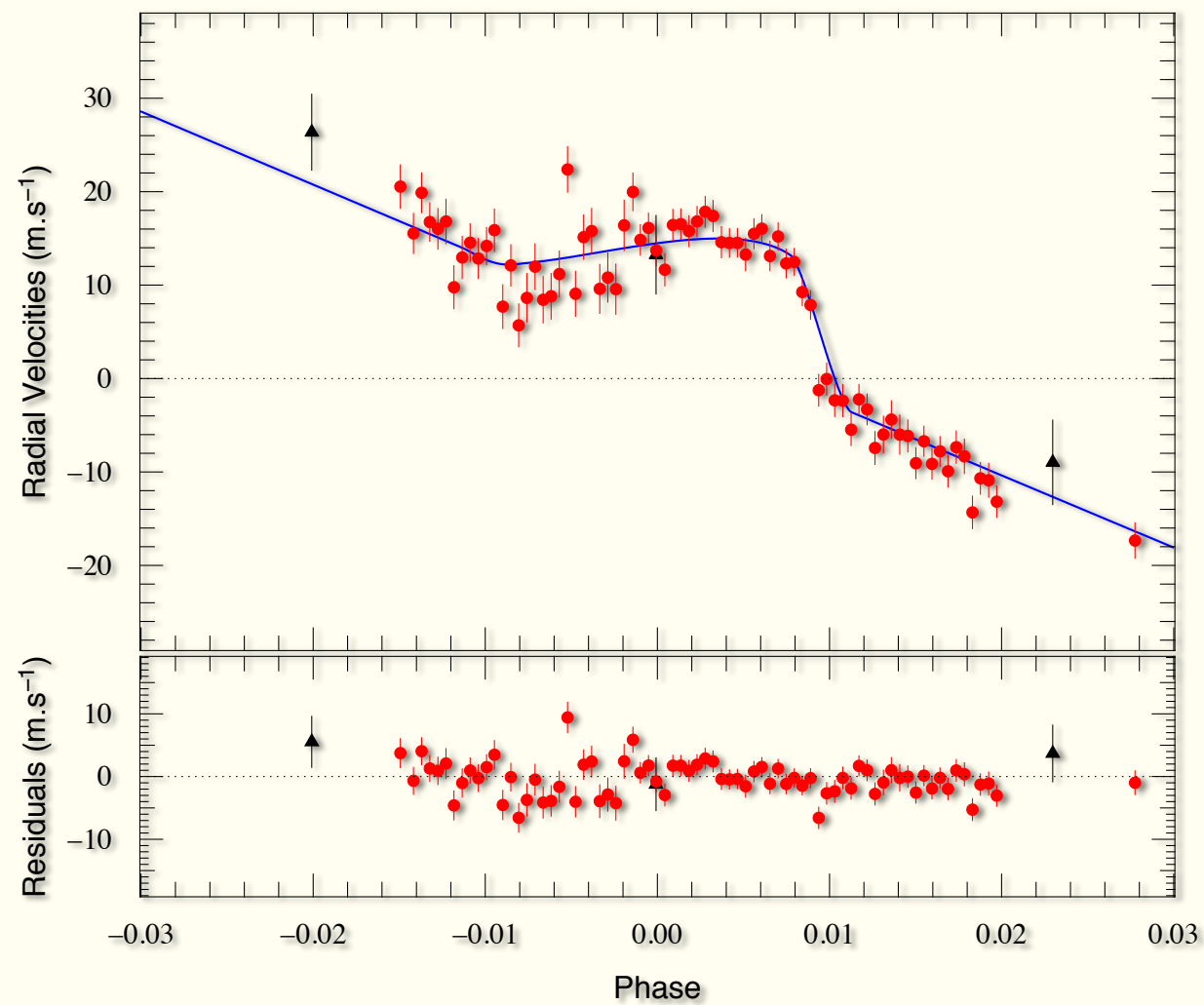


The Rossiter-McLaughlin effect superimposed itself above the Doppler reflex motion caused by the planet on its star.

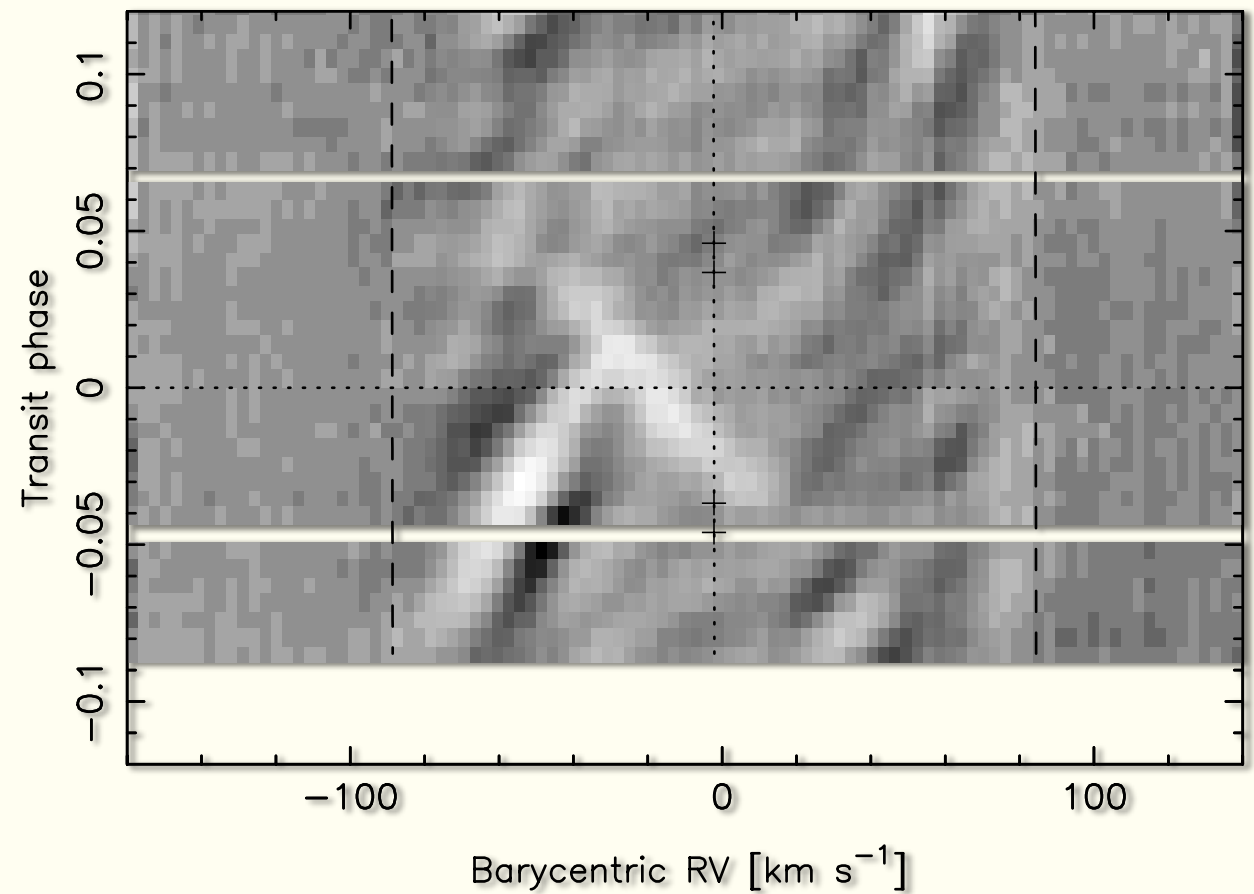
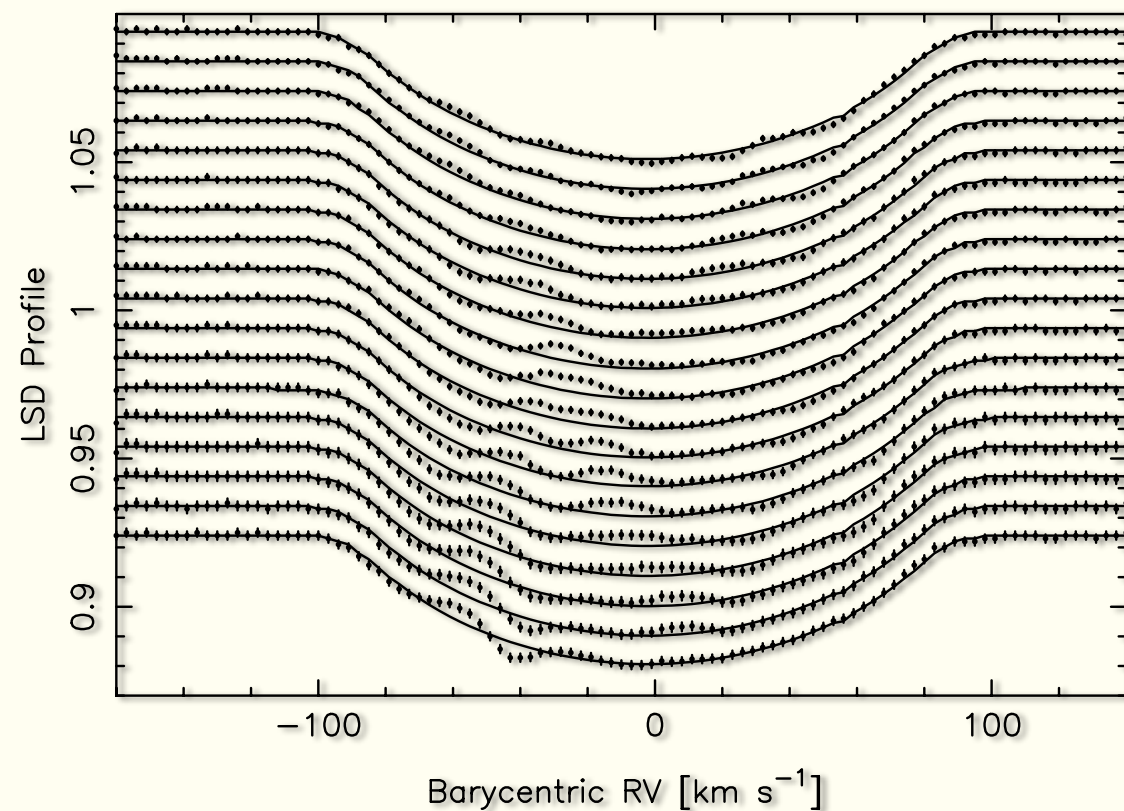
$V \sin I$ is also directly measured

HD 189733B

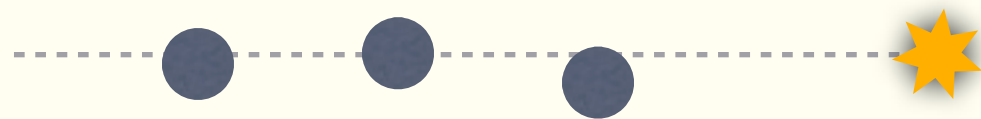
TRIAUD ET AL. 2009



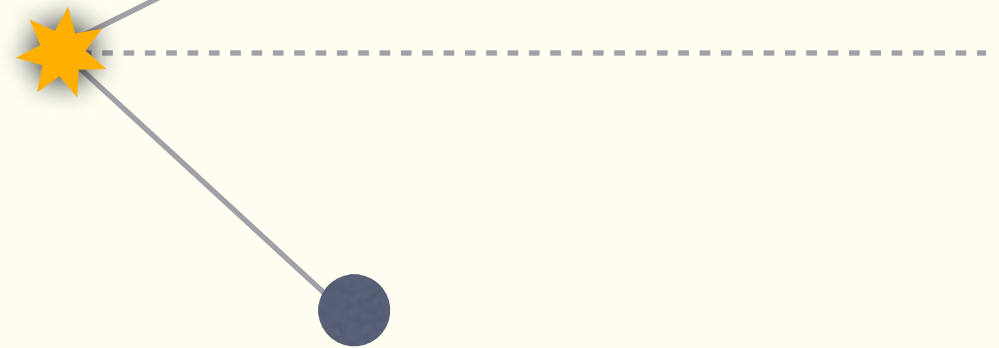
Planets can have retrograde orbits



A novel way to confirm planets, around hot stars

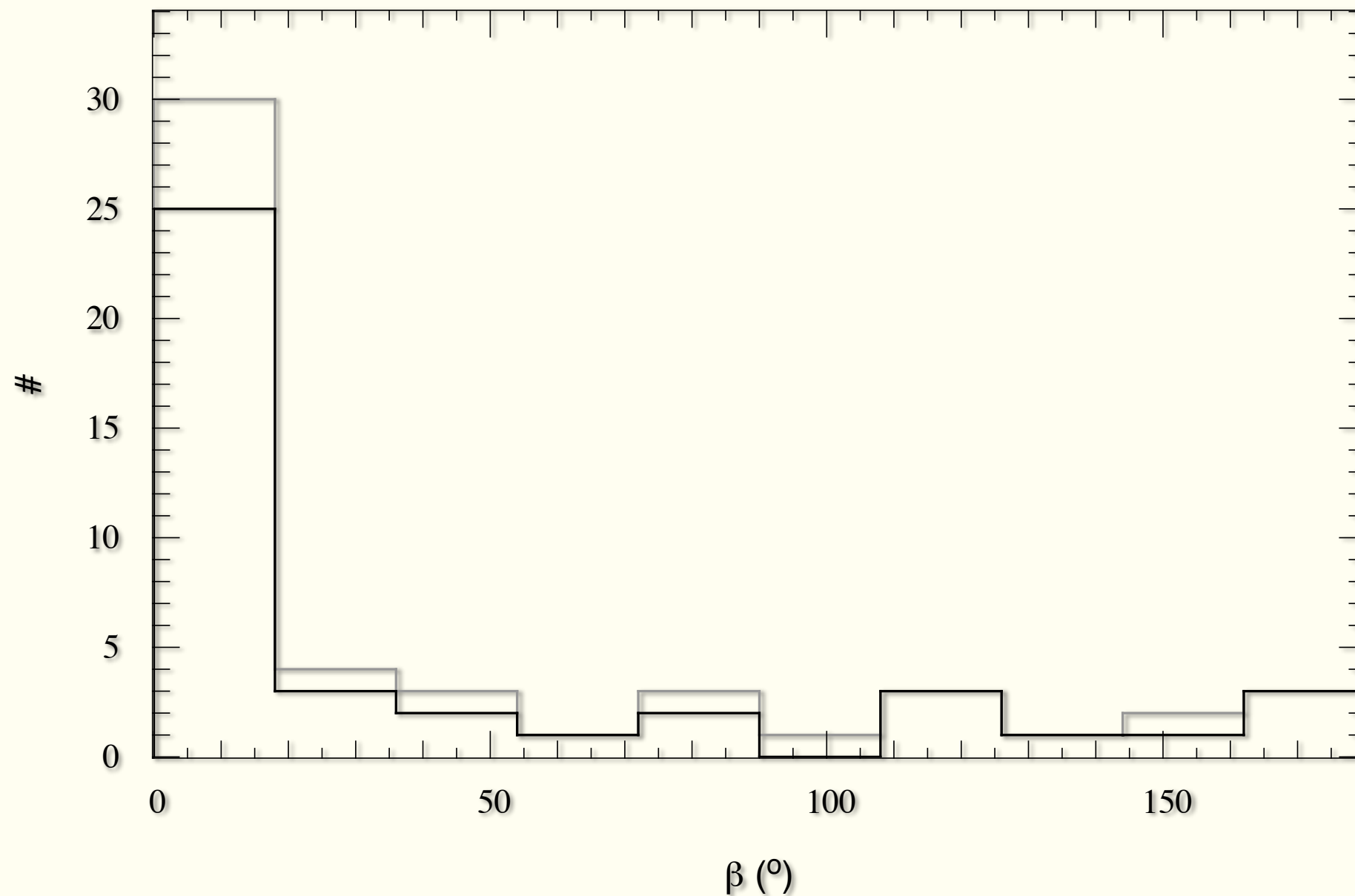


DISC MIGRATION

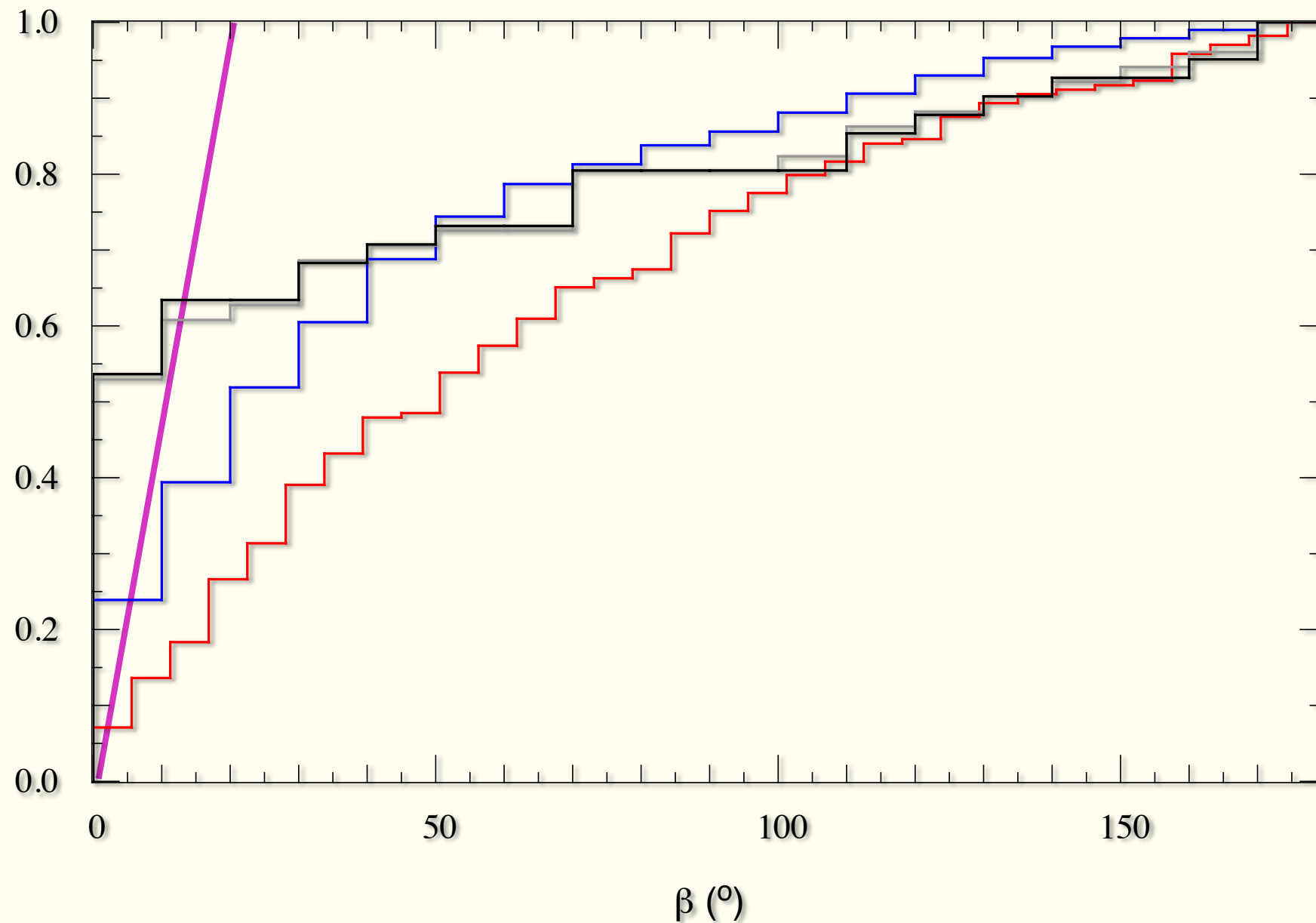


DYNAMICAL INTERACTIONS

We can test two scenarios
on the hot Jupiters population

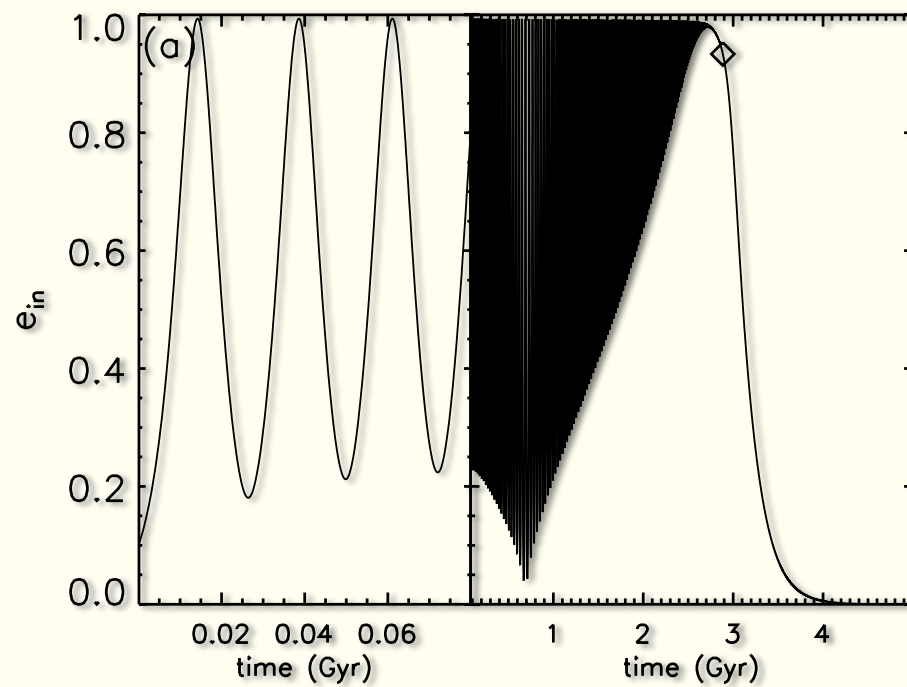


histogram of β , projected spin-orbit angle

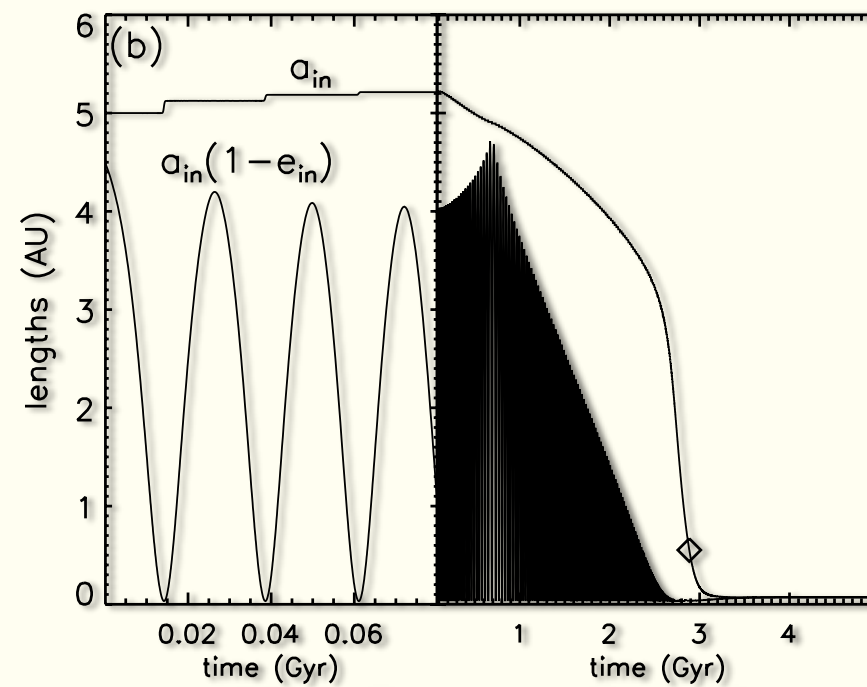


Transform theoretical ψ to β
Theory predicts about 50% of planet should appear aligned
2 theories: Fabrycky & Tremaine '07, Nagasawa et al '08

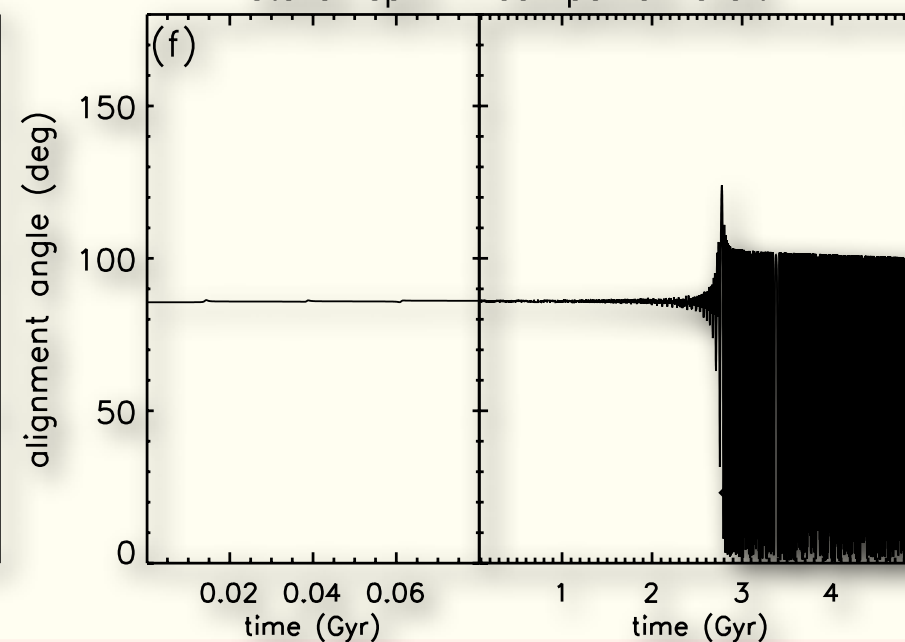
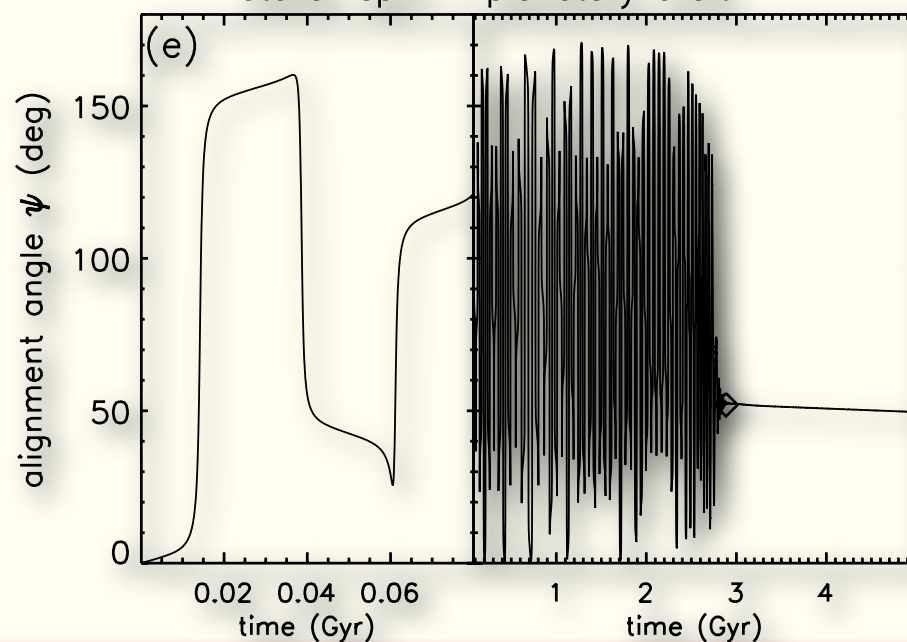
UPDATED FROM TRIAUD, CAMERON, QUELOZ ET AL. 2010



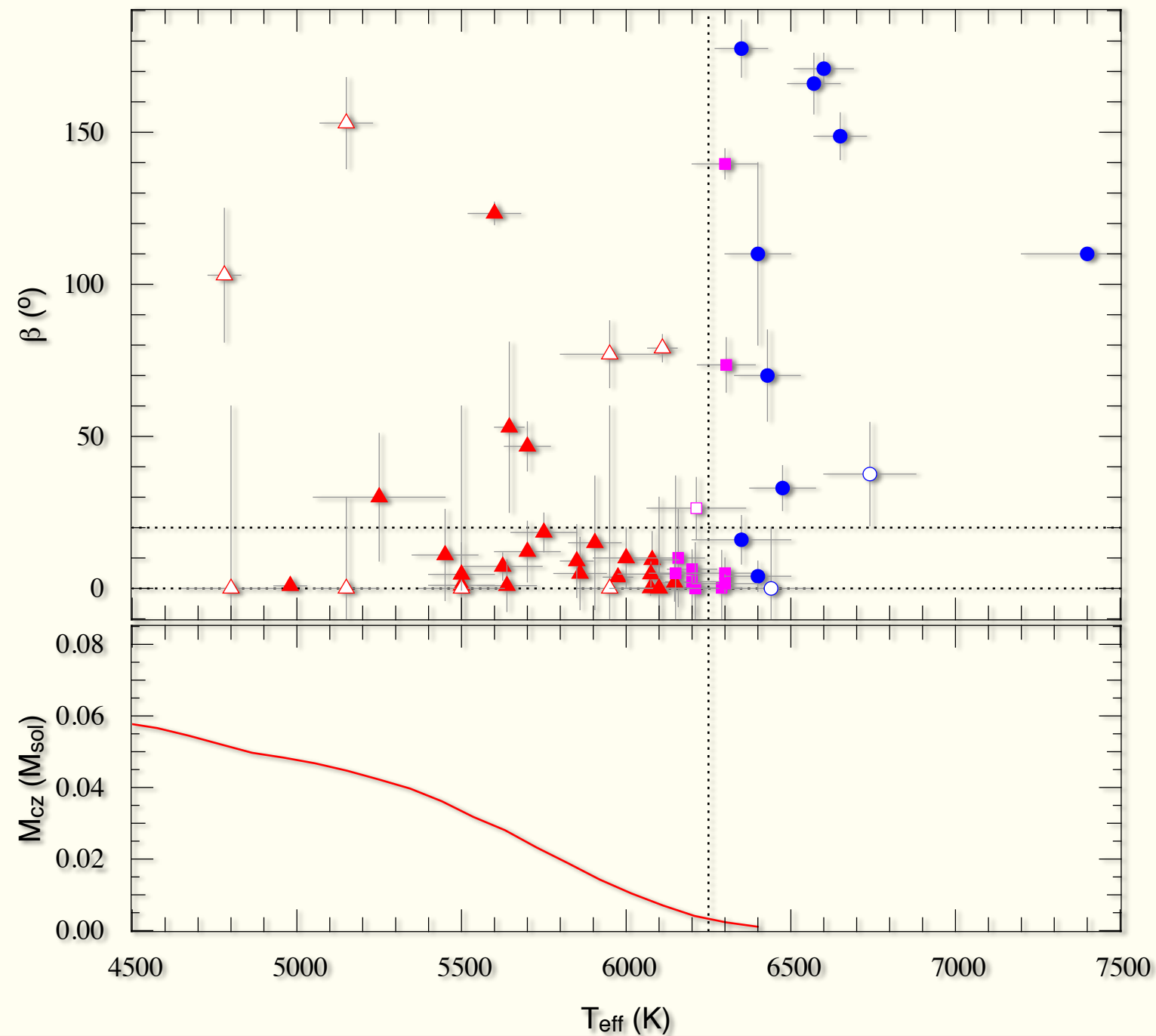
stellar spin – planetary orbit



stellar spin – companion orbit



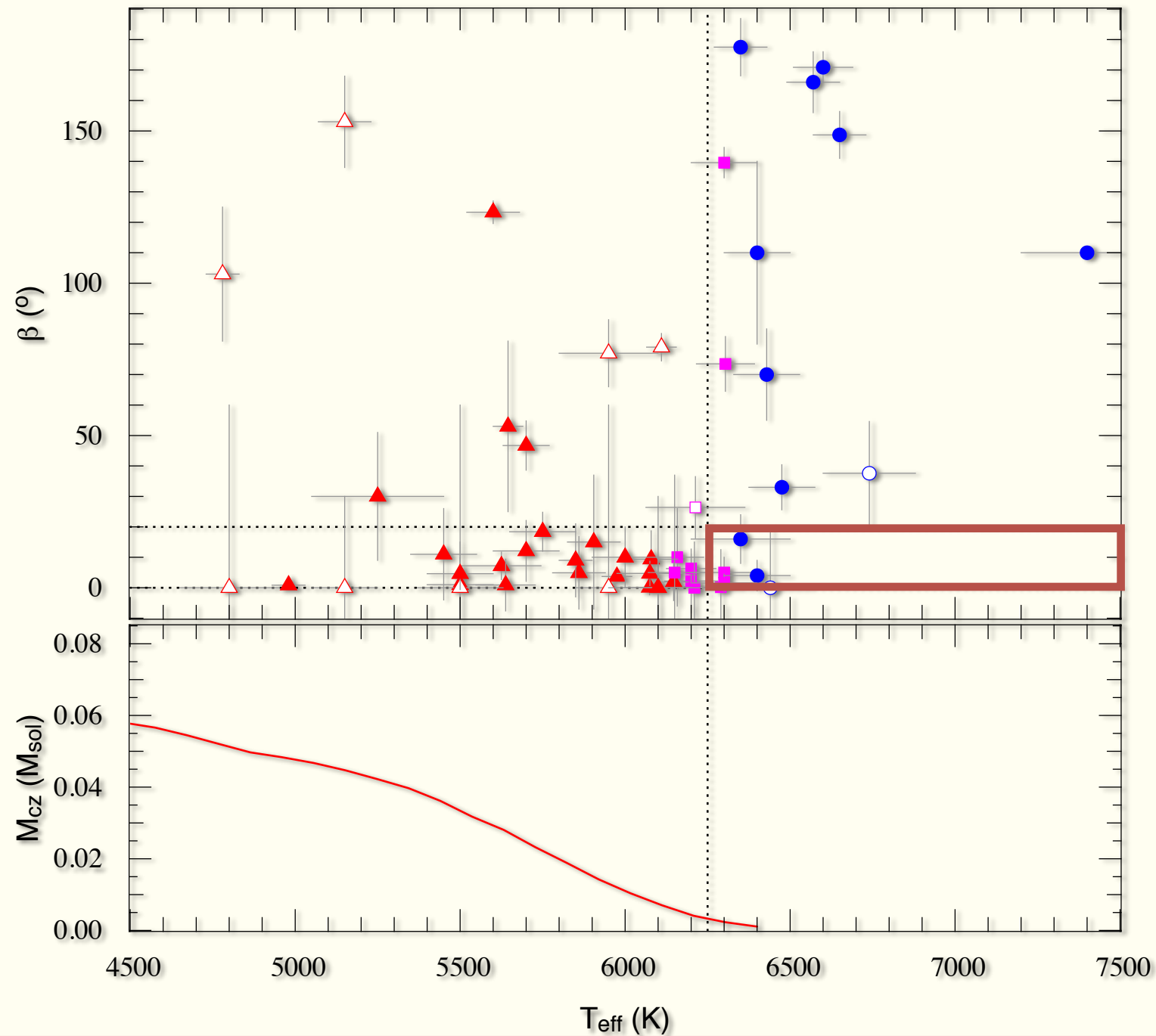
Binary is at 1000 AU, planet starts at 5 AU
produce a prediction of ψ from a simulations with
initial conditions matching binary observations



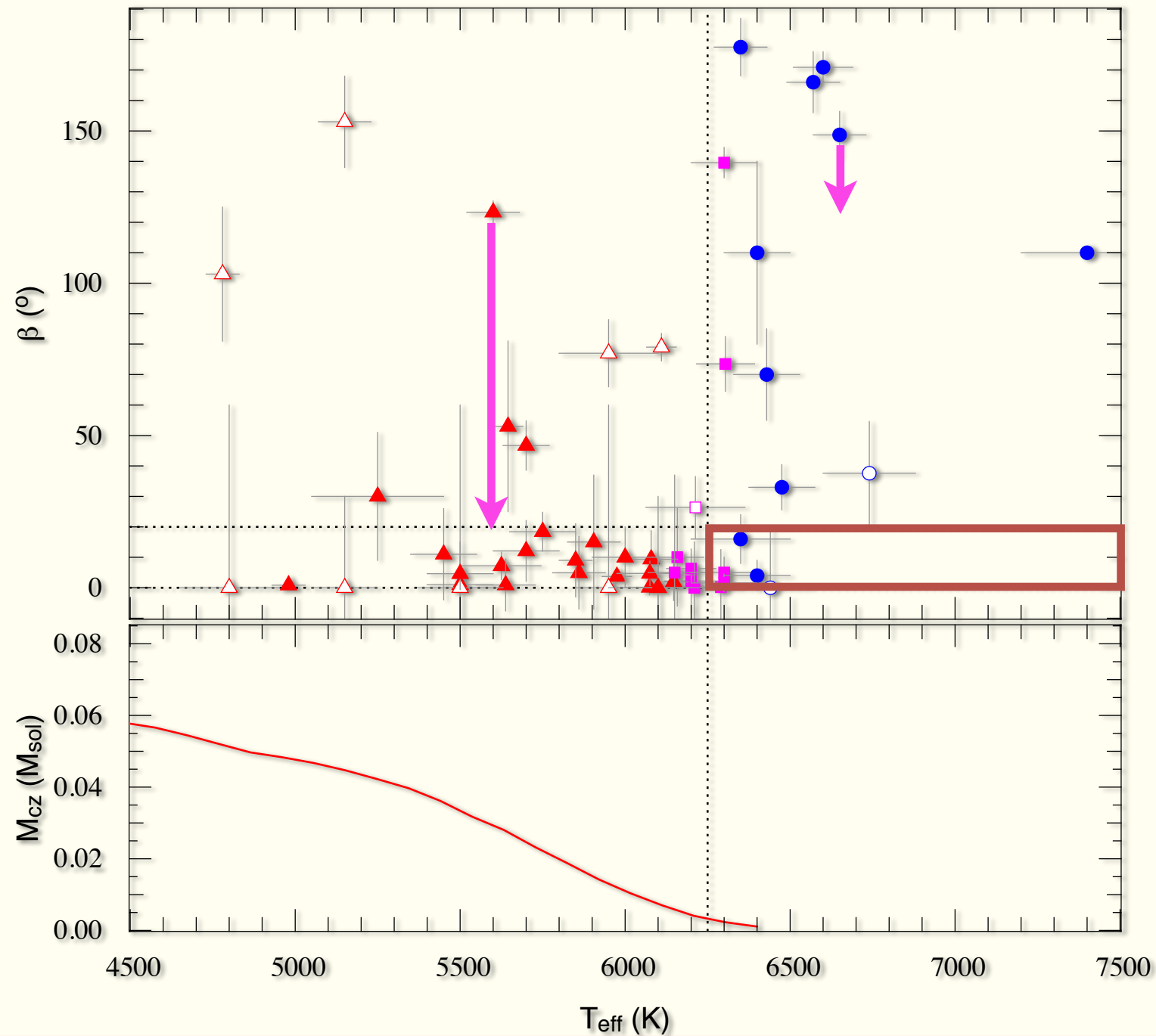
We are missing aligned planets around hot stars
results confirmed independently by Schlaufman '10

UPDATED FROM

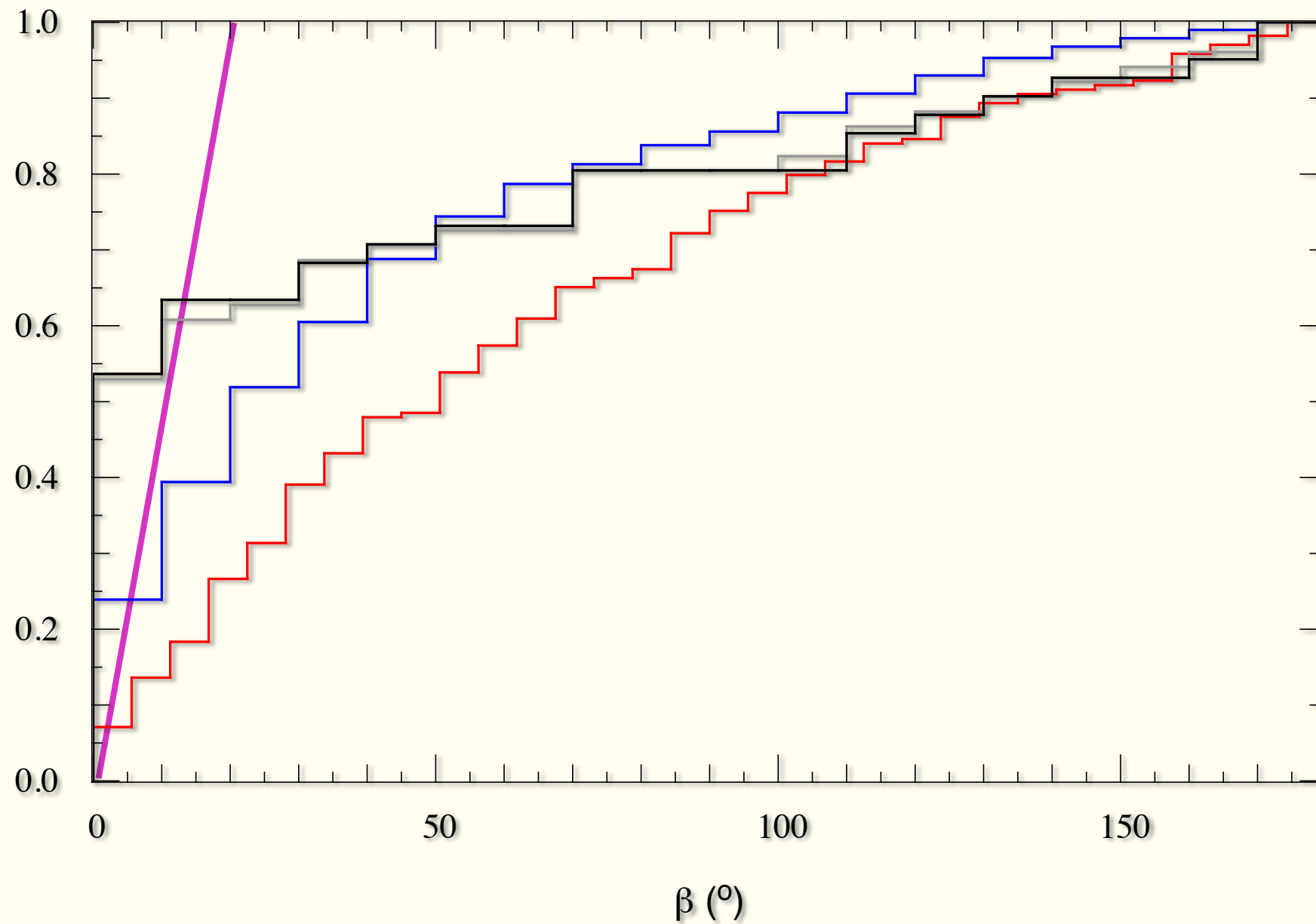
WINN ET AL. 2010



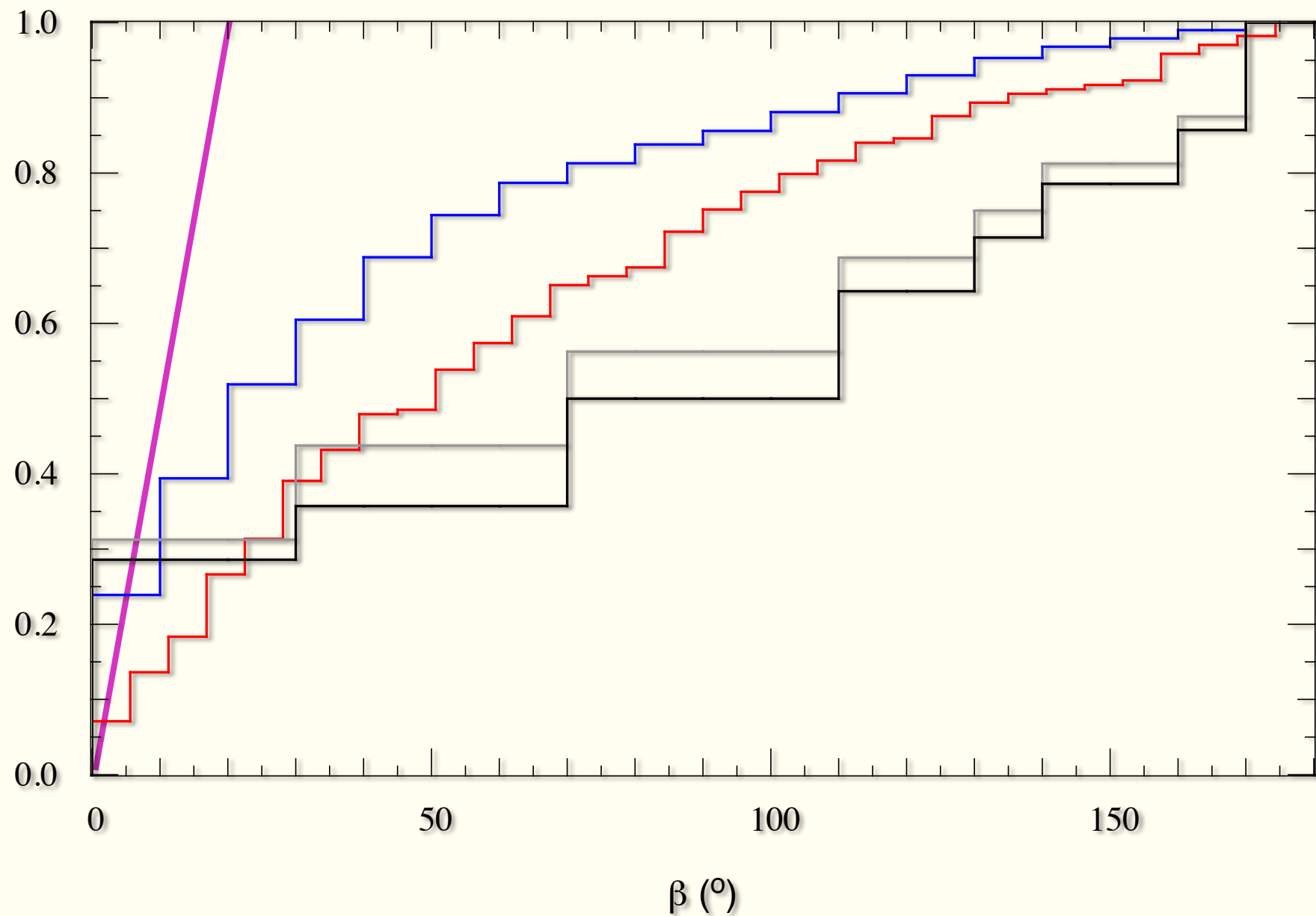
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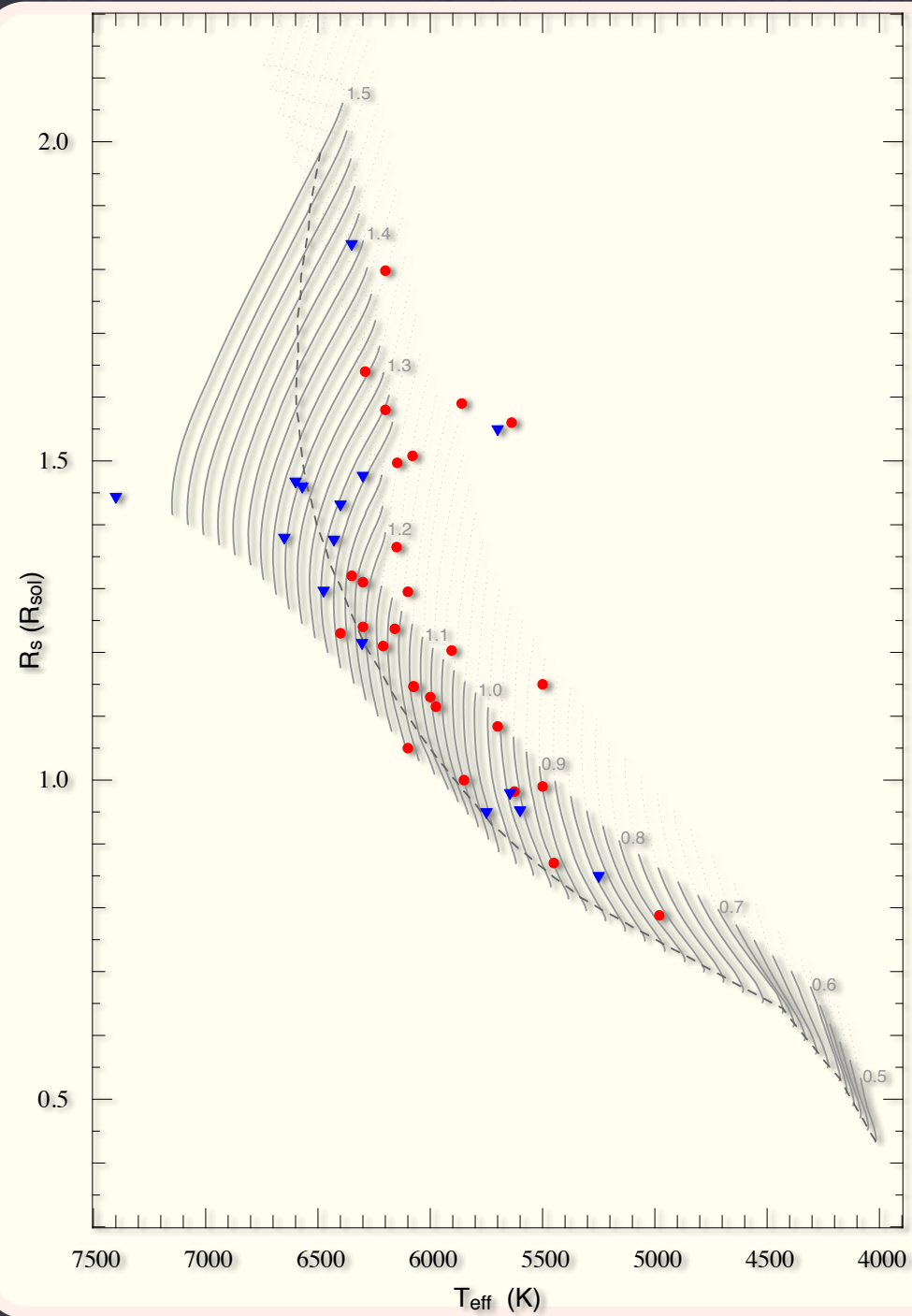
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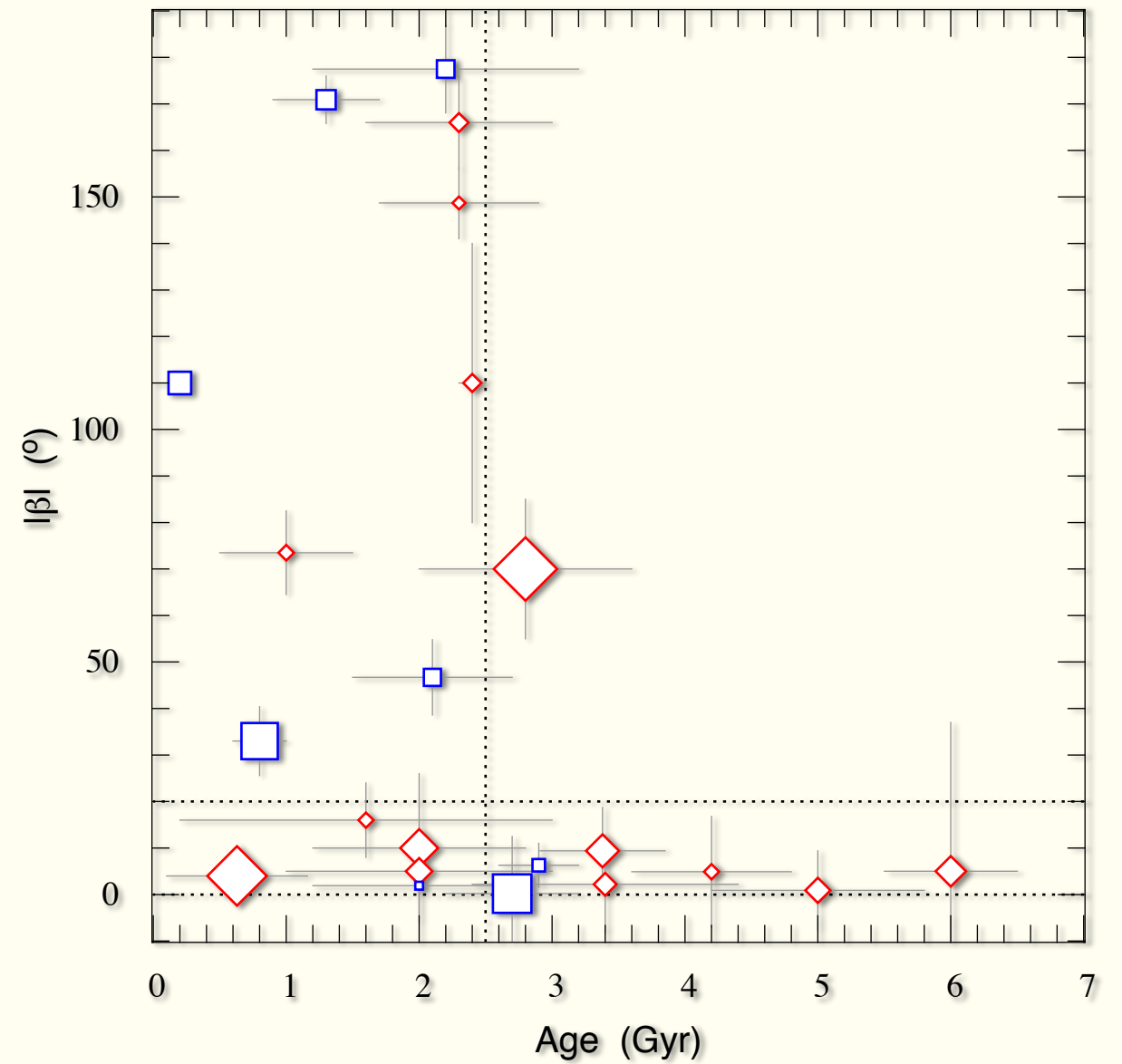
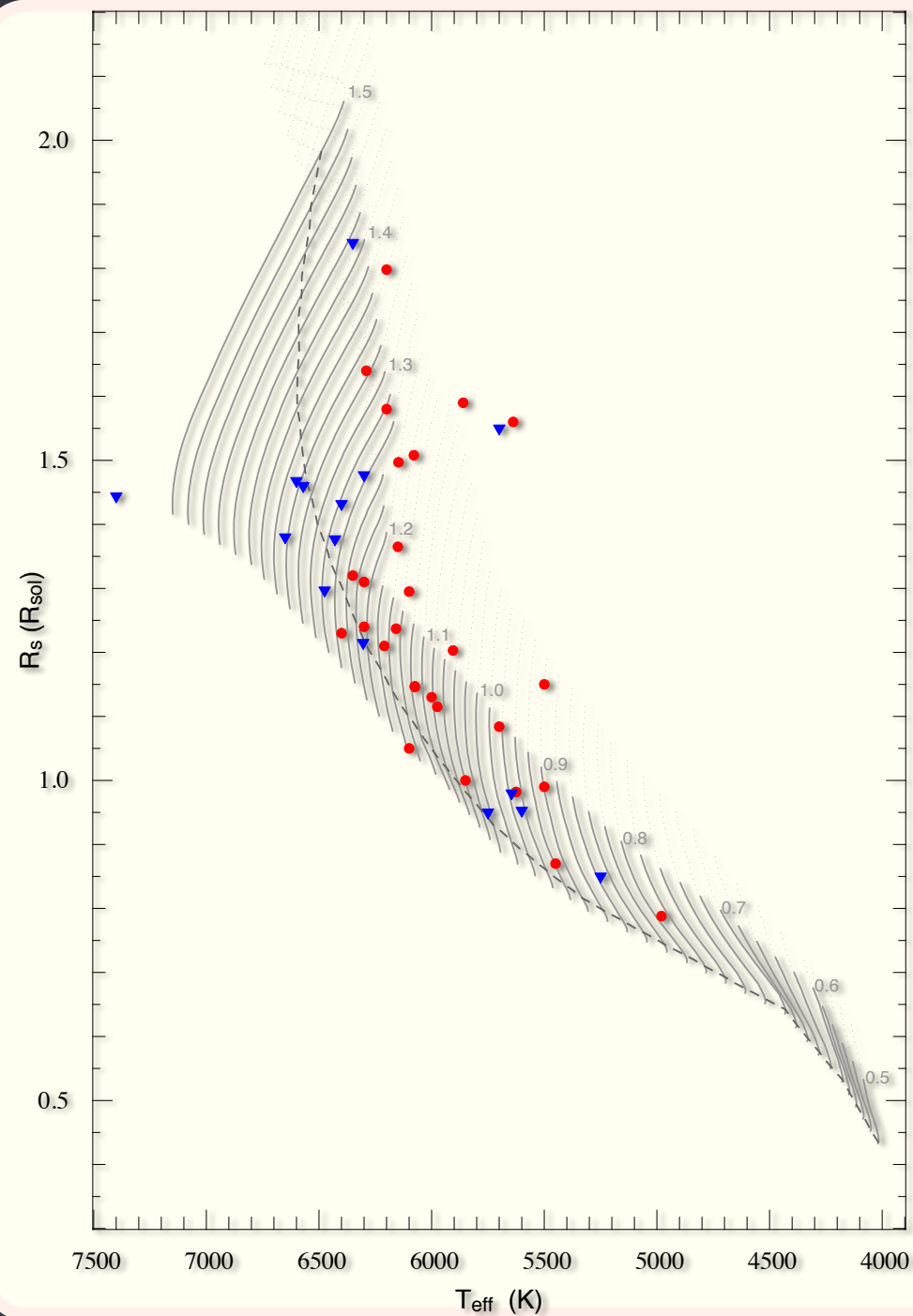
Take only planets on the «hot» side



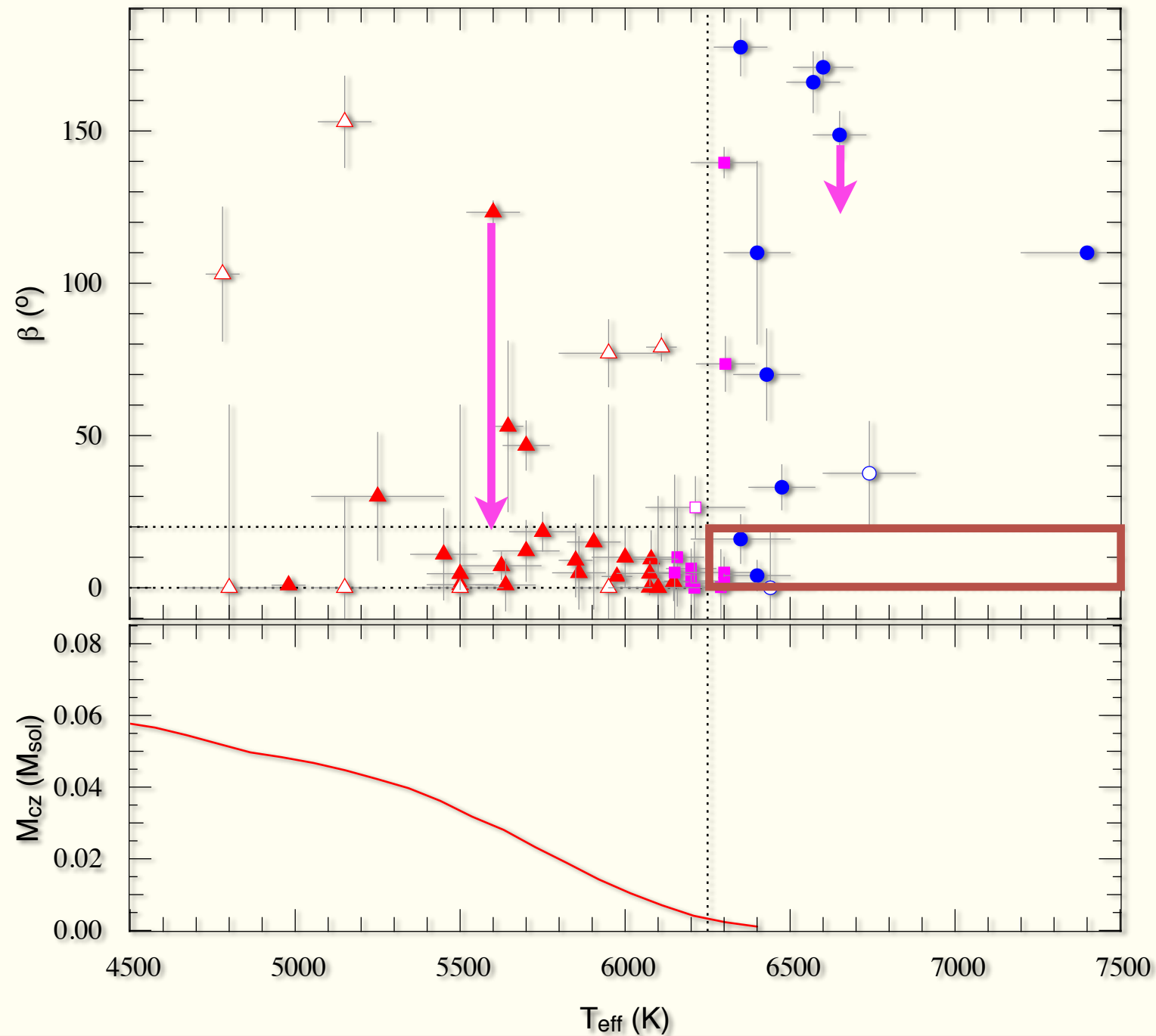
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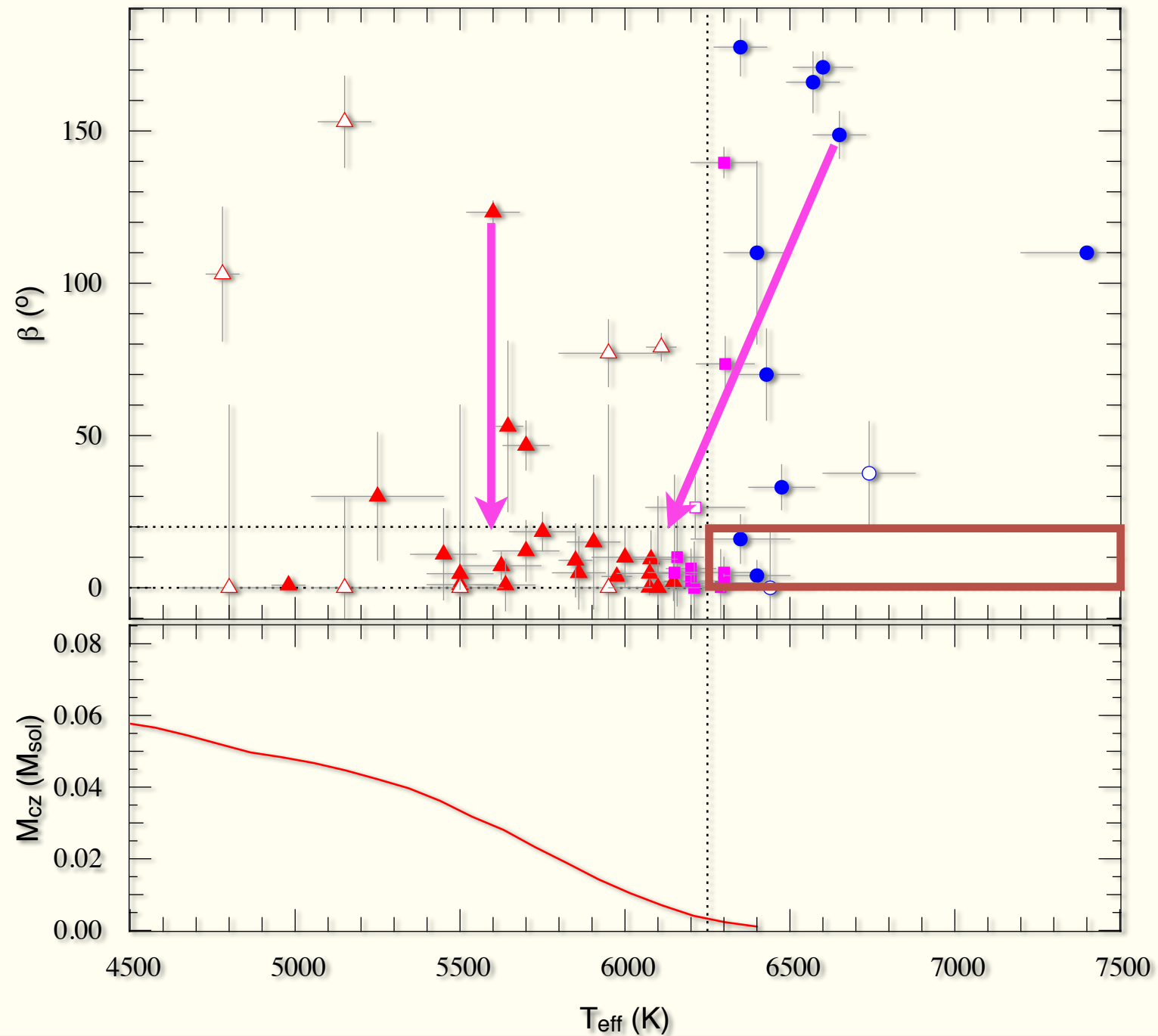
An additional explanation?



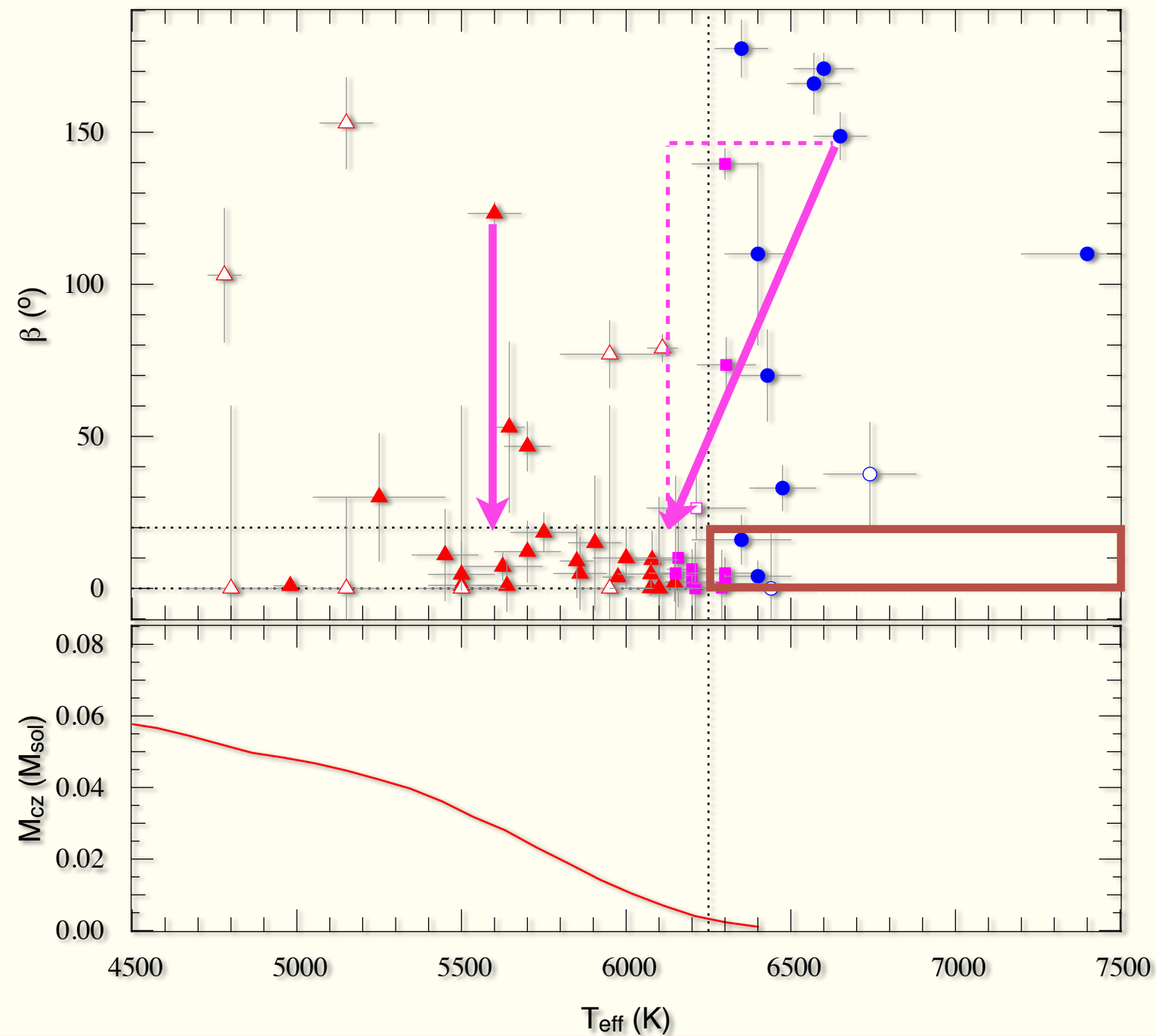
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Lack of aligned stars on stars > 6250 K Winn & Fabrycky '11

Lack of misalignment on stars > 2.5 Gyr Triaud '11

Lack of retrograde planets $> 5 M_{\text{jup}}$ Hébrard et al. '10 Moutou et al. '11

OBSERVATIONS SUGGEST

SPIN/ORBIT EVOLUTION

DISC MIGRATION

INACTIVE ON HOT STARS?

ALIBERT ET AL. '11

CREATES DYNAMICALLY FULL SYSTEMS

CAN FLIP? KAIB ET AL. '11

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DYNAMICAL PROCESSES

MORE EFFICIENT ON HOT STARS?

ISOLATED PLANETS

NAGASAWA ET AL '08

WU & LITHWICK '11

NAOZ ET AL '11

STELLAR ENCOUNTERS

MALMBERG & DAVIES

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2 PLANES? LODATO & PRICE '10

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TIDES

LEAD TO PLANET DESTRUCTION?

JACKSON ET AL '08

BARKER & OGILVIE '09

WRONG TREATMENT?

R_p , $R_\star$ EVOLVE, SO DOES Q'

LAI '11

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STAR MOVES

CÉBRON ET AL. '11

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OBSERVATIONS SUGGEST

SPIN/ORBIT EVOLUTION

OBJECTS TO FIND:

SMALLER MASSES AND/OR LONGER PERIODS

(INTENSITY OF TIDES LOWERED)

GJ436B & GJ1214B: MISALIGNED?

CLOSE PLANETARY COMPANIONS TO HOT JUPITERS

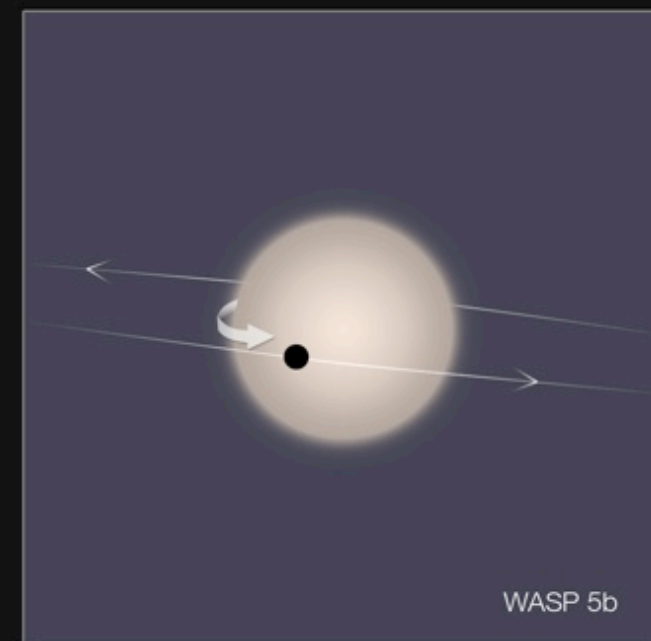
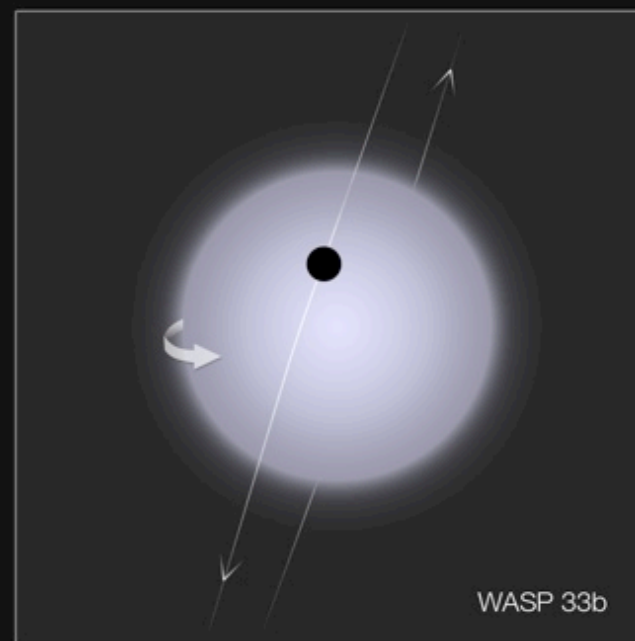
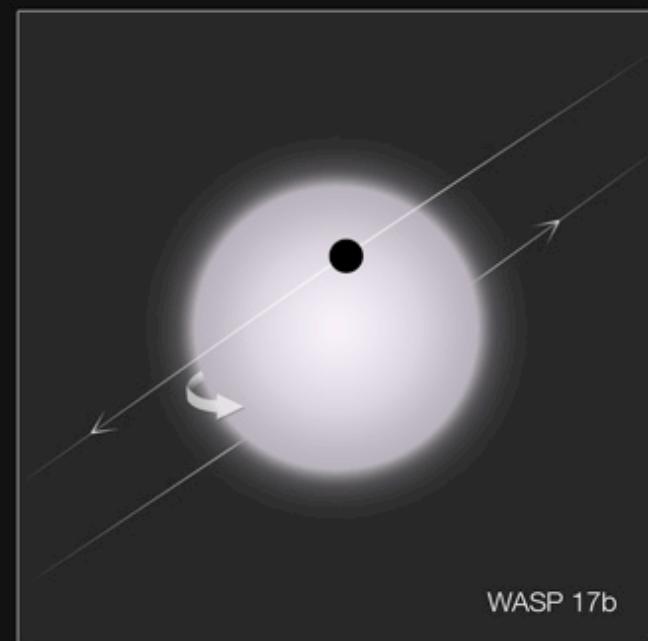
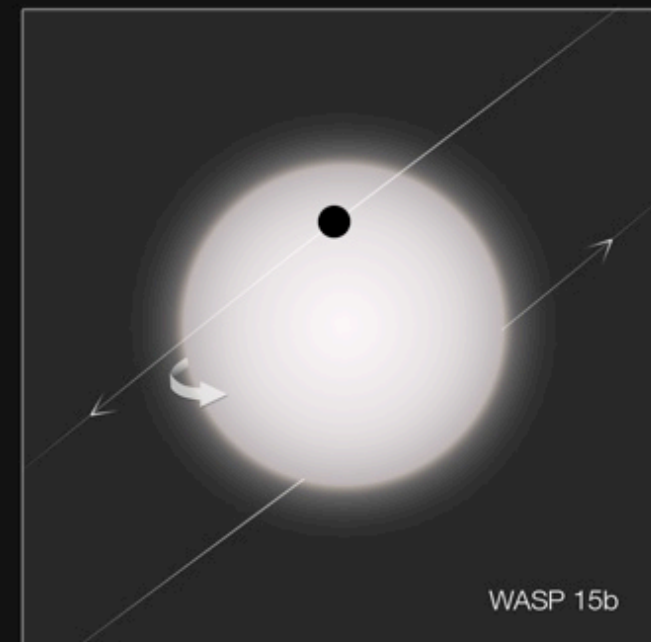
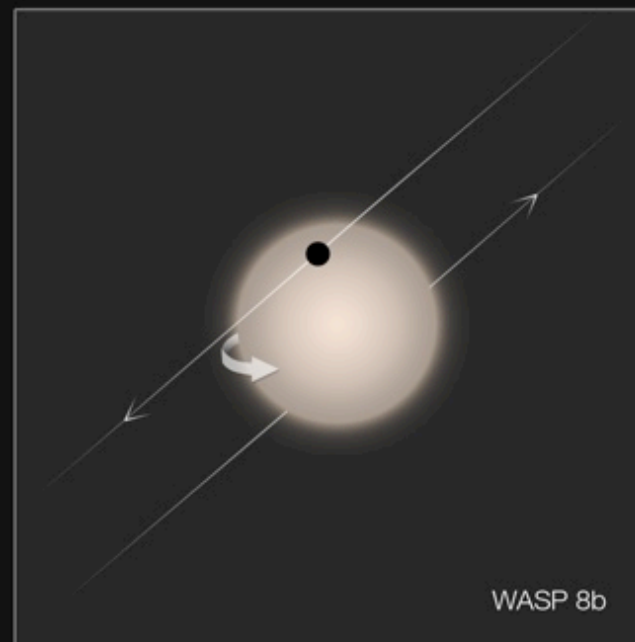
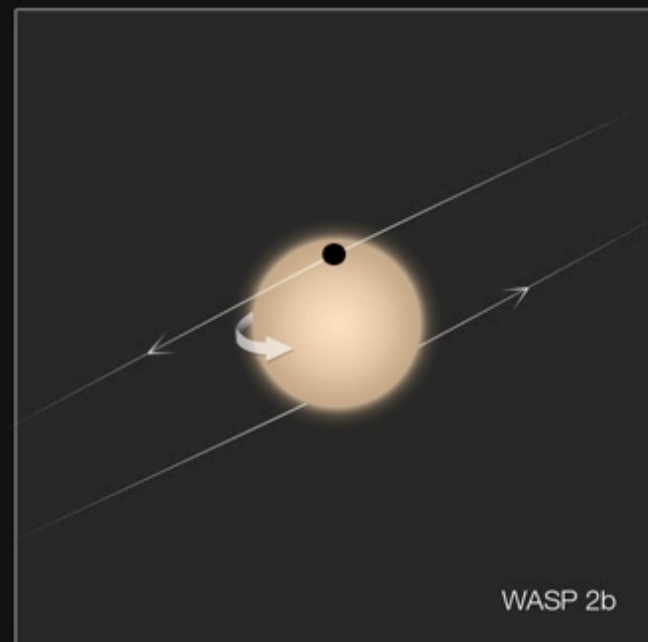
(KEPLER: TRANSITS OR TTVs)

MULTIPLICITY vs SOLITUDE

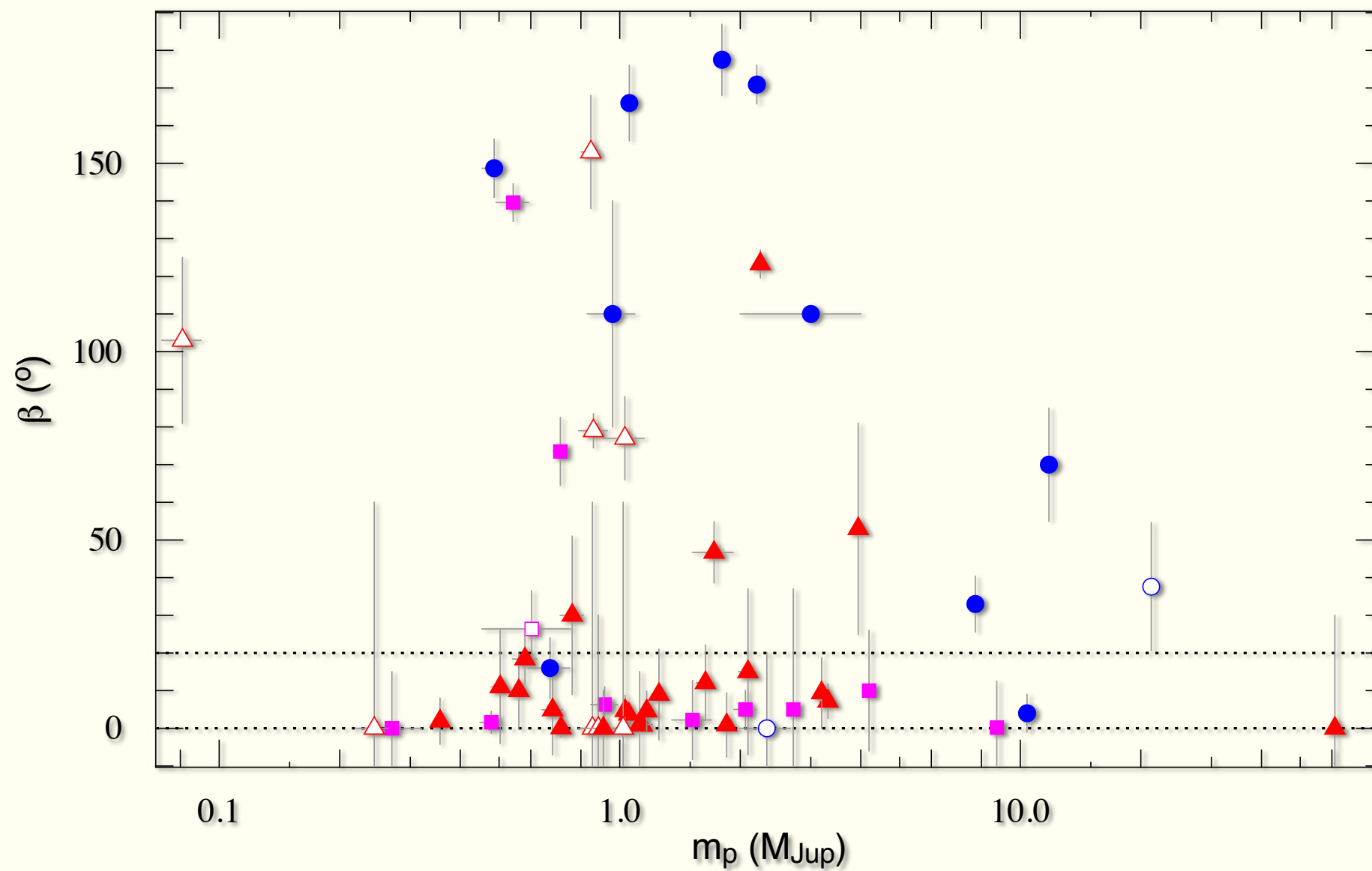
(HOT NEPTUNES WILL HELP)

also useful for stellar physics: spot latitudes, calibration of macroturbulence, formation of close binary stars, latitudinal & radial differential rotation...

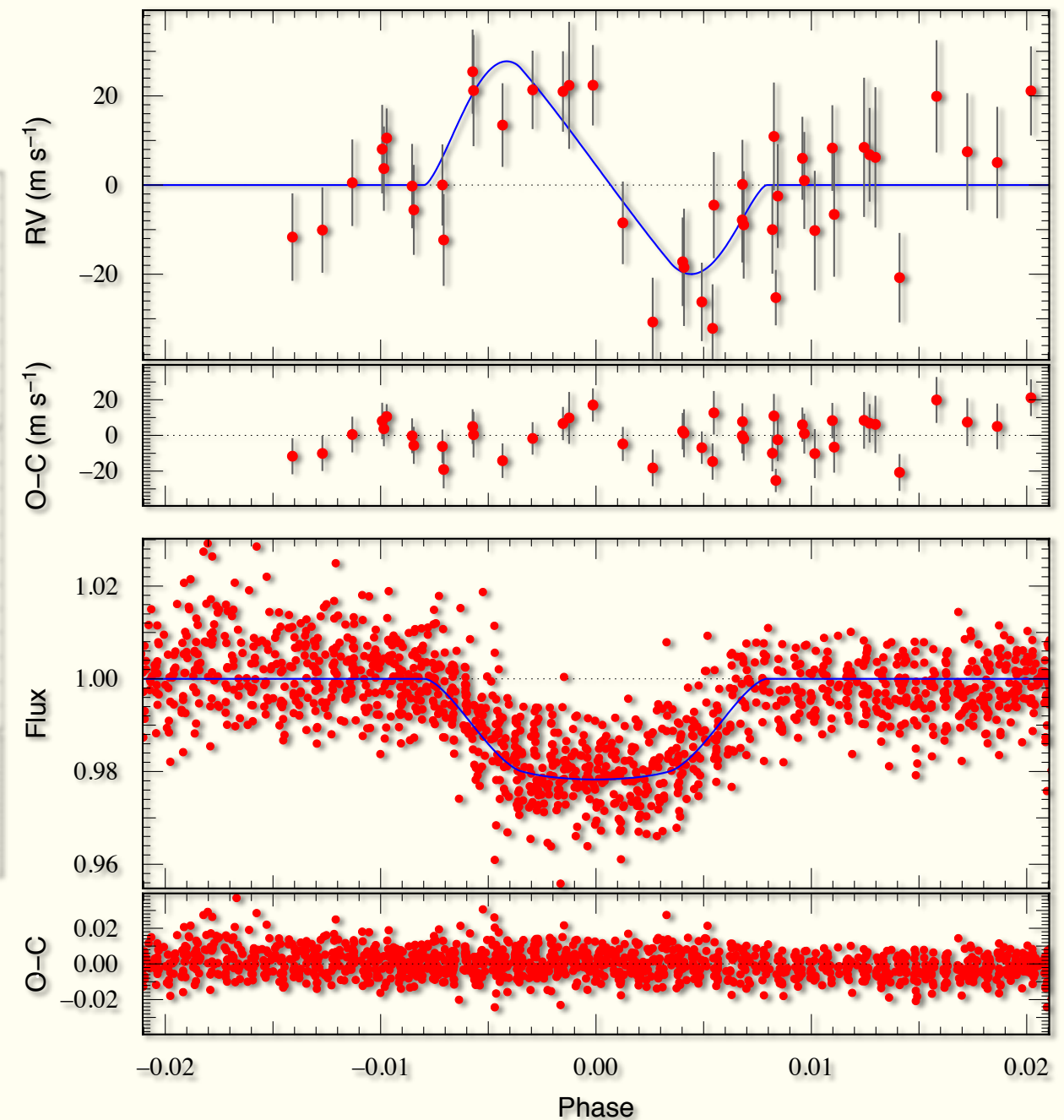
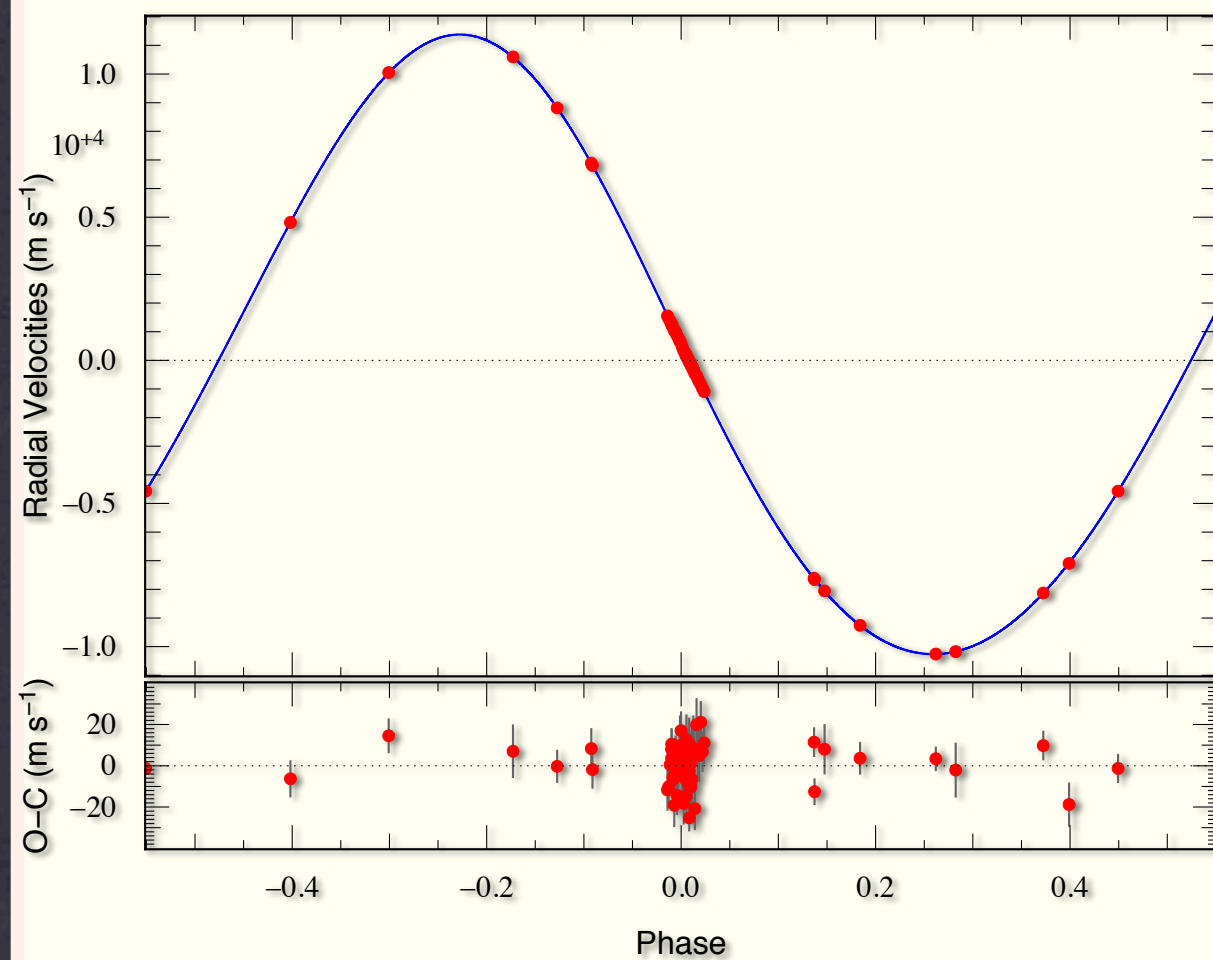
REFLECTIONS



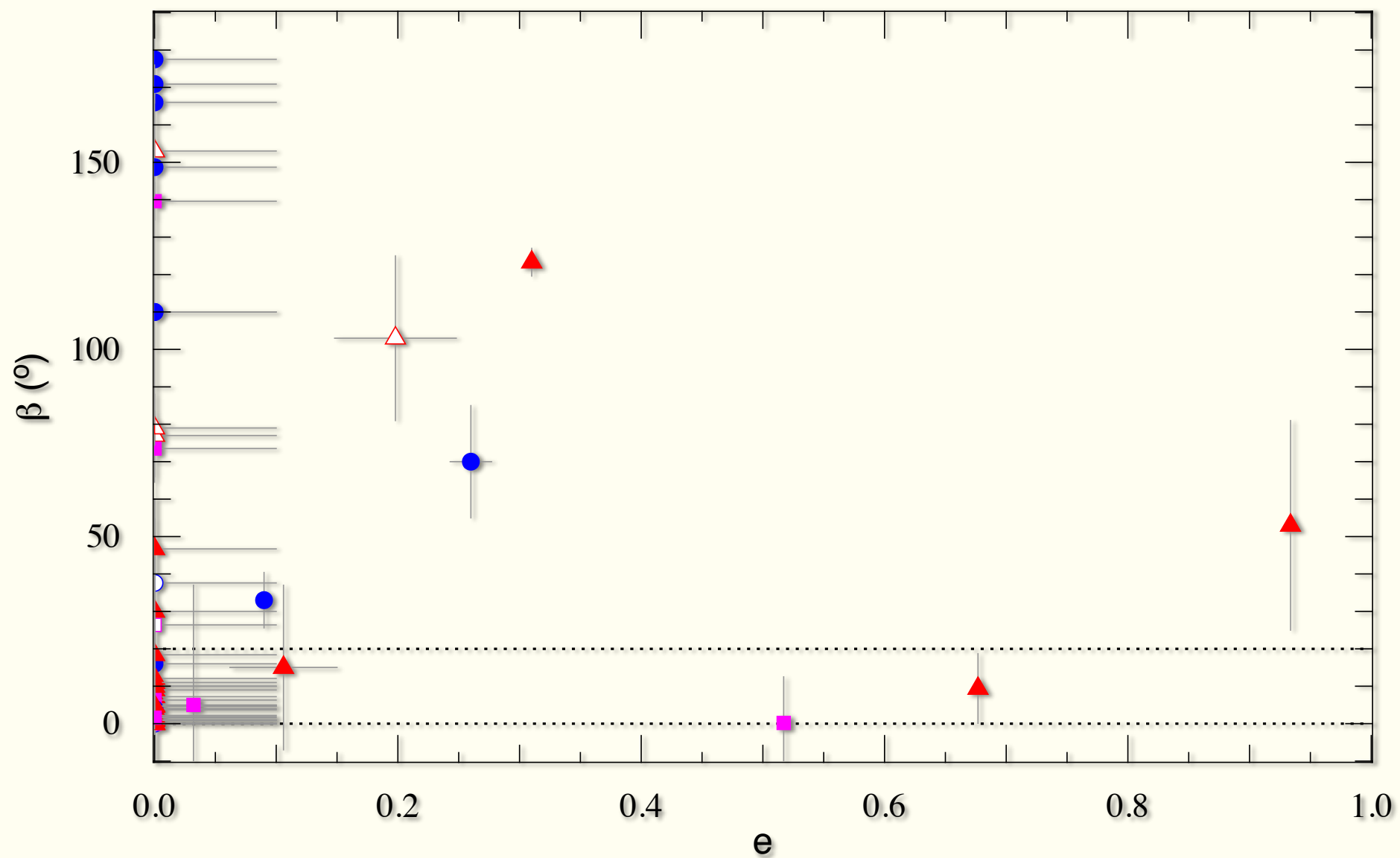
Results here thanks to the work of many teams including mine:
the WASP/Genève consortium (Anderson, Simpson, Brown, Miller, Collier
Cameron, Queloz) but also: Winn, Narita, Johnson, Hébrard, Moutou, Albrecht....



a hint of a pattern with planet mass?



the Rossiter-McLaughlin of a 0.1 $M_{\odot}$ on a 0.8 $M_{\odot}$ dwarf.



no striking correlation with eccentricity