Effect of stellar spots on high-precision transit light-curve

and the impact of the microlensing on the RM measurements

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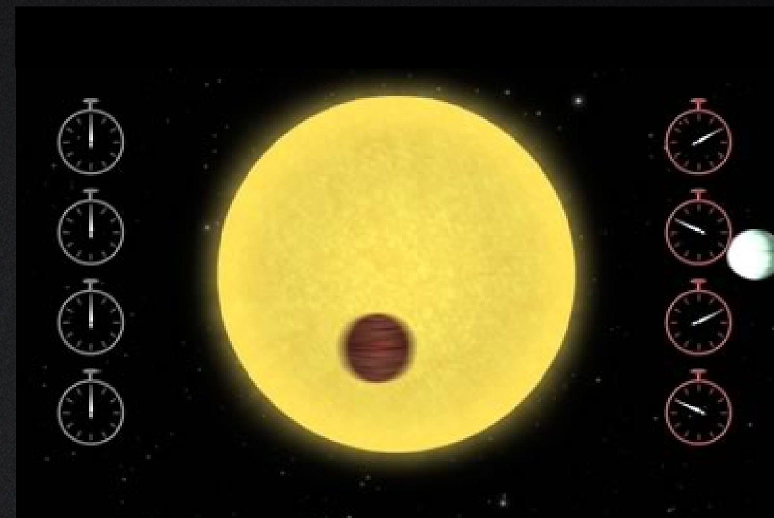
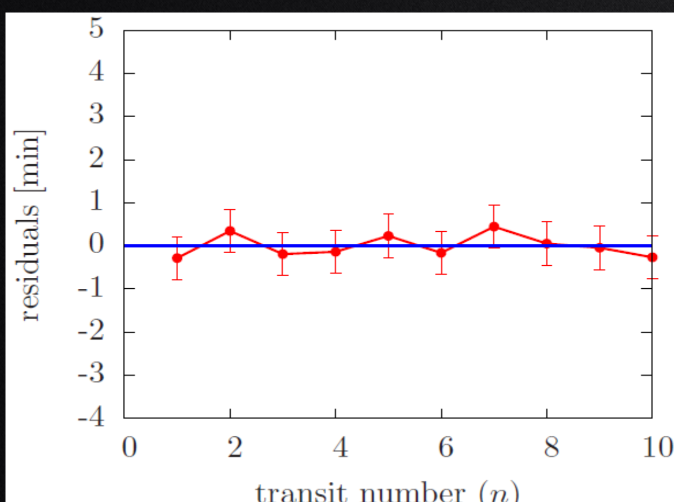
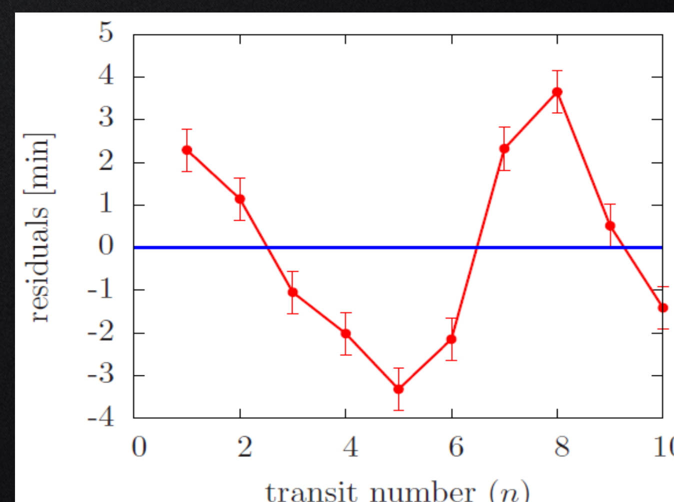
Outline

- Stellar spot effect on the transit light curve
- SOAP-T
- Quantifying the impact of spots
- Effect of lensing on RM effect
- Conclusion

Transit Timing Variation

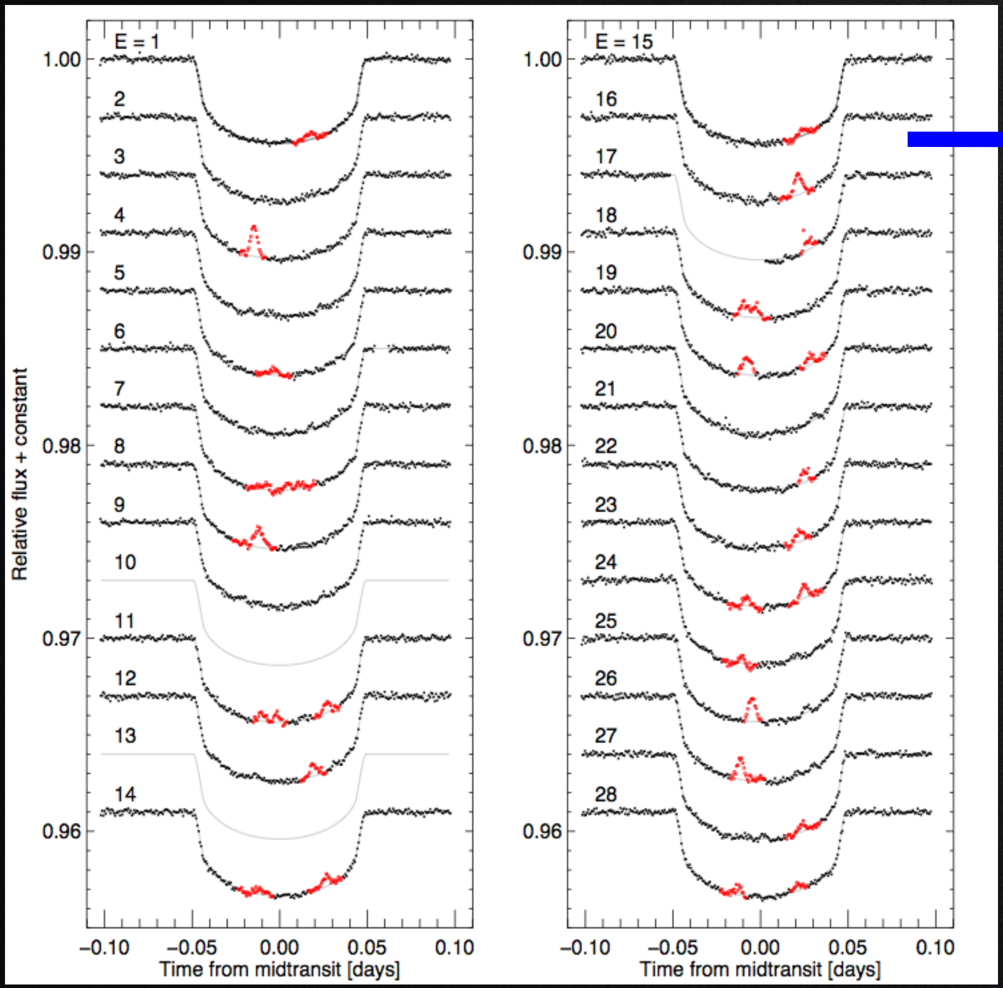






Spot-planet overlap

In the case that the spot anomaly is clearly identifiable, it is well known that it affects our transit timing measurements.



HAT-P-11b observed by Kepler

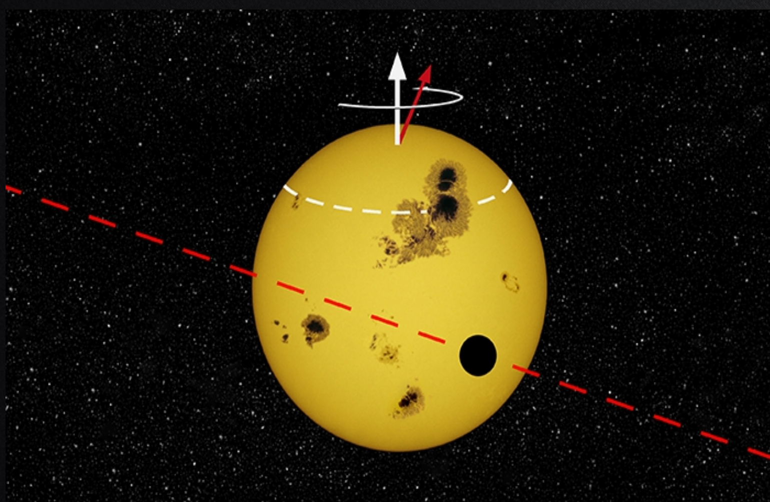
Some authors consider assigning a zero weight to the anomalous points of the light curve (e.g Sanchis-Ojeda & Winn 2011)

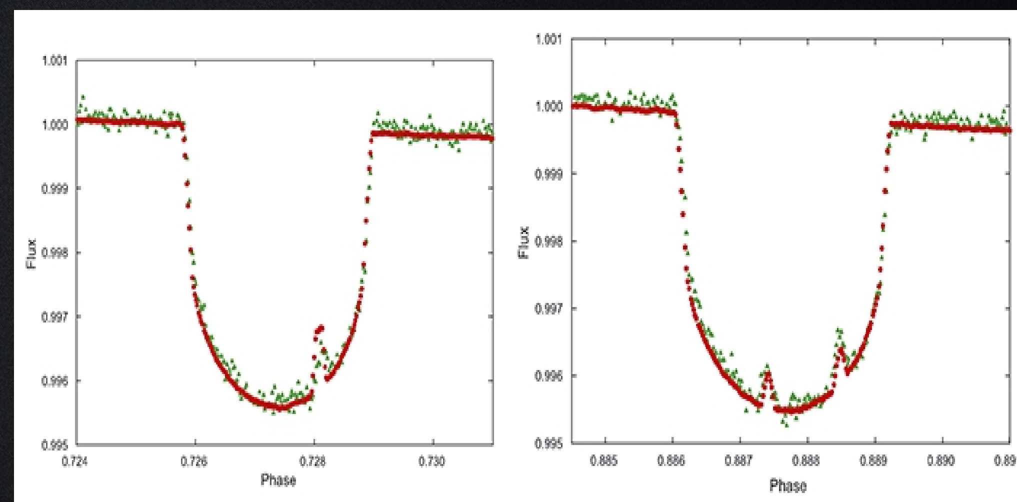
May not be the best approach, since the missing points in the transit light curve can produce TTV signal (Oshagh et al 2012, Barros et al 2013)

It is better to model them and then subtract them from light curve

SOAP-T

SOAP-T produces the expected light curve and the radial velocity signal of a system consisting of a rotating spotted star with a transiting planet. SOAP-T is able to reproduce the "*positive bump*" anomaly in the transit light curve due to a planet-spot overlap (oshagh et al 2013a).





I) Model spot anomalies in order to remove them

II) Use the occurrence of those anomalies in different transits to constrain the spin-orbit angle.

Spot anomaly

In case that the spot anomalies are not identifiable, we want to quantify their effect on our measurements.

We generated a large number of mock transit light curves with spot anomaly inside for different combination of planet radius and spot size and try to fit them with transit light curve without anomaly.

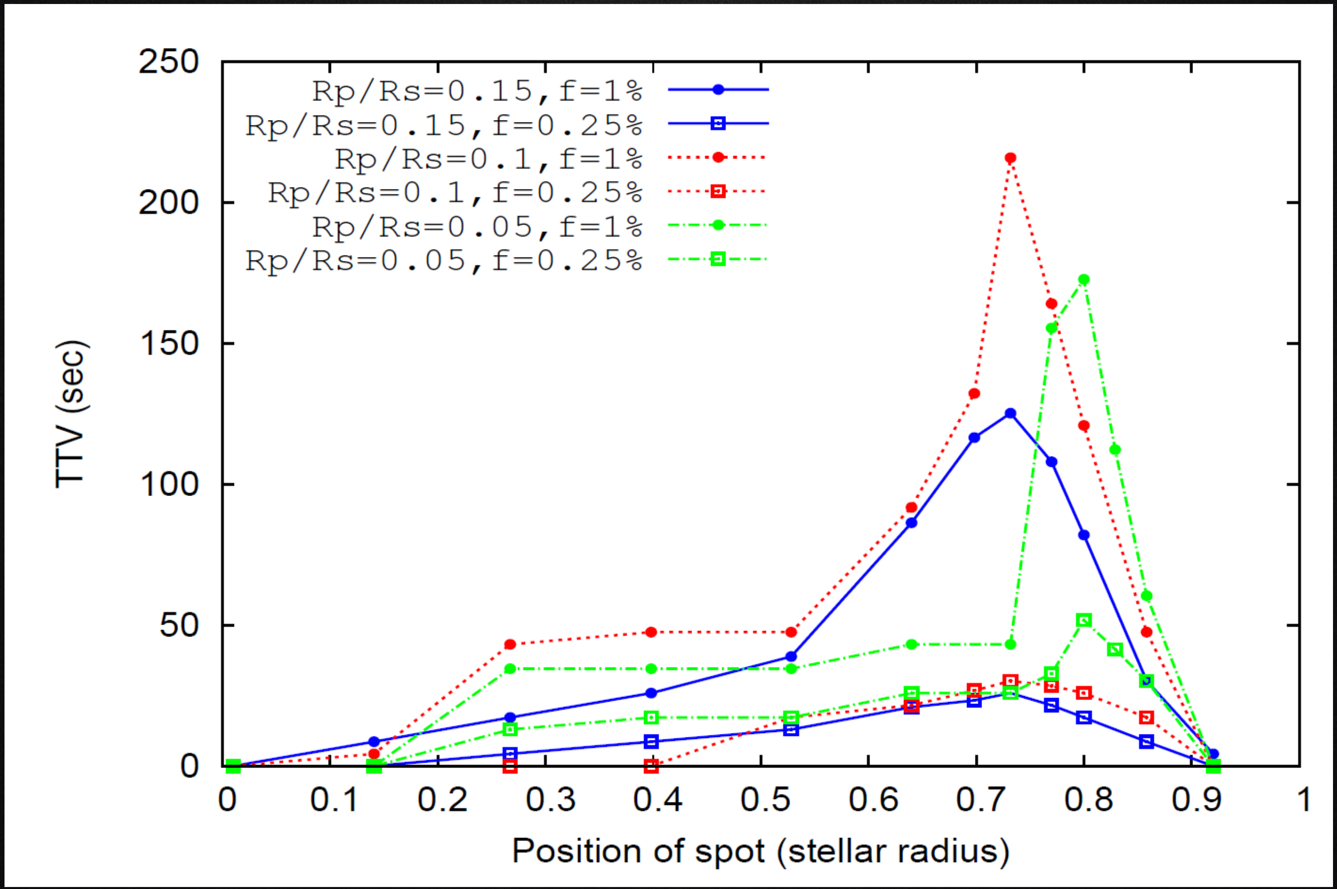
Transit depth, duration and timing are free parameters,

Compute the difference between fitted value and their actual value

TTV signal caused by spot anomaly

Rp/Rs=0.1 overlaps a spot with a filling factor of 1 %, produces the maximum value of TTV can exceed 200 seconds.

This amplitude of TTV can be induced by an Earth-mass planet in a mean-motion resonance with a Jovian-type body transiting a solar-mass star in a 3 day orbit



(oshagh et al 2013b)

TTV signal caused by spot anomaly

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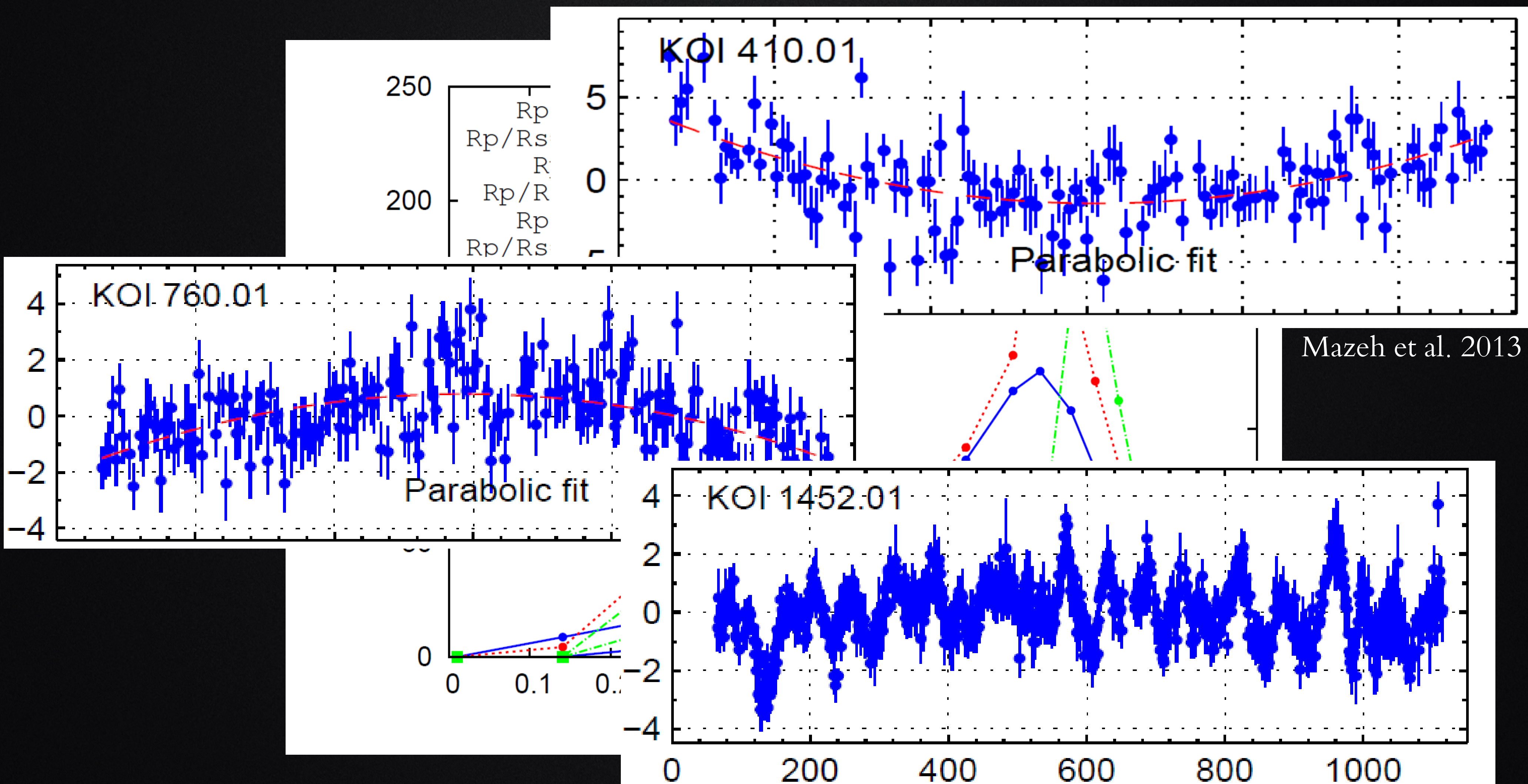
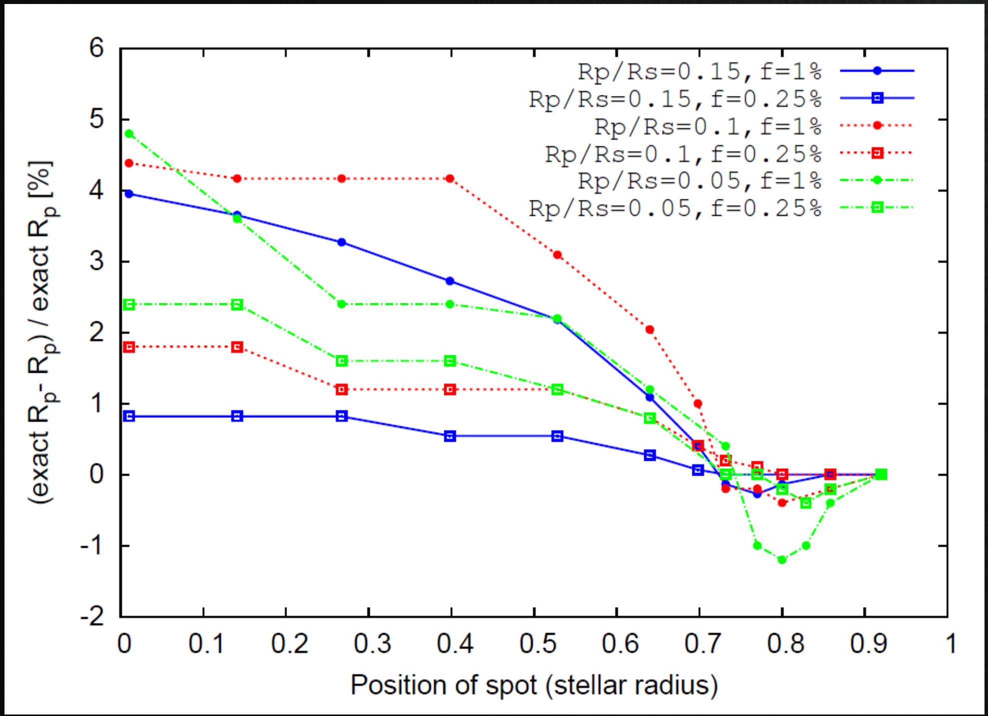
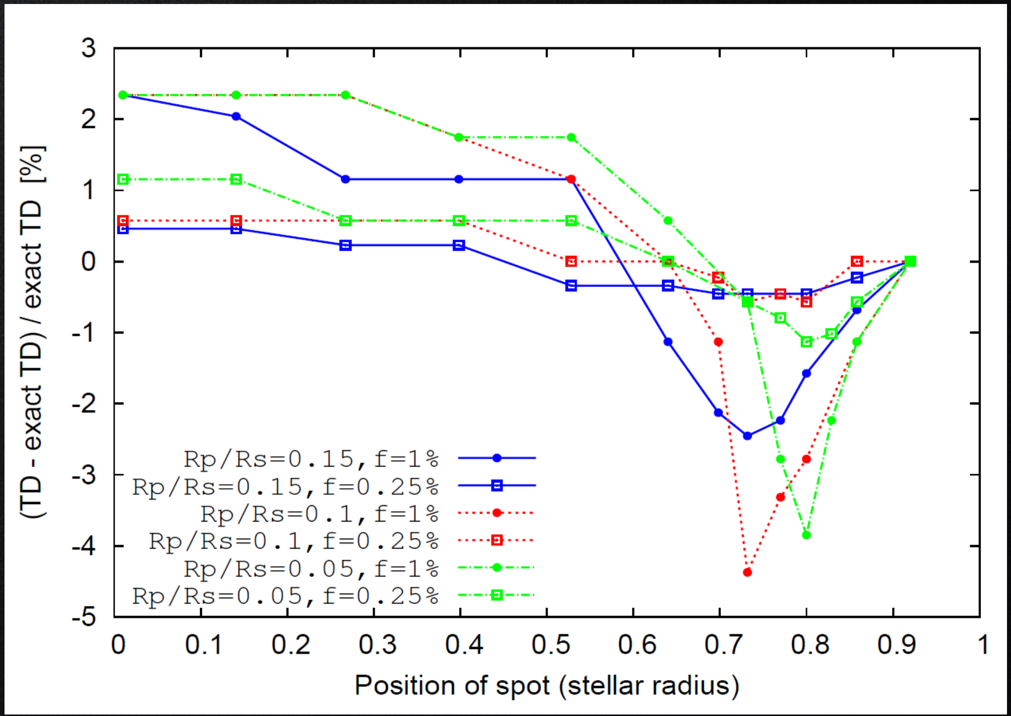


Deviation of planet radius caused by spot anomaly

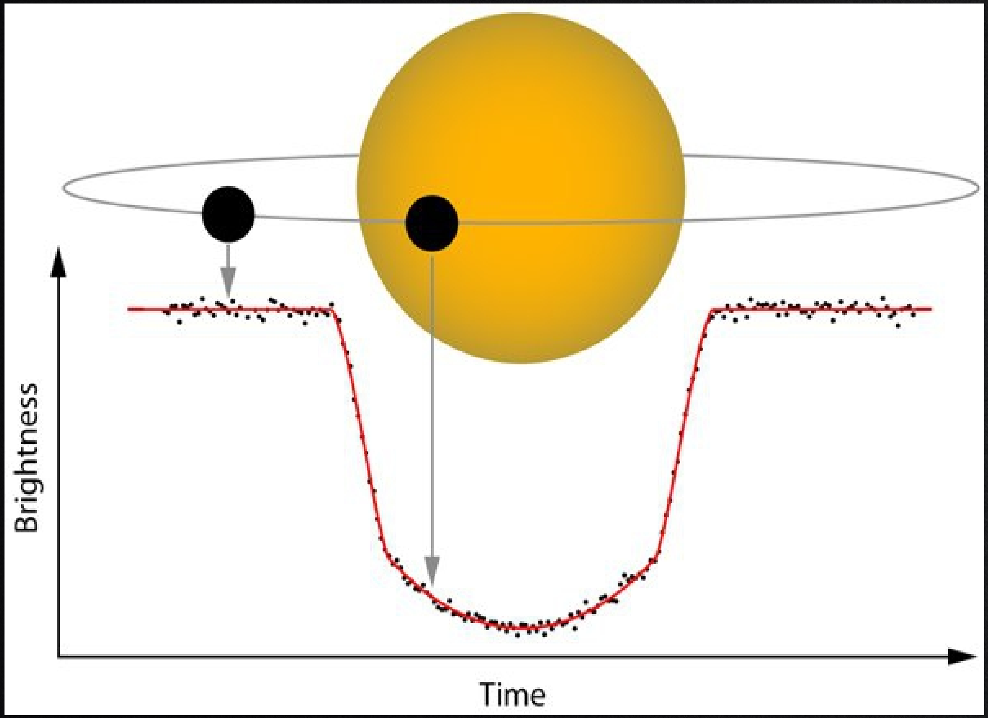
Rp/Rs= 0.05 and the spot's filling factor is 1 %, can cause the estimation of the radius of the planet to be 4% smaller. This value matches the values reported for the case of active stars and transiting planets such as the CoRoT-2 system (3%) (Czesla et al. 2009)

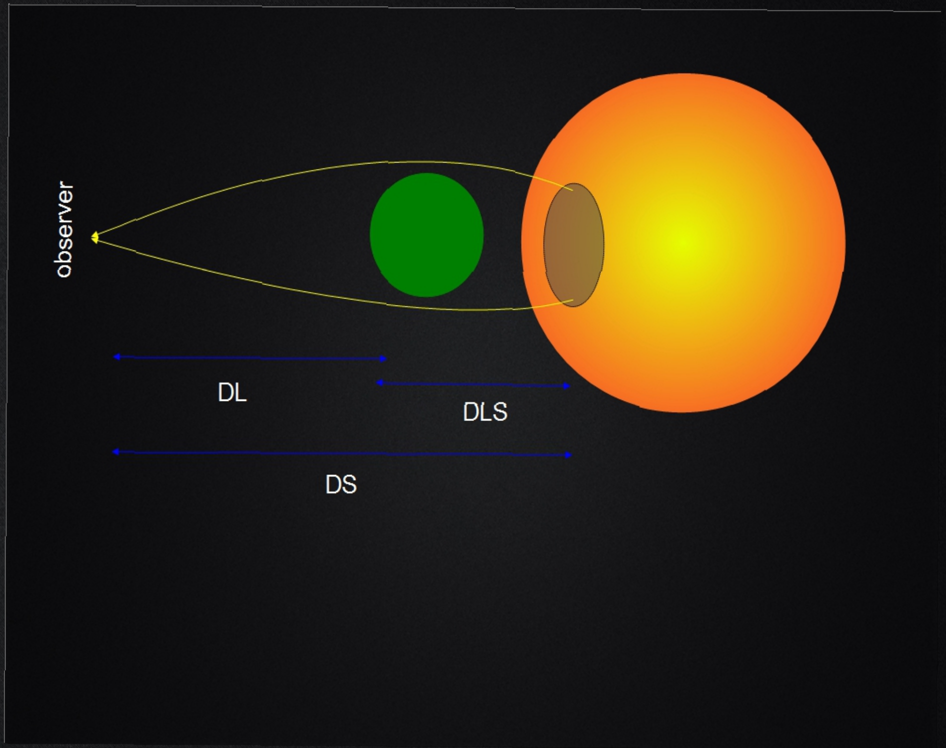
Rp/Rs=0.1 and spot filling factor of 1% causes transit duration to be 4%, longer or shorter





Microlensing effect on transit

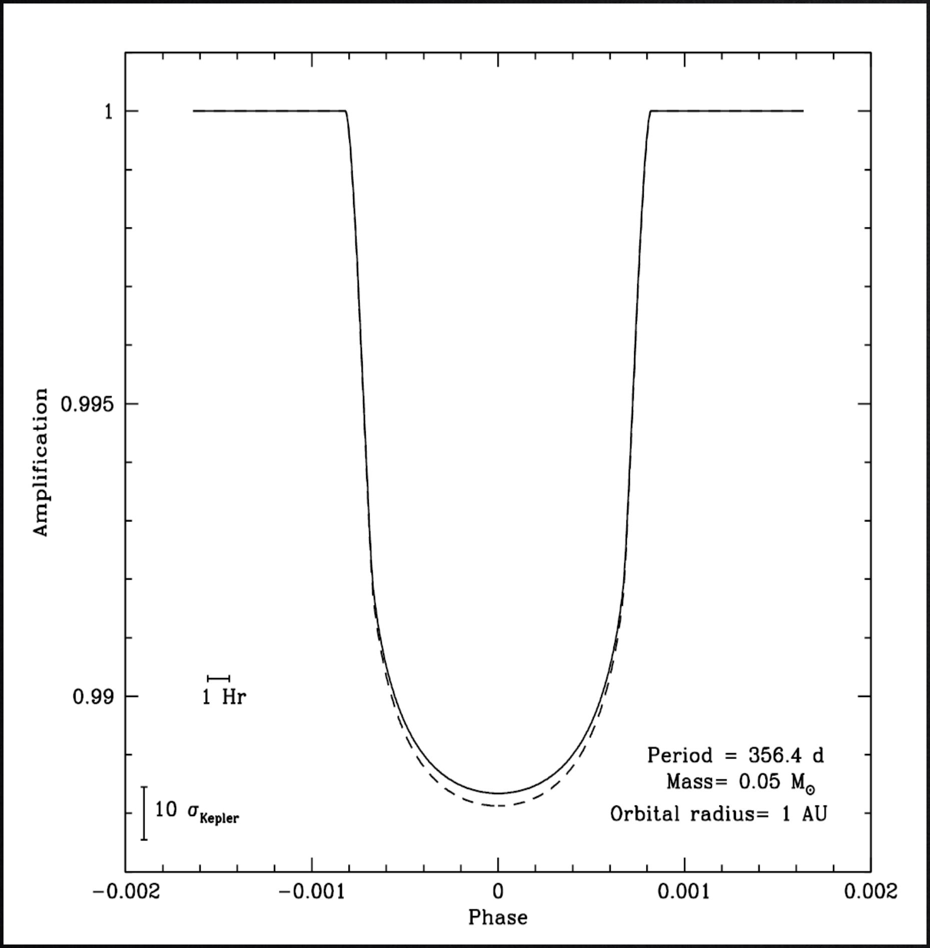


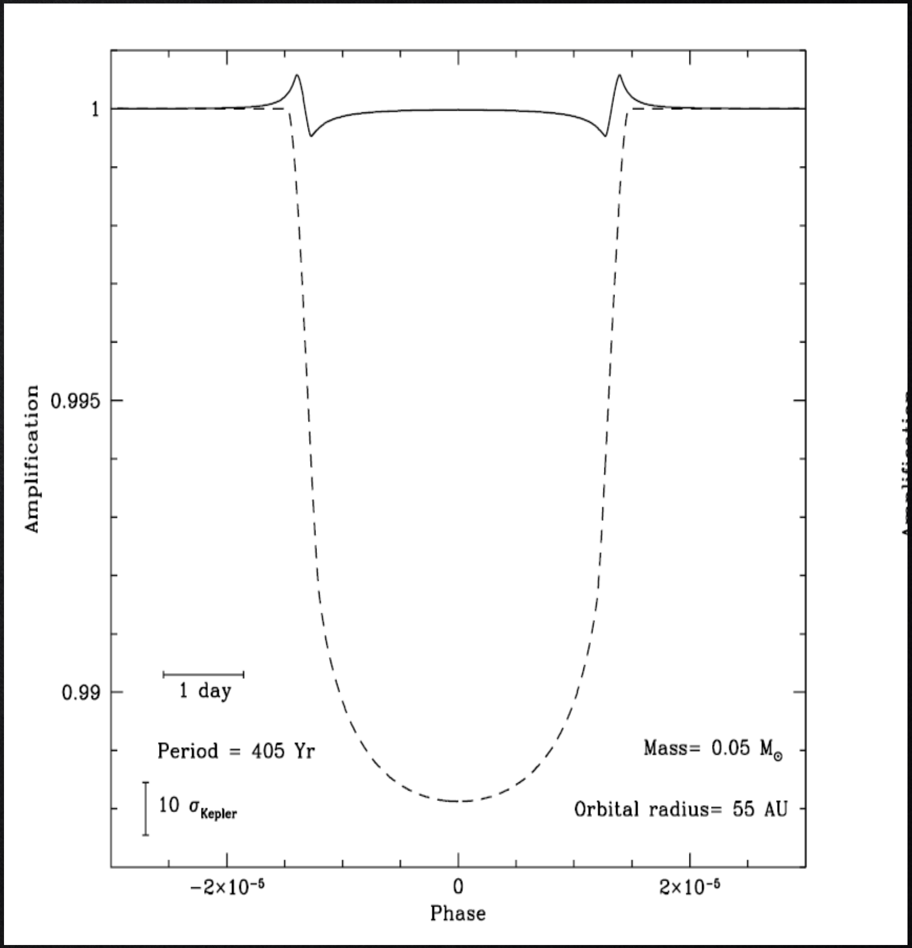


$$R_E^2 = \frac{4GM_L D}{c^2}, \qquad D = \frac{D_{LS} D_L}{D_S} \simeq D_{LS}.$$

$$A_\pm(d) = \frac{(d/R_E)^2 + 2}{2(d/R_E)\left[(d/R_E)^2 + 4\right]^{1/2}} \pm 0.5$$

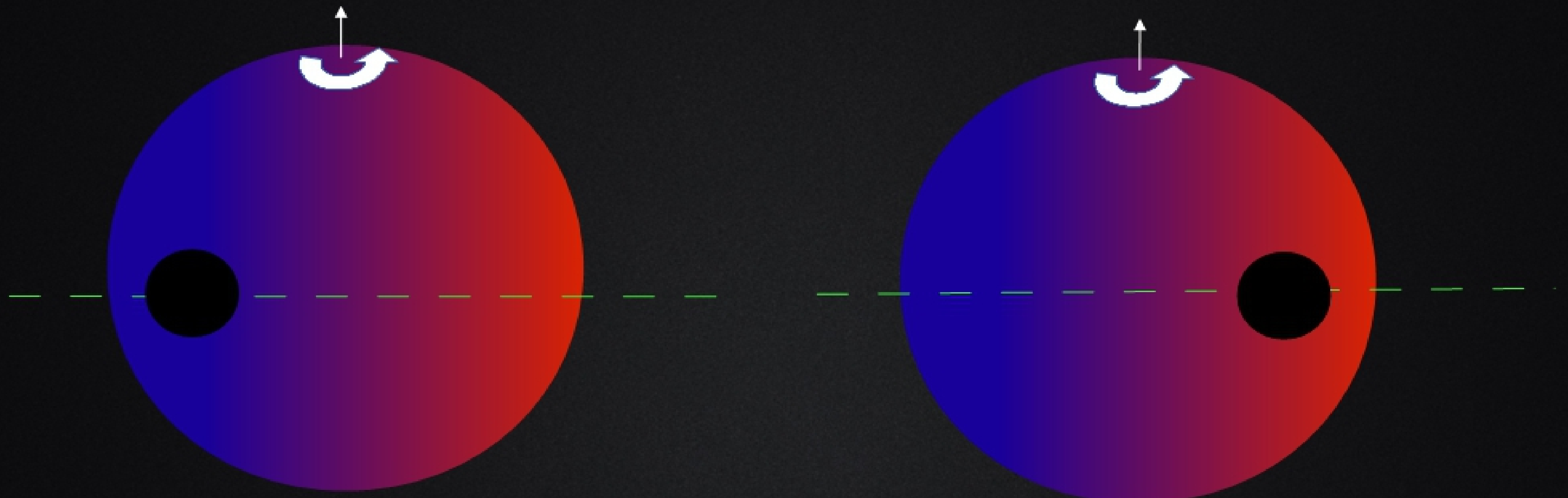
Microlensing effect on transit

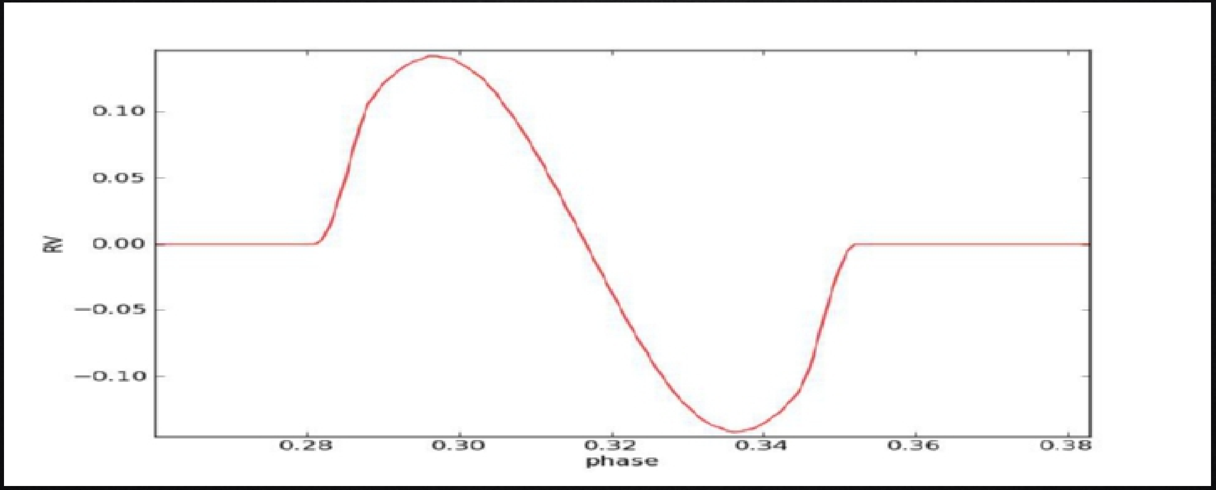




Sahu and Gilliland 2003

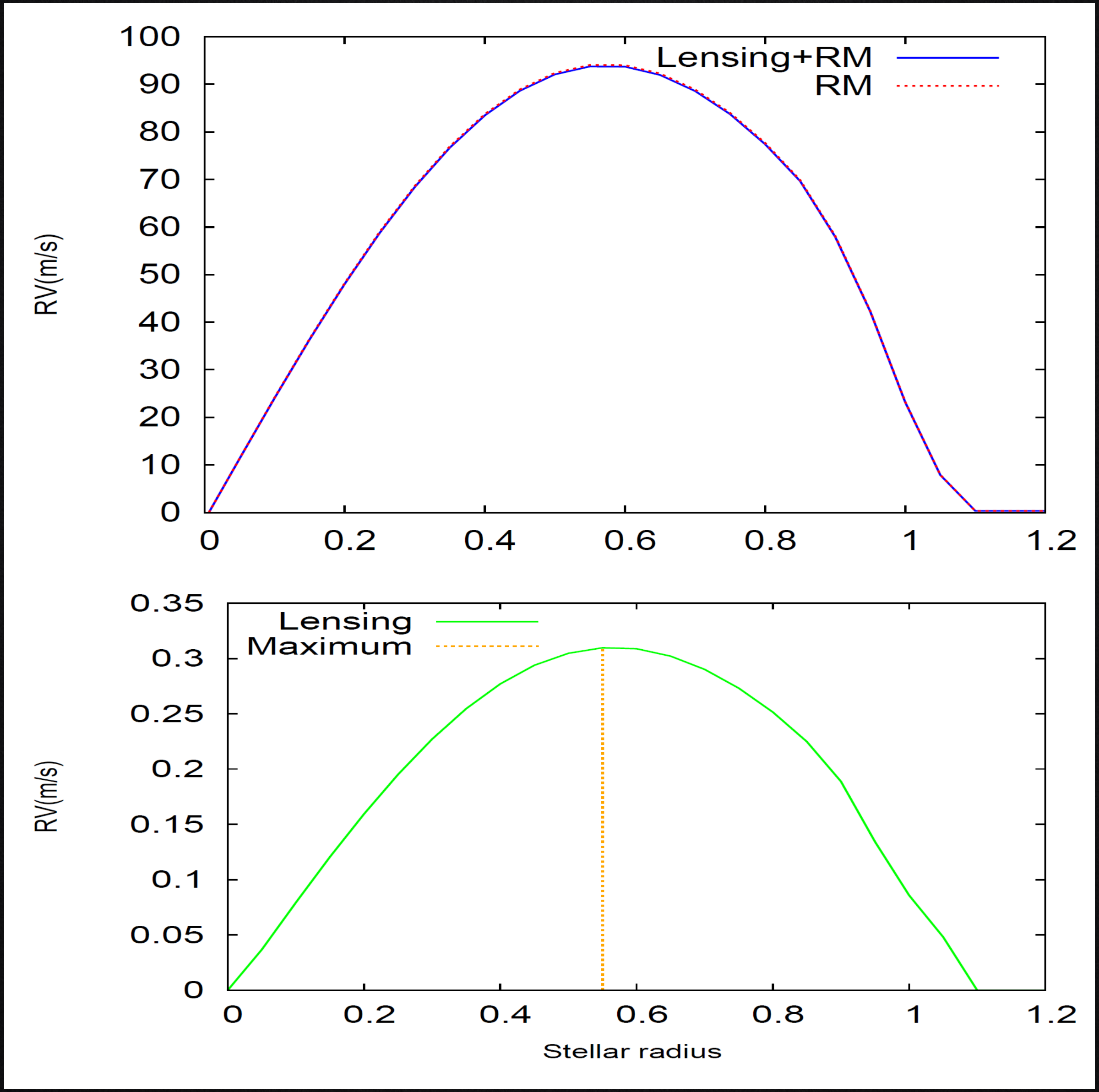
Rossiter–McLaughlin effect (RM)



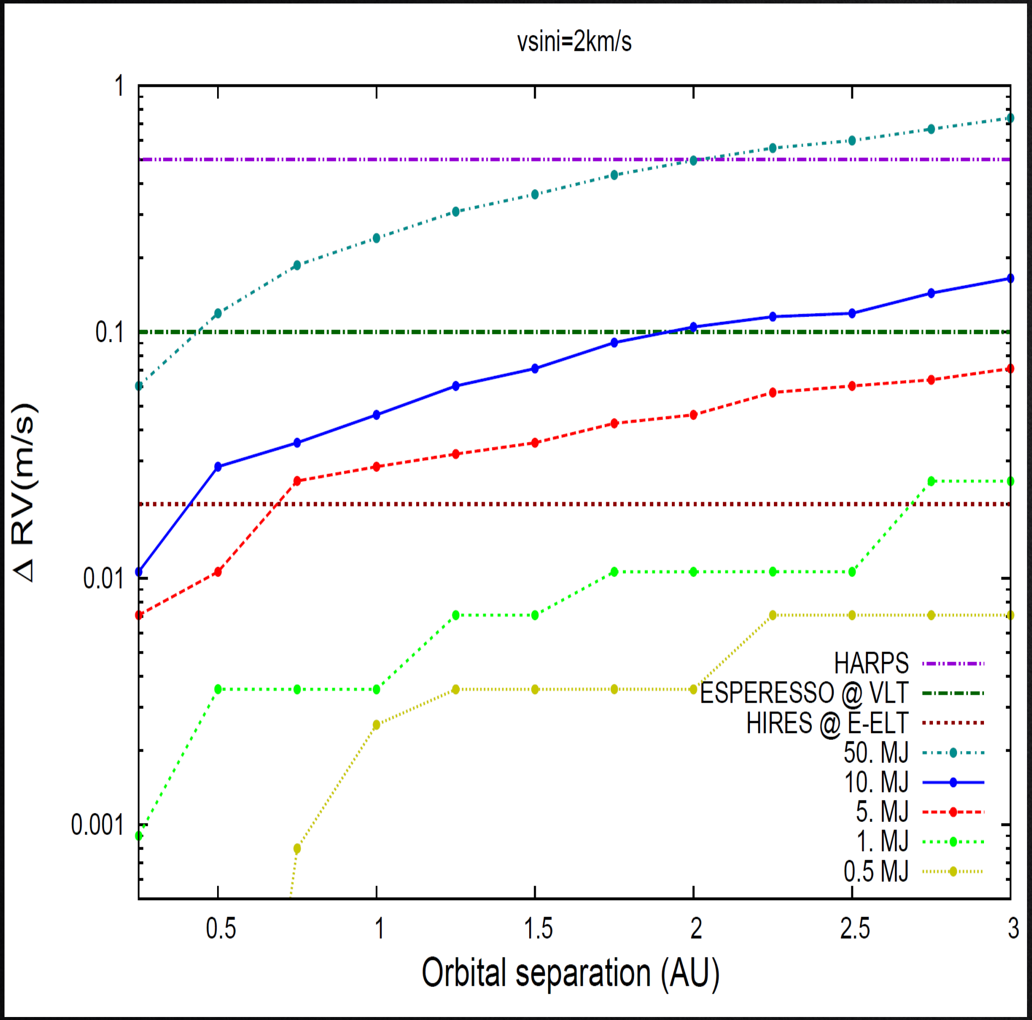


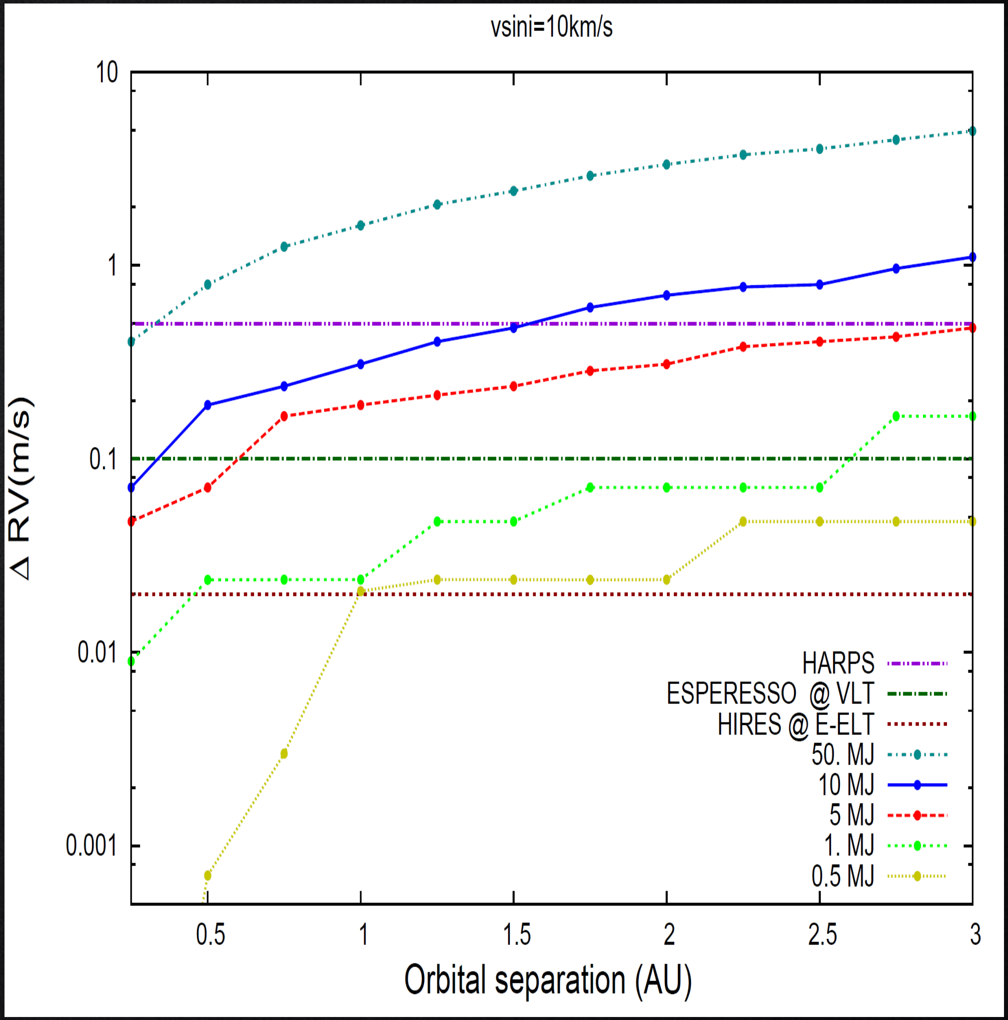
Microlensing effect on RM

Vsini=10 km/s
Rp/Rs=0.1
a=1 AU
M_p=10 M_{Jup}



Microlensing effect on RM





Oshagh et al 2013, submitted

Conclusion

Stellar spot can affect our estimation on the planetary parameters estimation such as planet radius and inclination. It can also lead to wrong transit timing variation measurements.

The effect of microlensing on the transit for massive planet on long orbit period is significant, and we obtain similar impact on the RM effect.

Thanks for your attention!