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# Detecting rings around exoplanets

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## Abstract

It is theoretically possible for rings to have formed around extrasolar planets in a similar way to how they formed around the giant planets in our solar system. However, no such rings have been detected to date. We test the possibility of detecting rings around exoplanets by investigating the photometric and spectroscopic transit signals of a ringed planet since they are expected to show deviations from that of a spherical planet. We develop a numerical tool (SOAP 3.0) to simulate ringed planet transits and quantify the detectability of rings based on these deviations. We found that it is possible to detect the signature of rings especially around planets with high impact parameter using time resolution $\leq$ 7 mins in the photometry and 15 mins in the spectroscopy. We also show that state-of-the-art instruments like CHEOPS and ESPRESSO present good prospects for detecting rings.

## 1. Introduction

Planetary transits offer very valuable information about planets which are not accessible through other planet detection techniques. When planets transit their host star, they obscure part of the stellar light. Photometrically, a dimming of the stellar light is observed thereby producing a light-curve. Spectroscopically, some of the radial velocity (RV) components of the rotating star is blocked causing an anomaly (line profile asymmetry) referred to as the Rossiter-McLauglin (RM) effect.

Planetary rings are unique features in our solar system yet to be detected around extrasolar planets. The rings of the Solar System giant planets have raised questions on the existence of rings around exoplanets [2][3]. The detection of exoplanetary rings could change or question our understanding of planetary formation and evolution.

### 1.1. SOAP 3.0 - Ringed planet transit tool

SOAP 3.0 is a numerical tool developed to simulate the transit light-curve, RM signal and the induced anomalies in these signals due to the transit of the ringed planet. The tool assumes that rings are circular, thin, opaque and extend beyond planet's radius. The ring is defined by 4 parameters: the inner and outer ring radii $R_{in}$ and $R_{out}$, the ring inclination $i_r$ with respect to sky plane and the tilt of ring plane $\theta$ with respect to orbital plane.

## 2. Detecting ring singnatures

Since giant close-in planets are the easiest planets to detect owing to the large transit depths and RV signal they produce, we test the scenario of detecting saturn-like rings around a close-in giant planet with parameters selected to satisfy the physical ring conditions. [3] showed that exoplanets with semi-major axis beyond 0.1 AU could host silicate rings and if optically thick, the rings would have long life time of up to $10^9$ yr. Ringed planet transits produce deeper and longer transits than spherical planets but the outstanding feature induced by rings is the anomaly seen when the ring's outer edge, inner edge, and planet edge contact the stellar disc at ingress and egress phases.

The ring signature in a transit signal is the residual between the ringed planet signal and the best-fit ringless planet model [1]. Therefore, the maximum residuals indicating the ring signature is positioned around ingress and egress. Figure 1 shows the ringless model fits to the light curve and RM signal of the simulated face-on and edge-on ringed planet transits. At edge-on ($i_r, \theta = 90, 90$), the rings are not visible since they are very thin and so no ring signature is noticed in the residual. However the face-on ringed planet ($i_r, \theta = 0, 0$) produces large residuals (455 ppm for flux and 3.15 m/s for RM) at ingress and egress phases. With a photometric and RV precision of 100 ppm and 1m/s respectively, these ring signatures can be detected.

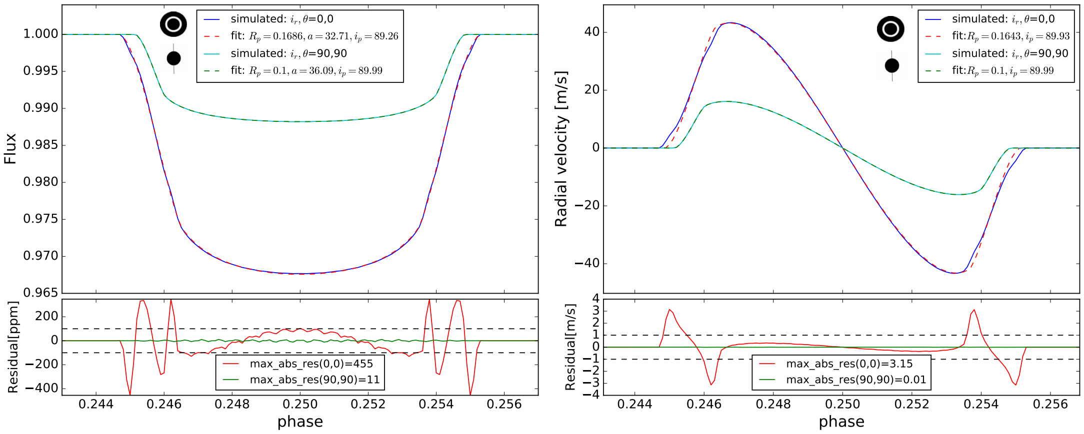

Figure 1: Ringless model fit to light-curve (left) and RM signal (right) of two ring orientations (face-on and edge-on) of the ringed planet. The black dashed line in residual plots show the detection limit of 100 ppm for photometry and 1 m/s for radial velocity. ($R_p$ = planet radius, $a$ = semi-major axis, $i_p$ = orbit inclination).

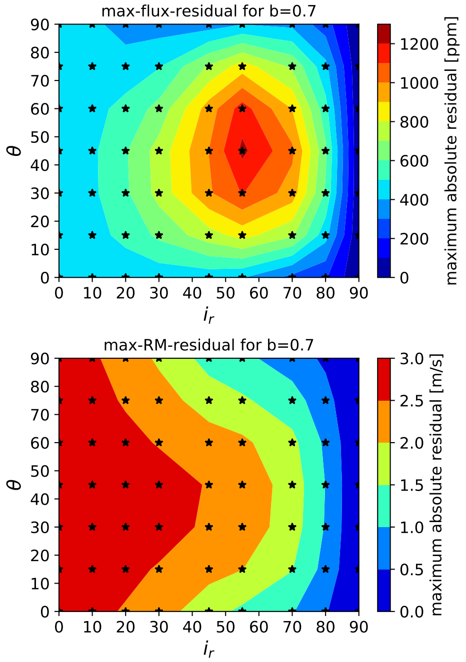

Figure 2: Contour plot from light-curve (top) and RM signal (bottom) fit residuals of 63 ring orientations.

In Fig. 2, we make contour plot of the residuals obtained from ringless fit to 63 different ring orientations of a simulated ringed planet. The red contours shows regions where ring signatures are high and easily detectable while the blue shows the low detectability regions.

## 3. Summary and Conclusions

We used the tool to characterise ring signatures considering different possible orientations of the ring and showed the ring orientations that are favourable for detection. We found out that high impact parameter transit can lead to large ring signatures. Also transits across fast rotating stars can lead to large spectroscopic ring signatures. We found that time resolution of $\leq$7 mins in the photometry and 15 mins in the spectoscopy is needed for ring detection. State-of-the-art instruments like CHEOPS and ESPRESSO will increase ring detectability with their better precisions.

## Acknowledgements

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## References

[1] Barnes, J. W., & Fortney, J. J.: Transit Detectability of Ring Systems around Extrasolar Giant Planets, ApJ, 616, 1193. 2004.

[2] Brown, T. M., Charbonneau, D., Gilliland, R. L., Noyes, R. W., & Burrows, A.:Hubble Space Telescope Time-Series Photometry of the Transiting Planet of HD 209458, 2001.

[3] Schlichting, H. E., & Chang, P.: On the Nature of Rings around Extrasolar Planets That Reside inside the Ice Line. ApJ, 734, 117. 2011.