Transit Zones of the Solar System Planets


Document Version:
Other version

Queen's University Belfast - Research Portal:
Link to publication record in Queen's University Belfast Research Portal

Publisher rights
© 2017 The Author(s).

General rights
Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.
Transit Zones of the Solar System Planets

Robert Wells¹, Katja Poppenhaeger¹,², Chris Watson³, René Heller³

1. Queen’s University Belfast, UK, 2. Harvard-Smithsonian CfA, USA, 3. Max Planck Institute for Solar System Research, Germany

Introduction

- We have now detected over 2700 transiting extra-solar planets, but where could transits of the Solar System planets be observed?
- To answer this, we introduce the concept of “transit zones” (TZs) – regions on the sky where full transits of the Solar System planets could be observed.
- The diagram on the right shows how these zones are projected as a disk around the Sun for any given planet.
- The equation gives the “transit zone angle”, i.e. the thickness of these disks, where d (Sun-planet distance) may vary throughout the orbit due to eccentricity.

Method

- Obtained heliocentric-ecliptic coordinates and the Sun-planet distance for 300 data points over a single complete orbit for all Solar System planets from JPL Horizons².
- Computed the transit zone angle at each point using the equation above.
- Computed boundaries of the transit zones by adding/subtracting \( \frac{\phi_{TZ}}{2} \) from the latitude at each point.
  - These are plotted below for all transit zones, where an observer situated within a coloured region could see transits of the related planet.

Geometric Transit Probabilities

- The probability of each planet being visible for a randomly positioned observer were evaluated.
- These were found by comparing the area of each transit zone and crossover to the area of a sphere, \( 4\pi r^2 \).
- We note significant differences when approximating the transit zone angle as \( 2R_\odot/(d) \), first utilised by Borucki and Summers 1984³.
- This approximation causes the probabilities to be overestimated by up to 17%, due to treating the planets as point object.
- We therefore note that this approximation should not be used for larger planets as it does not hold.

Estimated no. of Earth analogues in Earth’s transit zone

- From \( \eta_{\oplus} \) – the frequency of Earth-like planets in the habitable zone around their host star, we estimate how many we would expect to find the Earth’s transit zone.
- 1022 K and G dwarfs with \( V_m < 13 \) (PLATO limit) in Earth’s TZ in the Simbad catalogue. \( \sim 3000 \) accounting for catalogue incompleteness.
- \( \eta_{\oplus} = 22\% \) for 0.5-1.4\( R_\oplus \) around GK stars.
- Therefore expect 660 Earth-like planets in this sample of GK stars.
- Transitng probability of Earth = 0.46%.
  - Expect 3 planets which transit from our perspective.

Questions or Comments?

- If I’m around, just ask!
- Or else, email me at rwells02@qub.ac.uk

References