EPSC Abstracts
Vol. 13, EPSC-DPS2019-595-2, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Original Research By Young Twinkle Students (ORBYTS): Ephemeris Refinement of Transiting Exoplanets

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Abstract

We present an outreach research project to follow-up exoplanets with large uncertainties in their transit times. A fully robotic ground-based telescope network has been used to observe six planets and refine their ephemeris and orbital data. Such follow-up is key for upcoming ground and space-based telescopes which seek to characterise the atmospheres of these planets. For several planets we supplement our observations with TESS data. A significant portion of this work has been completed by students at two high schools in London as part of the Original Research By Young Twinkle Students (ORBYTS) program.

1. Introduction

ORBYTS is an educational programme in which secondary school pupils work on original research linked to the Twinkle Space Mission under the tuition of PhD students and other young scientists [2]. The ORBYTS program has been run since 2012 and is jointly funded by Blue Skies Space Ltd. (BSSL) and University College London (UCL). The Twinkle Space Mission[1] is a new, fast-track satellite designed for launch in 2022 and has been conceived for providing faster access to space-based spectroscopic data. A key science case for Twinkle is the observation of extrasolar planets via transit and eclipse spectroscopy. ORBYTS offers school pupils the chance to enrich our understanding of these new worlds by improving our knowledge of the molecules they're made of, their orbits and their physical properties. This provides a unique opportunity for pupils to undertake cutting-edge science that has a meaningful impact on a future space mission.

To achieve this, ORBYTS partners dynamic, passionate science researchers with secondary schools, where, through fortnightly school visits over an academic year, the researcher teaches the students undergraduate-level physics. The goal of every partnership is that school students will have the opportunity to use this new knowledge to contribute towards publishable research. Pupils get hands on experience of what is involved in scientific research and work closely with young scientists. By partnering schools with relatable researchers, the programme aims to not only improve student aspirations and scientific literacy, but also help to address diversity challenges by dispelling harmful stereotypes, challenging any preconceptions about who can become a scientist. The organisers and tutors strongly believe that all school students should have the opportunity to become involved in active scientific research and to be culturally connected to space missions. Previous projects have included calculating molecular transitions with the ExoMol group [1, 3] as these line lists are key for atmospheric retrievals.

Just after discovery, the time of the next transit for a planet is well known. Unfortunately the accuracy of predicted future transits degrades over time due to the increased number of epochs since the last observation. In extreme cases this can mean the transit time is practically lost, with errors of several hours. During this project the students selected suitable follow-up targets, scheduled observations and analysed the subsequent data.

2. Methodology and Results

2.1 Target Selection

The NASA Exoplanet Archive[2] was accessed in February 2019. We included all transiting planets, regardless of their discovery facility. The next transit of a planet, T_c, can be calculated from

$$T_c = T_0 + n \cdot P \tag{1}$$

where P is the period of the planet, T_0 is the last measured transit time and n is the number of epochs since this last observation. Both T_0 and P have errors

[1] http://www.twinkle-spacemission.co.uk

[2] https://exoplanetarchive.ipac.caltech.edu

associated with their measurement and thus the error on the predicted transit time, ΔT_c is given by

$$\Delta T_c = \sqrt{\Delta T_0^2 + (n \cdot \Delta P)^2} \quad (2)$$

assuming no co-variance between the two parameters. Given that it is highly unlikely that the period and transit mid time errors are uncorrelated, this calculated error is in fact a lower limit on the uncertainty. For this list of planets, we calculated the transit error by mid 2019 and suitable targets (i.e. those with a large transit uncertainty) were selected.

2.2 Robotic Ground-based Telescope Network

To facilitate follow-up observations we use the Telescope Live network of robotic telescopes[3]. Telescope Live is run by Konica Minolta who kindly provided access to their telescopes. The network currently consists of three telescopes: a Officina Stellare 40cm at Nunki Observatory in Greece, a Planewave 24 (60cm) at El Sauce in Chile and a Meade 14 LX200 (35cm) at Warrumbungle Observatory in Australia. This data has been supplemented with observations from amateur astronomers and the Transiting Exoplanet Survey Satellite (TESS).

2.3 Current Results

We have obtained data for six planets with multiple transit events (either partial or full) observed for most targets. Figure 1 shows a transit of WASP-83 b. This observation was planned, and the data analysed, by students from Preston Manor High School.

3. Summary and Conclusions

Researcher engagement with amateur astronomers, citizen science and in educational outreach offers an excellent opportunity to support future space missions. Stimulating this engagement and devising a coordinated approach to keeping exoplanet ephemeris ‘fresh’ will be imperative in the coming years. These collaborations can produce results which are suitable for publication.

[3]https://telescope.live

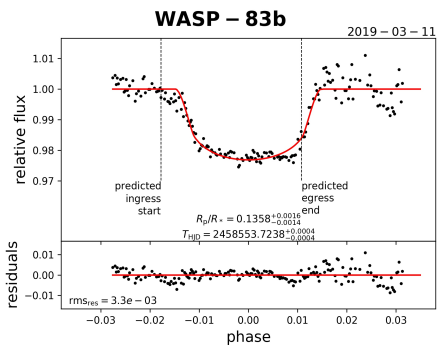

Figure 1: Transit light curve of WASP-83 which shows a shift in the transit time.

Acknowledgements

This work has been funded through the ERC Consolidator grant ExoLights (GA 617119) and the STFC grants ST/P000282/1, ST/P002153/1 and ST/S002634/1.

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