3rd WCPE World Conference on Physics Education
Hanoi, Vietnam, 13 - 17 December 2021
3RD WORLD CONFERENCE ON PHYSICS EDUCATION
Innovating physics education: From research to practice

Contribution ID: **97** Type: **Presentations in Wroclaw**

Analysis of Smartphone Recorded Transit Light Curves via Astronomical Software

Thursday 16 December 2021 11:20 (20 minutes)

Abstract. Exoplanet science is highly important in the understanding of the formation and evolution of planetary systems. In the last three decades extrasolar planet research has dramatically expanded and became a very exciting field of introductory astronomy courses. The most successful exoplanet detection method is the transit photometry. The aim of our study is to represent a cheap experimental setup for classroom demonstrations of the transit method and to analyse smartphone recorded transit track data by the FITSH software designed for real astronomical image processing, data analysis and planet characterization.

1 Introduction

Discovery and characterization of exoplanets, planet formation, determination of habitable zones and finding of Earth-like worlds are the most popular topics of the basic astronomy courses [1,2]. There are a number of methods for exoplanet detection in use such as radial velocity measurements through spectroscopy, gravitational microlensing or direct imaging, but the most common procedure is the transit photometry. Since the Nobel prize awarded discovery of an exoplanet orbiting a solar-type star in 1995 more than 75% of the 4528 confirmed exoplanets were found employing this method.

When a planet is orbiting it's host star and transits between the observer and the star, it shades the fraction of the star. This results in a measurable decrease in the observed brightness of the star. Plotting the star's brightness as a function of time, we get the concept of a light curve. Transits within our solar system can be observed from the Earth when Venus or Mercury is moving between us and the Sun.

The transit method of detecting exoplanets makes use of a sensitive light detector, usually placed on spacecraft, to measure small changes in the brightness of stars to look for periodic dips. The amount of time between the beginnings or ends of two transits is the planet's orbital period around the star. The measured orbital period and the mass of the star are used in Kepler's third law of planetary motion to calculate the planet's orbital distance. The size of the planet is determined by comparing the depth of the transit to the measured brightness and the size of the star. Transiting planets provide an opportunity to estimate mass and composition of these objects.

2 Experimental setup

Our experimental setup is inspired by the Dierking model [3]. As a model star we use a diffusive bathroom light cover with LED bulb (15 W, 1350 lm, 240-270° beam angle) which is placed in the middle of the carton box's ground base. The box is firmed using a wooden frame and dyed all around by blackboard paint. Various size rubber balls swinging on the string model orbiting planets. Model planets are rotating around the model star on a circular orbit employing an AC (24 V) synchronous motor removed from a microwave oven and a lever installed on the top of the box. We model the transit as an eclipse of an approximately spherical model star by an opaque sphere, as it is shown in Fig. 1. Unfortunately the modelled stellar disk is not of uniform brightness. As a light detector we use the PhyPhox [4] application running on a smart phone.

3 Data analysis

Having measured the light flux of the light bulb for a time interval that covers several transits, we plot the measured flux as a function of time. This allows selection of a singular transit event that we shall analyse. The size of the star and the planet determines the decrease in flux during the transit. Total transit duration highly depends on the so-called impact parameter (defined as the projected distance between the centre of the stellar disc and the centre of the planetary disc at conjunction).

Measurement data was analysed using the FITSH astronomical software [5] with the idea to compare light curves obtained by different size model planets, as well as to calculate model planet's size compared to model star's size and total transit duration. Measured and calculated light curves obtained for the maximal transit duration, when the centre of the model planet crosses the centre of the model star (impact parameter is 0) are presented in Fig. 1. Difference between measured and calculated planet sizes and transit duration times is up

to 5%.
Our further plan is to record and analyse light curves obtained by different impact parameters and orbit inclinations.

References
[1] M. Perryman, The Exoplanet Handbook, Cambridge University Press, 2018.
[2] M. LoPresto, Using real data from the Kepler Mission to find potentially habitable planets: An Introductory astronomy exercise, Phys. Teach. 57 (2019), 159-162.
[3] https://www.nasa.gov/kepler/education/models
[4] S. Staacks, S Hütz, H Heinke and C. Stampfer, Advanced tools for smartphone based experiments: Phyphox, Phys. Educ. 53 (2018) 045009 (6pp).
[5] A. Pál, FITSH –a software package for image processing, Mon. Not. R. Astron. Soc. 421 (2012), 1825–1837.

Primary authors: BORDÁS, Árpád (Bolyai High School, Senta, Serbia); KÁLMÁN, Szilárd (MTA-ELTE Exoplanet Research Group, Budapest, Hungary)

Presenter: BORDÁS, Árpád (Bolyai High School, Senta, Serbia)

Session Classification: Parallel 10 - Wroclaw

Track Classification: 7. Experiments and practical work in physics education