Catch a Star 2020

HD 10180 planetary system simulations using Scratch 3.0.

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ABSTRACT

In this project we present a program which makes a transit simulation of the six confirmed exoplanets in the Sun-like star HD 10180. For this purpose we created a script in Scratch 3.0, a JavaScript-based programming language developed at MIT and designed for children. To perform the simulation of orbits and transits, our program takes into account the orbital period of the planets and the semi-major axis. The result is an optimal simulation, which proof the excellent possibilities for children of using Scratch applied to astronomy.

1. Key words
planets and satellites: planet–star interactions - methods: Scratch 3.0 simulations

2. Introduction

Thanks to the advances in astronomical instrumentation, since the second half of the 20th century, astronomers have been searching for exoplanets applying scientific methodology, although their existence was supposed long before. The first confirmed detection was made in 1995 by the renowned astronomers Michel Mayor and Didier Queloz, for which they won the Nobel Prize in Physics in 2019. Since then the number of planets discovered has not stopped growing, exceeding today the 4000[1]. The high number of these and their distribution suggests the existence of thousands of these planets in our own Galaxy and throughout the universe. In recent years, rich planetary systems such as Kepler-90, TRAPPIST-1, Kepler-11, or HD 10180 have been discovered, the latter being the objective of this work.

3. Methodology

Scratch[2] is a open source programming language and online community developed at the Massachusetts Institute of Technology (MIT) and intended for children of ages 8-16, as a help learn code. Scratch is a JavaScript-based codebase, and also offers great possibilities in the field of astronomy. In this project we have used Scratch 3.0 as a basic tool applied to the simulation of exoplanetary transits. Scratch's structure allows to easily switch to more complex programming languages like Python in a natural way. To develop the simulation, the calculations had to be performed using Kepler's laws and implemented in the Scratch script.

4. The HD 10180 planetary system

This planetary system was discovered in 2010 by a research team led by Christophe Lovis of the University of Geneva. The planets were detected using the HARPS spectrograph and the ESO's 3.6 m telescope at La Silla Observatory in Chile, using spectroscopy techniques. In table 1 we show the main orbital parameters of the 6 confirmed planets.

[1] http://exoplanet.eu/, Dec. 1, 2020 (4379 planets).
[2] https://scratch.mit.edu/

5. Scratch simulations

To develop the simulations with Scratch 3.0, we have taken into account the semi-major axis and the orbital period shown in table 1. Future improvements will make the program applicable to other planetary systems taking into account other parameters such as eccentricity, the radius of the planet or the angle of inclination. We have chosen a visualization in our line of sight, but Scratch also allows us to visualize the movement of the planets from different views. The interface includes a Period counter in days to three decimal places.

This program also allows users to do more complex studies, such as conjunctions and near resonances.

Exoplanet	Semimajor axis (AU)	Orbital period (days)
c	0.06	5.76
d	0.13	16.36
e	0.27	49.75
f	0.49	122.74
g	1.43	604.67
h	3.38	2205

Table 1. Main orbital parameters of the planetary system.

A dynamic visualization of a short of the project can be seen at the following link:
https://www.youtube.com/watch?v=9wq8fWzDhYk

The full script and the complete visualization is available here, where you can run the simulator:
https://scratch.mit.edu/projects/455953976/fullscreen/

Below we show screenshots of each of the transits:

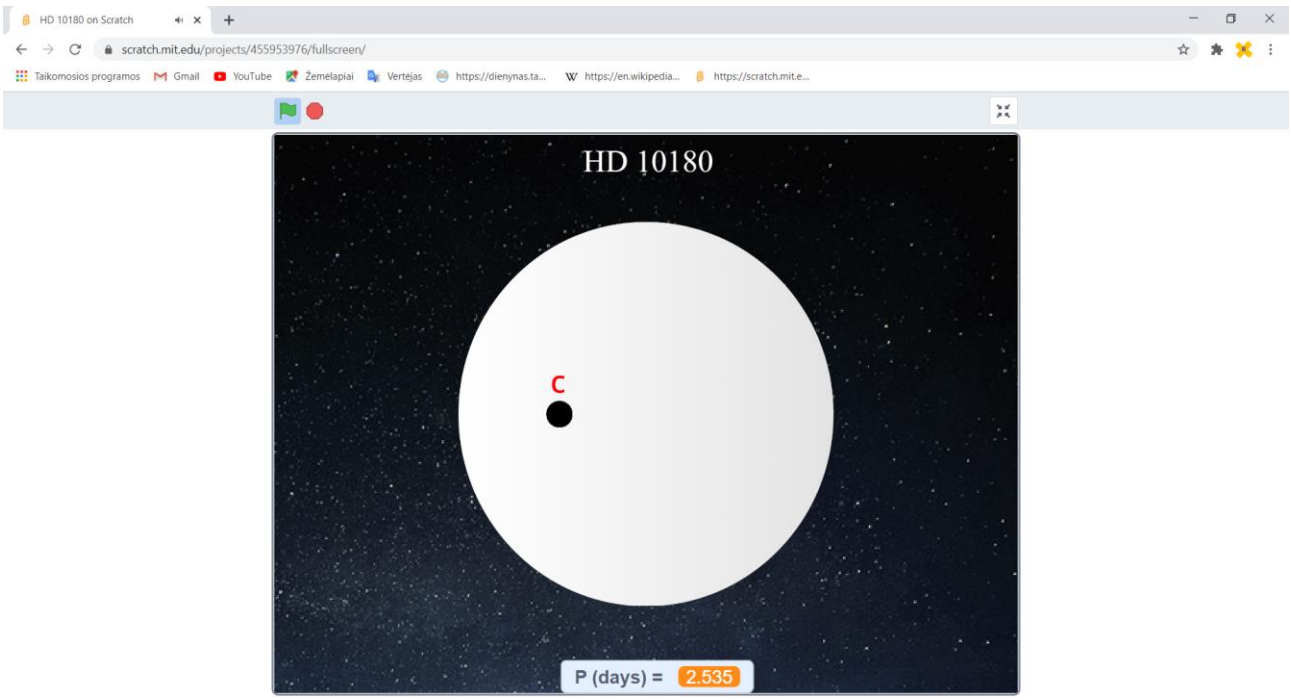

Figure 1. Transit of HD 10180 b during the simulation

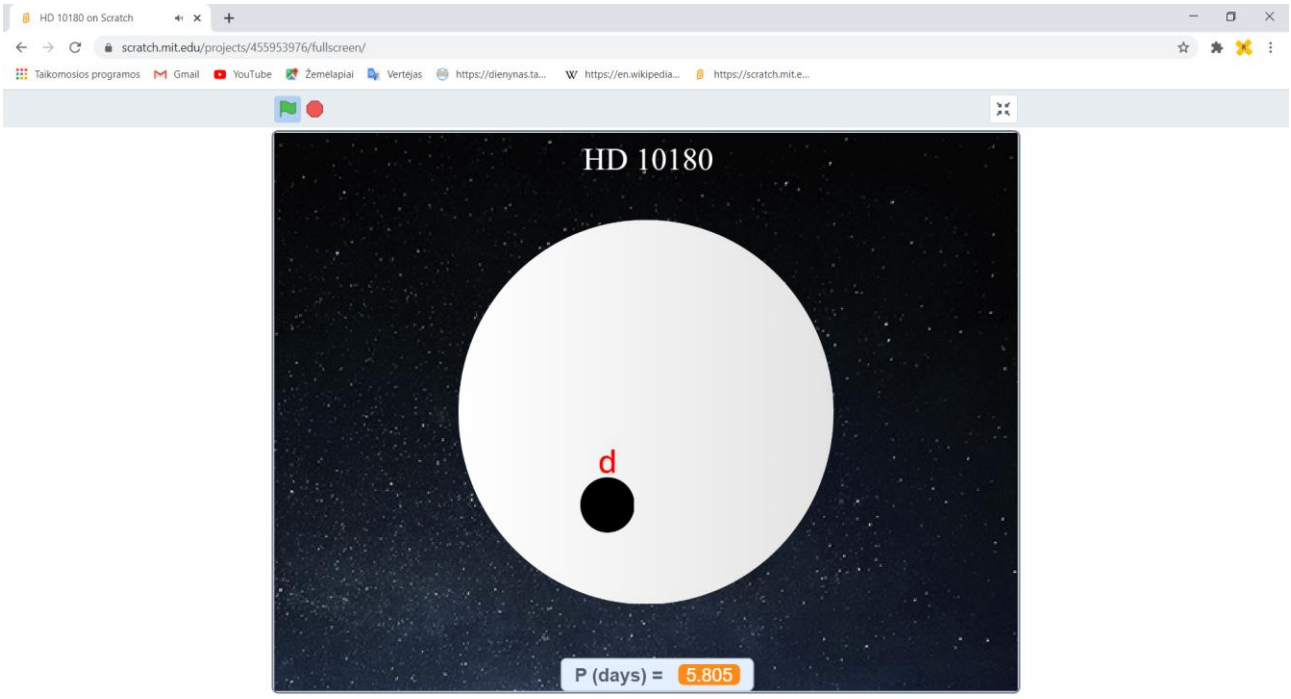

Figure 2. Transit of HD 10180 d during the simulation

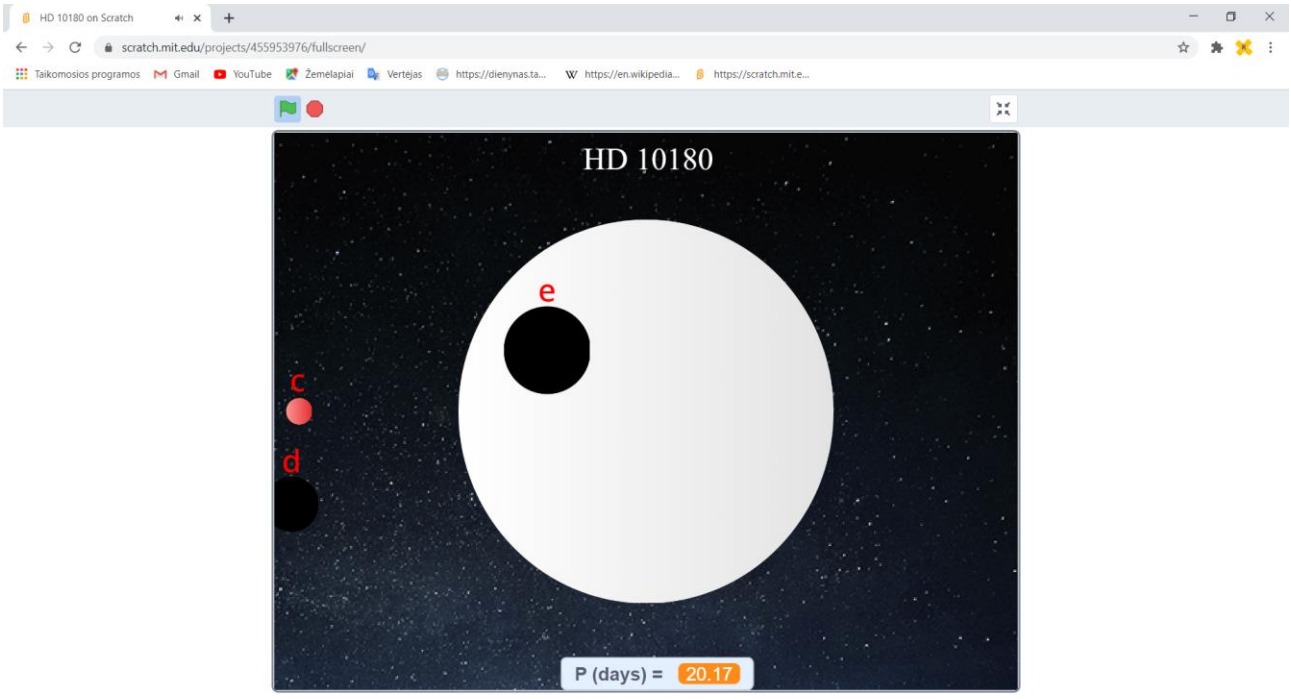

Figure 3. Transit of HD 10180 e during the simulation

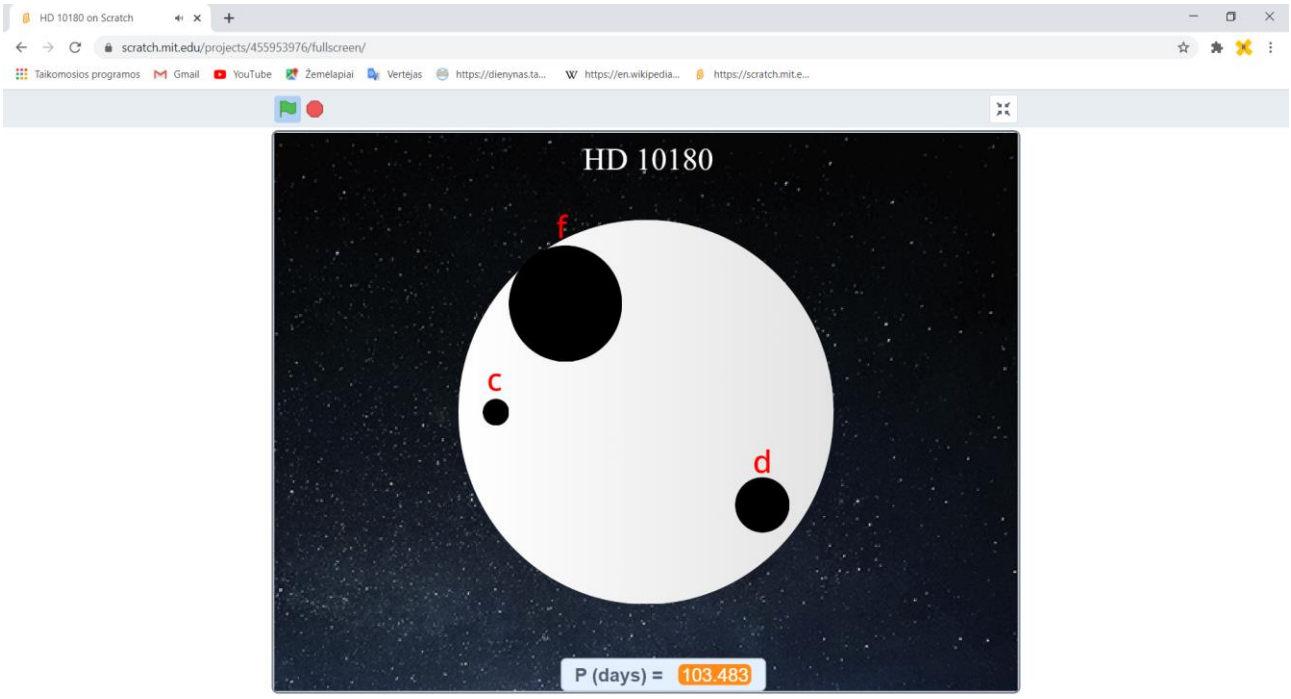

Figure 4. Transit of HD 10180 f during the simulation

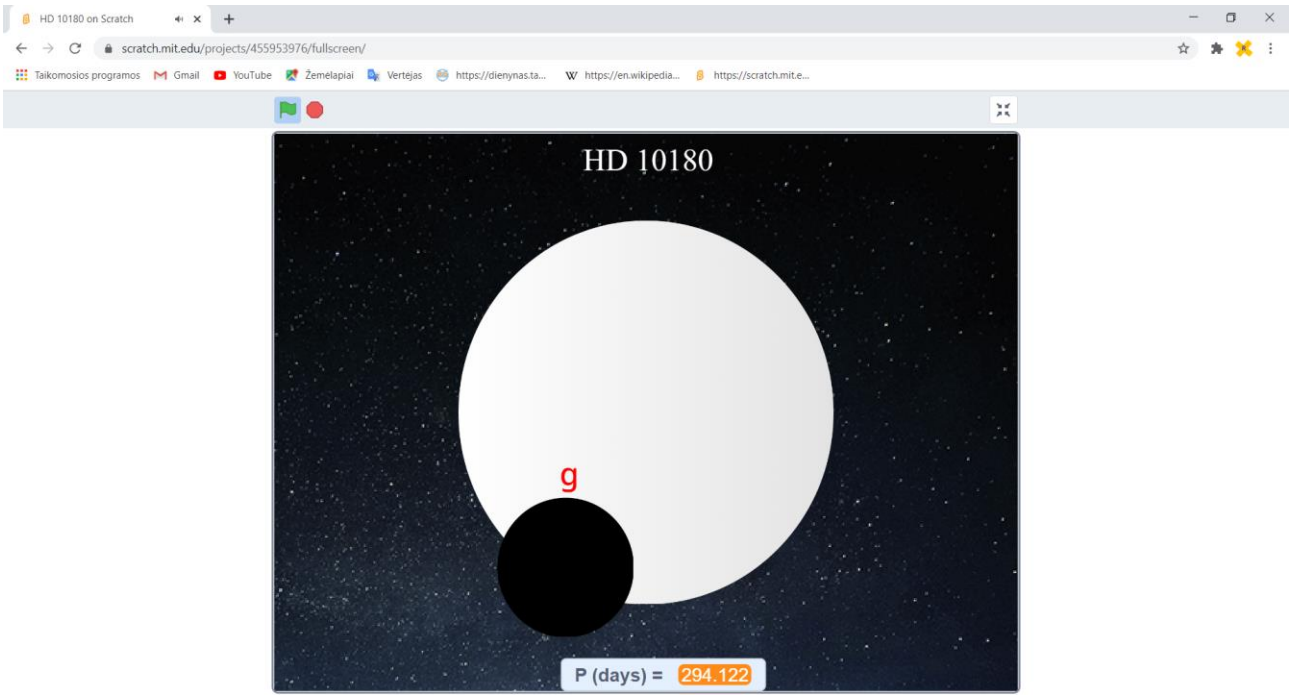

Figure 5. Transit of HD 10180 g during the simulation

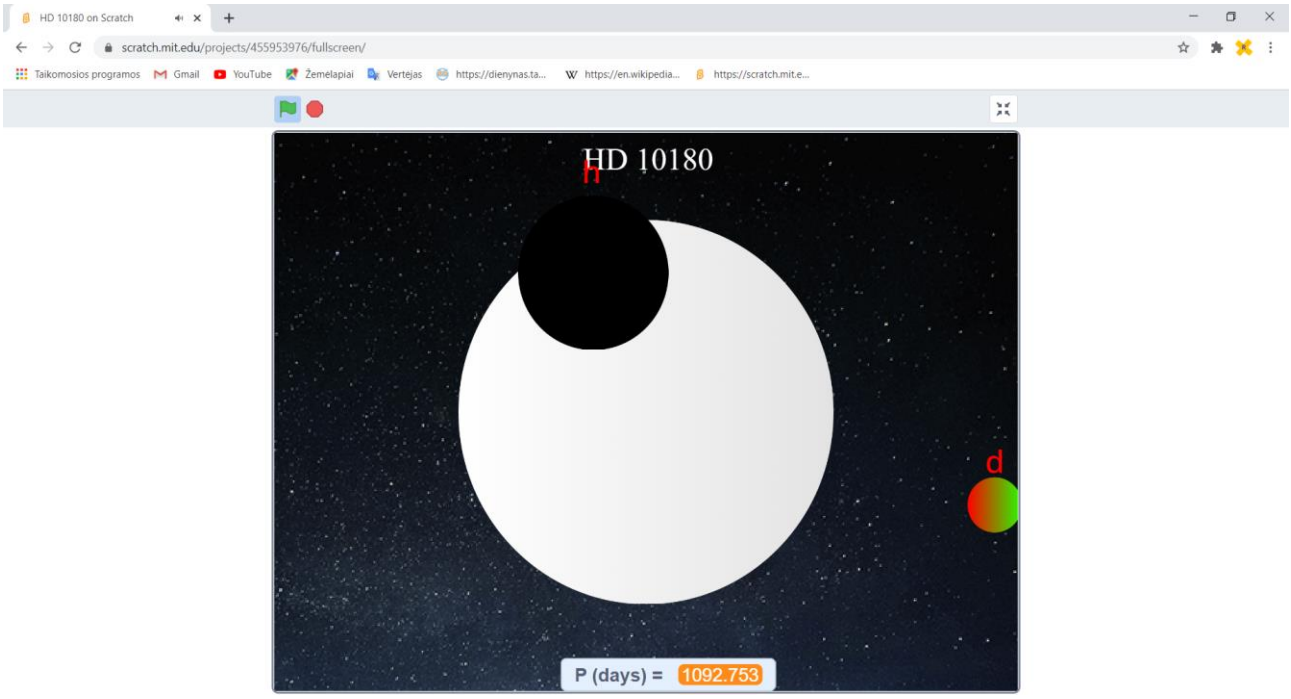

Figure 6. Transit of HD 10180 h during the simulation

6. Conclusions and future prospects

In view of the work carried out, we conclude that Scratch is an excellent tool to be used by children also in astronomy projects. Our intention is to improve the script, so that it can take into account other inputs such as eccentricity or angle of inclination, and adapt it to other exoplanetary systems. Other improvements could also be the visualization from different lines of sight and different field of view (FOV).

This project can be the seed and the starting point for the creation of the first planet simulation software for children with Scratch, and example for other children to develop similar software. Scratch is free and open software, which allows the improvement of projects by other users, so the interaction and collaboration with other teams is very welcome. We hope this program will inspire other groups to do science with Scratch.

7. References

Lovis, C; et al. (2010). "The HARPS search for southern extra-solar planets XXVII. Up to seven planets orbiting HD 10180: probing the architecture of low-mass planetary systems". Astronomy & Astrophysics. 528: A112.

Vorderman, C. *Computer Coding for Kids*, DK, London, 2015.

About the Author:

Rytis Babianskas (Lithuania, 11 years old)

Rytis is the author of the exoplanet simulator with Scratch 3.0. He is a 5th grader at Kauno Pilėnų progimnazija, in the second largest city in Lithuania. He has taken part in robotics courses, and is an enthusiast about astronomy and computer science, successfully participating in several ESA and EuroPlanet projects. He is very friendly, and he likes to learn languages, as well as swimming in the Sea and rollerblading. He has a little brother named Vakaris. In Lithuanian, Rytis means day and Vakaris means night. Rytis would be glad to share his ideas and projects with other children around the world! ☺

You can visit all his projects in Scratch 3.0 at the following link:
https://scratch.mit.edu/users/rytikinis/