Exoplanet Accurate Orbits and Transit Simulator v.0.1
A Exoplanet Accurate Transits and Orbits Simulator (ExAcTOS)¹

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ABSTRACT

We launch ExAcTOS v0.1, the first exoplanet simulator with Scratch 3.0 created by and for children. We have developed a tool that allows simulations of exoplanets in different orbits. The software allows combinations of semi-major axis, orbital velocities and periods, resulting in an excellent tool to do elementary science for students. The tool has a user interface that allows users to enter parameters such as the spectral type of the star, and a window that provides information on the chosen simulation. The tool is written in the free code programming language Scratch 3.0, created at MIT and accessed by a community of millions of users from around the world. At the time of this report, the author of ExAcTOS is already working on version 0.2, which includes new features and improvements.

1. Key words

planets and satellites: planet–star interactions - methods: Scratch 3.0 simulator

Figure 1. ExAcTOS v0.1 main screen.

¹ The simulator source code is available at https://scratch.mit.edu/projects/461709013/
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2. Introduction
The planetary science has undergone a great development in the last decades. Every day it is more frequent to receive news of discoveries of planets outside our solar system. This awakens an interest in children, who are becoming more and more familiar with the subject. Having a useful tool to simulate the movements of the planets can help to better understand the subject as well as increase motivation.

3. Methodology
To create this software we have used an open source programming language available for students called Scratch⁴, developed at the Massachusetts Institute of Technology (MIT) and intended for children of ages 8-16. In the Scratch community there are millions of projects, the vast majority video games. Although it is less frequent, the structure of Scratch allows to create scripts to be used in science. The structure of ExAcTOS can be continuously improved, keeping the essence of the original source-code. This gives us the opportunity to create new versions of the software. The source code is available to users in the Scratch community, and can be taken and improved also by other Scratch users.

4. ExAcTOS v0.1
The first version of ExAcTOS allows to simulate the movement of exoplanets in 3 orbits and 5 different orbital speeds. This provides the possibility of simulating 15 different exoplanets, with periods between 2 and 34 days. It also allows you to choose the spectral type of the host star. The simulator has a main presentation screen (figure 1), which redirects to the instructions for use. It also has a graphical interface that allows data on the orbital velocities, the semi-major axis and the spectral type of the host star to be entered (figures 3 to 5). At the moment the simulator has been designed taking into account the direction of light and shadows, so that the planet side facing the star is always illuminated, and the other side is in shadow.

![Figure 2. Internal structure of ExAcTOS.](image)

It also has an interface that shows information about the simulation (figure 9). It provides a time counter (in days) that allows the orbital period to be calculated. Since the software simulates almost circular orbits, it is possible to use as a formula for the orbital velocity:

\[
v \approx \frac{2\pi a}{T}
\]

where \(a\) is the length of the semimajor axis in meters, and \(T\) is the orbital period. The period can be obtained with the counter; at the moment we leave “a” as a free parameter, but in future versions it will be possible to enter the distance in (AU) or the speed in Km/s.

The best way to get to know the simulator is by using it. Below we leave the links to the source code of the simulator and to an explanatory video.

⁴ https://scratch.mit.edu/
Video presentation and explanation of how ExAcTOS works (intro):

https://www.youtube.com/watch?v=gTiZV42LotI

The full script and the complete visualization is available here, where you can run ExAcTOS:

https://scratch.mit.edu/projects/461709013/

Below we show screenshots with the main functionalities:

![Star color selection interface.](image)

Figure 3. Star color selection interface.
Figure 4. Planet orbital velocity selection interface.

Figure 5. Orbit selection interface.
Figure 6. Simulation of the smallest orbit.

Figure 7. Simulation of the second orbit.
Figure 8. Simulation of the largest orbit

Figure 9. Information window, with the time counter in days and the surface temperature of the star.
5. Conclusions and future prospects
The result of this work is the first exoplanet simulator created by and for children using the Scratch programming language. The author of the code is already working on new updates and improvements for version v0.2. This will include new parameters, such as eccentricity, the possibility of simulating several planets at the same time (multiple planetary systems), as well as introducing mathematical formulas giving the possibility of choosing between different sets of orbital speeds and semi-major axis. Also the visualization from different perspectives, and the possibility of simulating light curves during transit, as well as the displacement of the lines by the Doppler effect.

6. References

Rytis Babianskas (Lithuania, 11 years old)

Rytis is the author of ExAcTOS v0.1 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. Rytis spends the weekends and part of the holidays at his grandparents' house in Daniunai, a small Lithuanian village where the skies are clear and the nights are starry, inspiring him when he watches with his telescope. 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/