Table Top Teaching Aid for Exoplanet Detection using Transit Photometry

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INTRODUCTION

Exoplanet detection has advanced significantly through various observational techniques, including radial velocity, direct imaging, and gravitational microlensing. Among these, the transit method—which detects exoplanets by observing the temporary dimming of a star as a planet transits across its face—has been particularly effective, accounting for many exoplanet discoveries. In this work, we introduce a tabletop model designed to simulate the transit detection process, offering an engaging educational tool for teaching this technique.

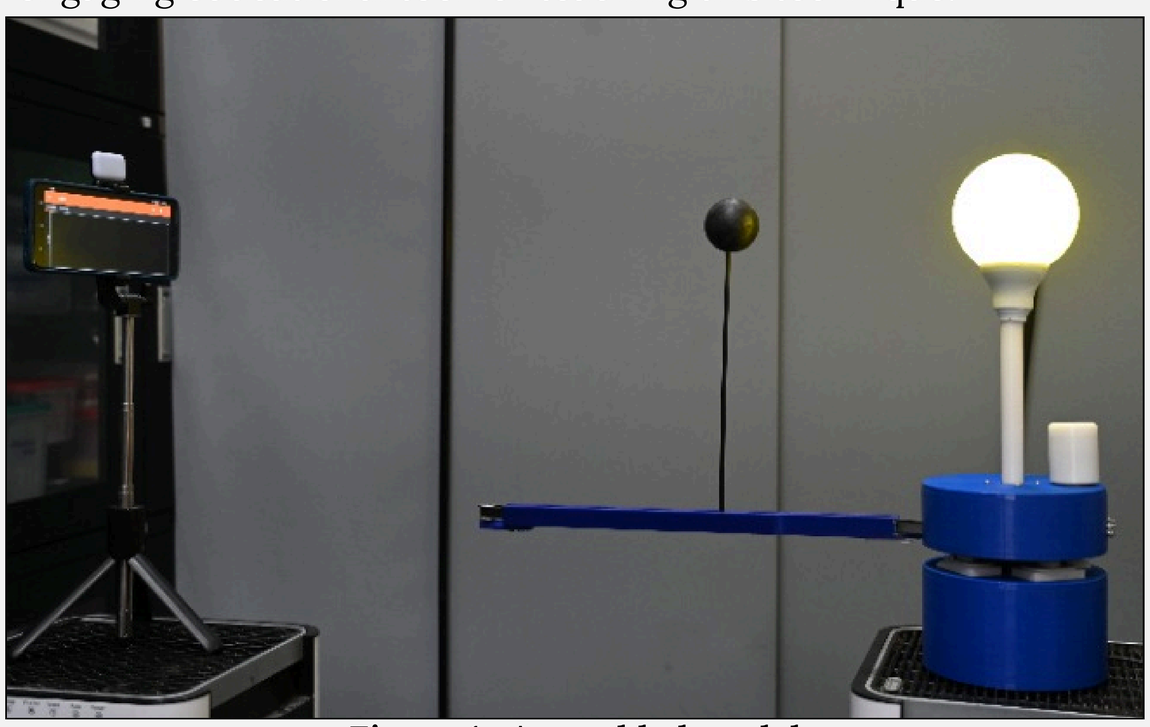

Figure 1: Assembled model

SIMULATING TRANSITS

Steps to Simulate a Transit:

- **Establish Connection**: Connect your device to the ESP32 microcontroller housed in the model's base.
- **Adjust Orbital Parameters**: Modify the planetary orbit by inputting the desired star-planet distance via the web interface accessible on the device .
- **Transit Simulation**: The microcontroller calculates the time period in accordance with Kepler's Law, scales it to the model's dimensions and commands the actuators to initiate the planet's revolution around the star.

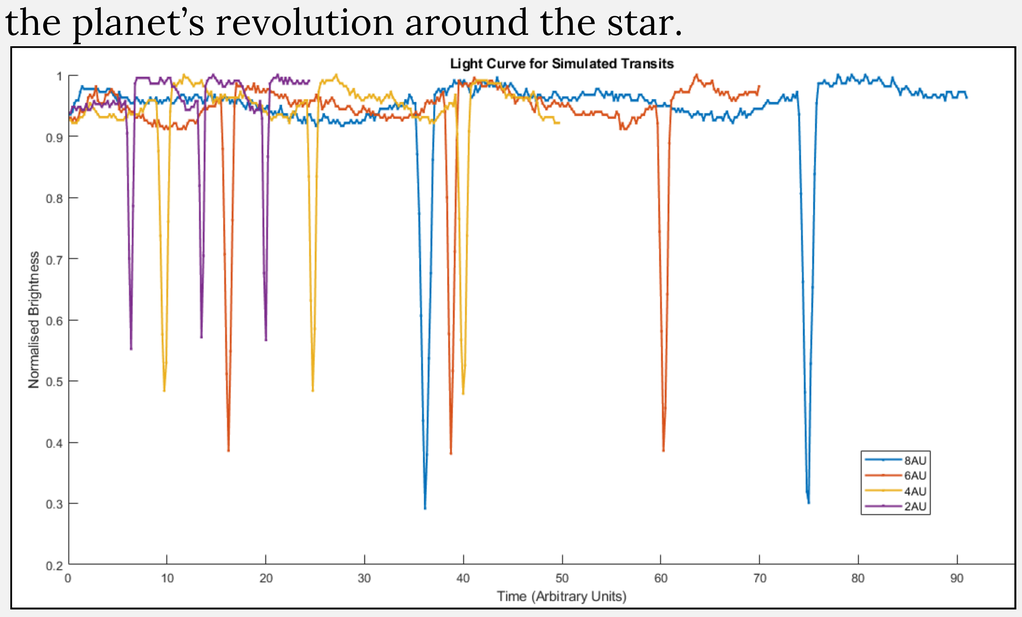

Figure 2: Simulated transits for different star-planet distances

DESIGN OF THE MODEL

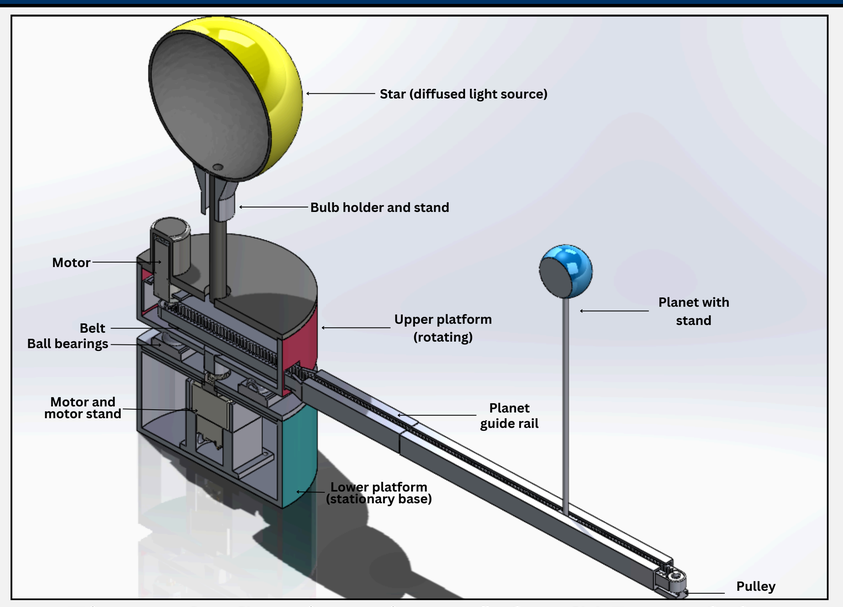

Figure 3: Section view of the CAD model

Hardware Design:

- The model consists of a miniature star (LED light source) and a motorized exoplanet system that simulates planetary transits.
- Adjustable planetary orbit to model different star-planet distances and corresponding orbital periods as per Kepler's law.
- Planets of varying sizes can be used to demonstrate the impact of planet radius on transit observed.
- 3D-printed components for modularity and ease of replication.

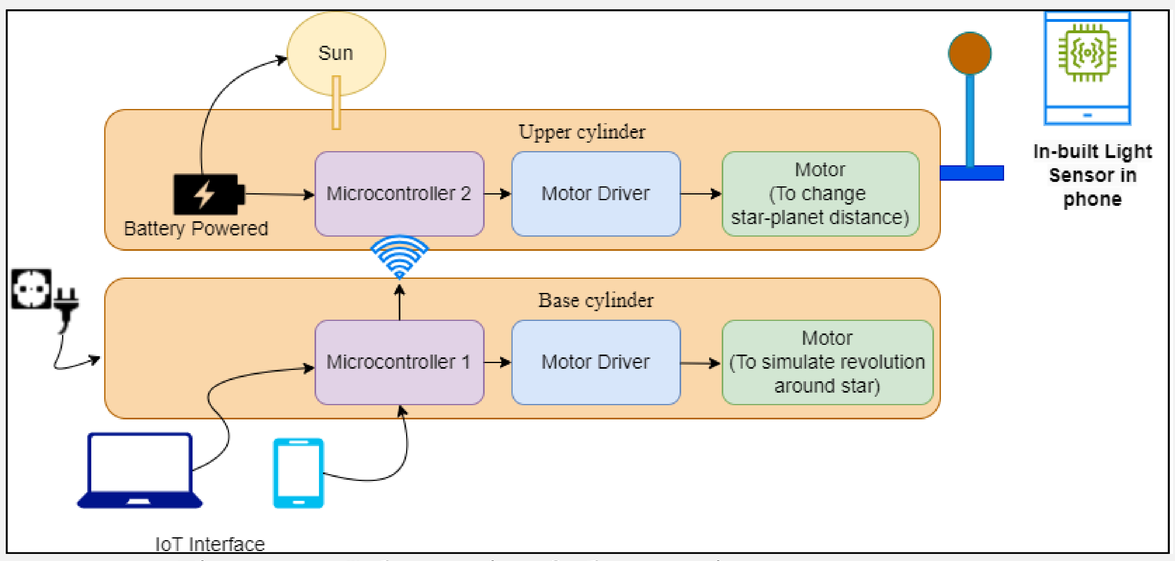

Figure 4: Schematic of Electronic components

Electronics and Software:

- ESP32 microcontroller for wireless control via a web interface.
- A light sensor records light intensity variations during a transit

Figure 5: Example web interface

OUTREACH

Figure 6: Model demonstration to school students

The model aims to serve two primary educational purposes:
(i) in-depth learning - by recreating various exoplanet transit scenarios and recording the synthetic observational signal, users can gain a comprehensive understanding of the transit method, and
(ii) hands-on engagement - designing and assembling the electro-mechanical system fosters creativity and innovation.
The simplicity of the design make it an excellent pedagogical tool that transforms abstract concepts into engaging experience for the classroom.

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