# ROBOTIC TELESCOPE PROJECT

Suggested Class Schedule

This schedule assumes that class periods are at least an hour long and that your class has 3-4 available computers for groupwork. If this is not the case, contact Jenna and she can develop a program specifically for your group.

Class 0: Project Introduction

Before you begin the project, introduce the concept to your students in a short 10-minute introduction at the end of an earlier class. Define exoplanets and how we know about them. Explain that your students will be using a telescope in California to observe transits of exoplanets and that the telescope is operated remotely online. This gives them some time to understand the concept of exoplanets and develop questions for the guest speaker to answer in the subsequent class.

WASP-52b Transit August 26-27
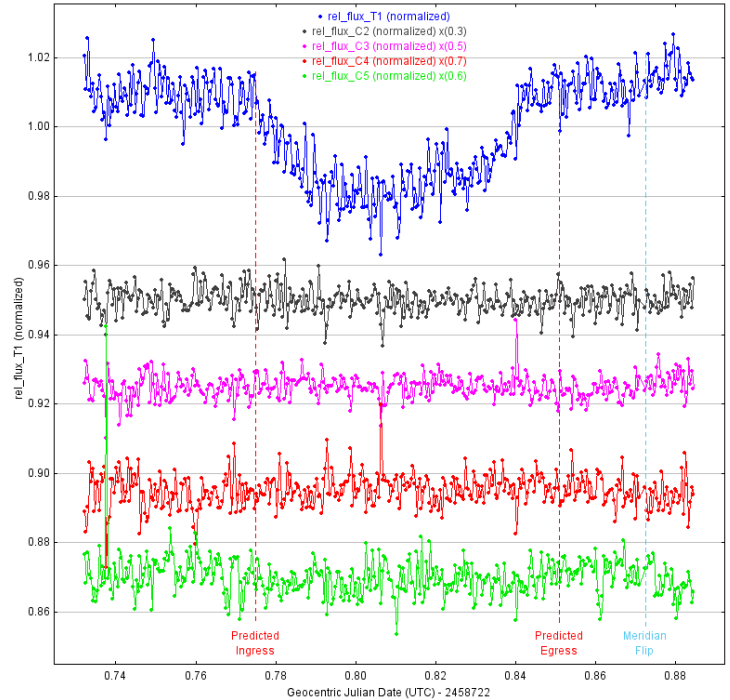
Class 1: Guest Expert from l'institut de recherche sur les exoplanètes

Speak with Jenna to arrange a time for a guest speaker from the Institute for Research on Exoplanets to visit your classroom via Skype. They will discuss the history of exoplanetary research, and how their specific research fits into the field as a whole. This will provide context for the research your students will be doing and shows examples of real-world applications of math and physics.

Class 2: Target Selection

Have your students follow the provided tutorials in order to choose their exoplanet targets.

From this point onwards, it is recommended that all data processing be done in small groups. This allows students with various skill levels to contribute and means that the groups will be able to compare their data analyses to one another.

Resources and Links

Exoplanet Transit Finder link

NASA Exoplanet Catalogue

Exoplanet Data Form download

1. Split class into 3 or 4 groups and assign each a Wednesday to research beginning at least three weeks from this class. Example: if this class lands on October 9th, assign students Wednesdays starting from October 30th onward.

2. Have each group work together to choose targets that meet the criteria listed in the tutorial.

3. If a group does not find a suitable target on their assigned day, have them choose the next available Wednesday not actively being researched by another group.

4. Once students find an acceptable target on their date, have them fill out the Exoplanet Data Form accordingly and scan (or save) and send to us.

5. By the end of the class, you will have 3-4 potential targets. We will confirm that all are good targets (within listed parameters) and will begin imaging. We will attempt the earliest reasonable target. If weather or other circumstances preclude us from taking data on that target, we will attempt the next feasible target.

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Class 3: Data Review and Preparation for Analysis
OPTIONAL

Depending on your class's skill level and the length of your class period, you can choose to do this entire lesson (all three steps), only the latter two (Meridian flip if necessary, and stabilization) or just the last (stabilization). We are happy to do earlier steps for you if you need. If you decide to do all three steps, you may need an additional class period.

Step 1: Apply bias, dark and flat frames
20 minutes
Bias, dark and flat frames adjust for inherent biases in your data caused by errors in the chip used to record the data, errors caused by certain exposure times and errors caused by dirt, dust, and vignetting in and on the telescope itself. The process is relatively simple, but understanding what the frames are actually doing can be a bit confusing. There are tutorials that explain bias, dark and flat frames in more detail, as well as specific instructions on how to apply these to their data.

Step 2: Adjust for meridian flip
20 minutes
Only some data sets will involve meridian flips. During a meridian flip, the telescope flips upside down and for this reason some frames of your data will be inverted. You will know in advance if your data will require adjusting for a meridian flip (this can be determined if, on your Exoplanet Data Form, the Hour Angle changes from negative to positive).

Step 3: Stabilization
20 minutes
The telescope drifts a bit during data collection. To be able to measure the brightness of our target and check stars, they must stay in the same location in our images.

Class 4: Data Analysis Basic

Finally! Acquiring data from the images. This will take some fiddling and trial and error when looking at check stars. It's best to give your students an entire class period to play with their data and, if they finish early, they can look for other stars in the frame that might also have exoplanets or may be variable stars. That's part of the fun!

Once students have completed their data analysis in AstroImageJ, they can export their charts and send them to you so that you may compare charts from all students at the front of the class. Did anybody find an exoplanet transit?

Lead a discussion regarding possible sources of error in your results. These could include:

- Atmospheric conditions (clouds, moisture, changes in seeing)
- Obstructions (roof, horizon, birds)
- Unintentional sources of brightness (planes, satellites passing in front of target or check stars)
- Meridian flip (sometimes leads to a change in brightness)
- Poor choice of check stars (stars that vary naturally, or perhaps stars that have other exoplanets)
- Poor parameters (dip in brightness due to exoplanet was too small to see, timing was off, star wasn't bright enough)
- Planet has changed since initially catalogued (perhaps lost mass to its star, causing its orbit to change)

What else can your students come up with? Have them picture what it would be like in that solar system that may cause issues.

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Class 5: Data Analysis Extended

Follow the tutorial to have students plot extra data, such as the change in brightness of their check stars. This will produce a graph like the one on the first page of this document. Students can also follow a short tutorial on how to determine if there are other interesting objects in their data set, if they so choose. While you can get by on just one lesson for data analysis, giving students more time to play with their data set and look for abnormalities allows for inquiry-based learning and fosters curiosity and imagination!

Homework and Publication

Students can complete a lab report regarding this project for homework and submit to you for grading. Excerpts from lab reports could also be published in the Journal of the Royal Astronomical Society of Canada or in SkyNews, the RASC's magazine.

As another option, students can choose to write a short blog or article about their process, challenges they faced, or a story from their data analysis. Stories will be more likely to be featured in the RASC's publications. Students whose work is chosen will receive two free copies of the publication: one for themselves and one for their class.

See our telescope!

Check out the RASC robotic telescope in its natural environment! Live views of our telescope are available on this page. It is the telescope on the right in the fifth feed. If you check it out at night, you might be able to see it move around!

This one's ours!

Exoplanet Teaching Resources

NASA Exoplanet Exploration
This has a database of all discovered exoplanets, a timeline of human knowledge about planets and exos, details on how we find exoplanets, information about the search for life outside our solar system, news articles, and a link to the Exoplanet Travel Bureau, hosting poster downloads of various exoplanetary systems.

Exoplanets: Worlds Beyond Our Solar System
Hosted by Space.com, this article summarizes the history of exoplanets in a less interactive format. Suitable for visually impaired students. Somewhat out-of-date, having been written in 2018.

Sky and Telescope: Exoplanets
Find current exoplanet news here!

Questions? Ask us!

Contact the Royal Astronomical Society of Canada's Youth Outreach Coordinator, Jenna Hinds, for clarification on any element of this project here:

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