Rubin's Opening Act — Moving Objects First Look Teacher Guide

Introduction

This teacher guide is designed to provide ways for you to actively engage your students in exploring the First Look moving object products. The moving dots in these products represent only natural Solar System objects. Satellites, which would move much more quickly through the area, have been removed.

There are three moving object products:

- The video: Rubin's Opening Act — a Swarm of New Asteroids
- The Orbitviewer spatial visualization tool
- An image in the Skyviewer with asteroid tracks

Rubin's Opening Act — a Swarm of New Asteroids

This video is designed to communicate the scale of Rubin Observatory discoveries in just seven nights and in a relatively small area of sky (about 24 square degrees).
The first part of the video (up to 28 seconds) shows closeups of asteroid images cut out from the data. The brightness of each object is partially determined by what filter the observation is made in. Since all observations are not made using the same filter, it is not possible to infer any meaningful information by comparing the relative brightness of objects.

In part two of the video (28-41 seconds), four groups of moving objects (all new discoveries by Rubin) are represented as dots color-coded by their types. These new detections include 2015 MBAs, 7 NEOs, 9 TNOs, and 11 Jupiter Trojans.

- Main Belt Asteroids (MBAs) are teal
- Near Earth Objects (NEOs) are yellow
- Trans-Neptunian Objects (TNOs) are bright purple
- Jupiter Trojans are bright blue

The dots are added when they are detected, so you may notice slight transitions between nights and also observe that the numbers of dots increase night to night as new detections are added. Consider playing this part of the video at 50% speed and replaying it several times as you use the questions below.

The last section of the video (starting at 42 seconds) illustrates the area of the Solar System that was observed over the 7 night period. The dots are now rearranged to show both their relative distance from the Sun and the relative numbers of each group. The objects extend

beyond the known main asteroid belt (dark blue colored region), but they may be difficult to see without magnification because there are many less Trojans and TNOs.

Below are some questions and information you can use to engage students to make observations and interpretations of what they see in the video. Answers are displayed in blue.

Questions for Discussion and Engagement

1. Which group of the newly discovered objects has the largest number in this video? Why do you think this is? What was the color given to these objects?
MBAs, because over 1 million of these objects have been previously discovered. It is by far the largest group of known objects in the Solar System. Teal.

2. Watch the portion of the video from 28-41 seconds. In what direction do most of these objects appear to be moving? From left to right and upward
Note: The motions seen in the video are not due to the objects' orbital motions around the Sun. Rather, the apparent motions over the span of a week is primarily due to Earth's revolution around the Sun.

3. There are a few objects that appear to be moving faster than the majority of objects. What is causing them to appear to move faster? They are closer to the Earth.
Note: A few nearby (teal and yellow) objects appear to move faster. Think about it this way: If you are riding in a car and look at nearby objects (such as the grass or road signs), they appear to be moving much more quickly than far away objects (such as a distant tree or building). The purple objects (TNOs) may appear to be moving backward or not at all. These objects are the farthest from Earth so their apparent motion is minimal.

4. There are several objects that are moving in directions different from the majority of objects. Why do you think these objects have motions different from the majority of objects?
Objects moving faster than the speed of Earth's revolution around the Sun may appear to move in the opposite direction to most objects.

The Orbitviewer spatial visualization tool

The Orbitviewer displays planets, NEOs, MBAs, TNOs, Jupiter Trojans, Centaurs, and interstellar objects. Each group can be toggled on and off, and multiple (or all) groups can be displayed at once. There is also an option to toggle the groups to see previously-detected objects, new discoveries by Rubin, or all objects (two groups combined). Comets are not included in this first version of Orbitviewer.

This tool allows users to view Solar System objects in three dimensions and to compare their relative distance from the Sun. The view can be zoomed or tilted. Users can move forward and backward in time to see how the different types of objects in our Solar System move around the Sun. A few objects labeled with icons display more detail by clicking or tapping on them.

Questions for Discussion and Engagement

1. Why do most objects orbit in the same direction?
The cloud of gas and dust that formed the Sun and Solar System was rotating in a particular direction, so the planets and the majority of other bodies that formed in the Solar System all orbit the Sun in the same direction as the cloud was rotating.

2. What are the most distant objects that have been detected? TNOs

3. Which objects have the longest orbital period? TNOs

4. Which (small Solar System) objects are closest to the Sun? NEOs

5. Which (small Solar System) objects have the shortest orbital period? NEOs

6. Where in the Solar System would you search to discover Centaurs?
Since many of the Centaurs appear to be between Jupiter and Saturn, this is where we should focus our search. (Note: It may be that a greater number of discoveries will actually happen between Saturn and Neptune since Rubin is able to detect many more dim and slow-moving objects than previous telescopes.)

7. Where in the Solar System would you search to discover the Trojans? At the distance of Jupiter's orbit. They are in two groups, one on either side of Jupiter.

Skyviewer with asteroid tracks

There is an option in Skyviewer to turn on asteroid tracks that can be accessed from the Main Menu at the upper left corner of the Skyviewer. Tracks appear as multicolored streaks because four different filters were used on different days and the images from these filters were assigned colors in order to create a full color image.