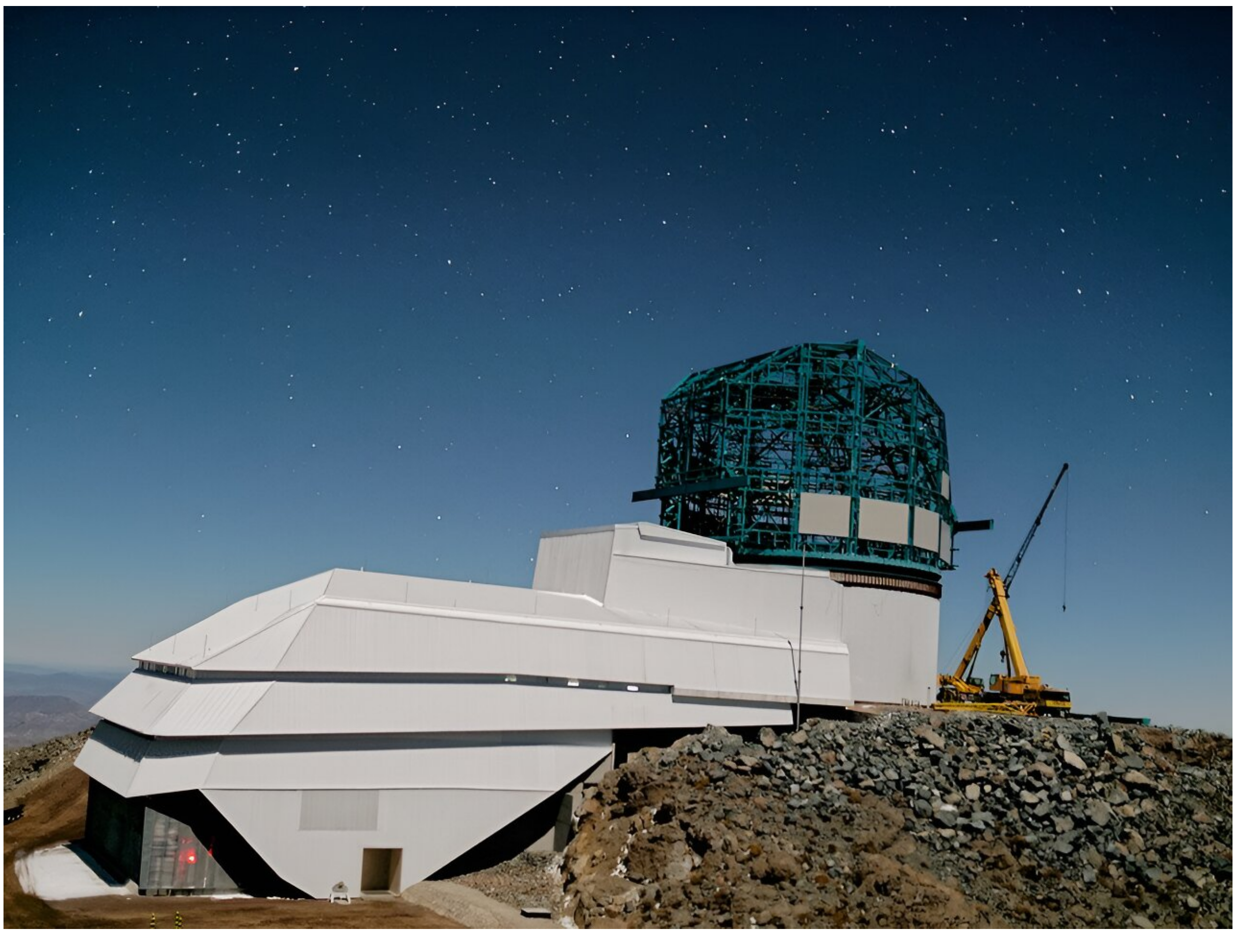
Vera Rubin Observatory could find up to 70 interstellar objects a year

November 1 2023, by Nancy Atkinson



The Vera C. Rubin Observatory is under construction at Cerro Pachon, in Chile. This image shows construction progress in late 2019. The observatory should be able to spot interstellar objects like 'Oumuamua. Credit: Wil O'Mullaine/LSST

Astronomers have discovered two known interstellar objects (ISO), 'Oumuamua and 21/Borisov. But there could be thousands of these objects passing through the solar system at any time. According to a new paper, the upcoming Vera Rubin Telescope will be a fantastic interstellar object hunter, and could possibly find up to 70 objects a year coming from other star systems.

The Rubin Observatory is a ground-based telescope located high in the Chilean Andes. It is expected to see first light sometime in 2025, a timeline that has already been pushed back a few times. The observatory's 8.4-meter Simonyi Survey Telescope will take images of the sky using the highest resolution digital camera in the world, a 3,200-megapixel camera that includes the world's largest fish-eye lens. The camera is roughly the size of a small car and weighs almost 2,800 kg (6,200 lbs). This survey telescope is fast-moving and will be able to scan the entire visible sky in the southern hemisphere every few nights.

One of the main projects for Rubin Observatory is the Legacy Survey of Space and Time (LSST), expected to last at least 10 years. Researchers anticipate this project will gather data on more than 5 million asteroid belt objects, 300,000 Jupiter Trojans, 100,000 near-Earth objects, and more than 40,000 Kuiper belt objects. Since Rubin will be able to map the visible night sky every few days, many of these objects will be observed hundreds of times.

Because of the telescope's repeated observations, there will be an enormous amount of data to calculate the positions and orbits of all these objects. With all that data and mapping, it is expected that Rubin will be able to detect faint interstellar objects—and these speedy ISOs might even actually stand out among all the other objects. Basically, the LSST will be able to capture a timelapse view of interstellar objects on their fast journeys through our solar system.

Various estimates and predictions have been coming from various astronomers about how many interstellar objects Rubin will be able to detect. One estimate said five a year, another 7, another 21.

A new pre-print paper published on *arXiv* suggested that LSST could find up to 70 interstellar objects every year. "The annual rate at which LSST should discover 'Oumuamua-like interstellar objects ranges from about 0–70 detected objects per year," write astronomers Dusan Marceta and Darryl Z. Seligman.

‘Oumuamua (l) and 2I/Borisov (r) are the only two ISOs we know of for certain. Credit: Left: By Original: ESO/M. Kornmesser; right, Hubble Space Telescope/NASA/ESA

To come up with this number, they applied recently developed tool called the Object In Field (OIF) algorithm.

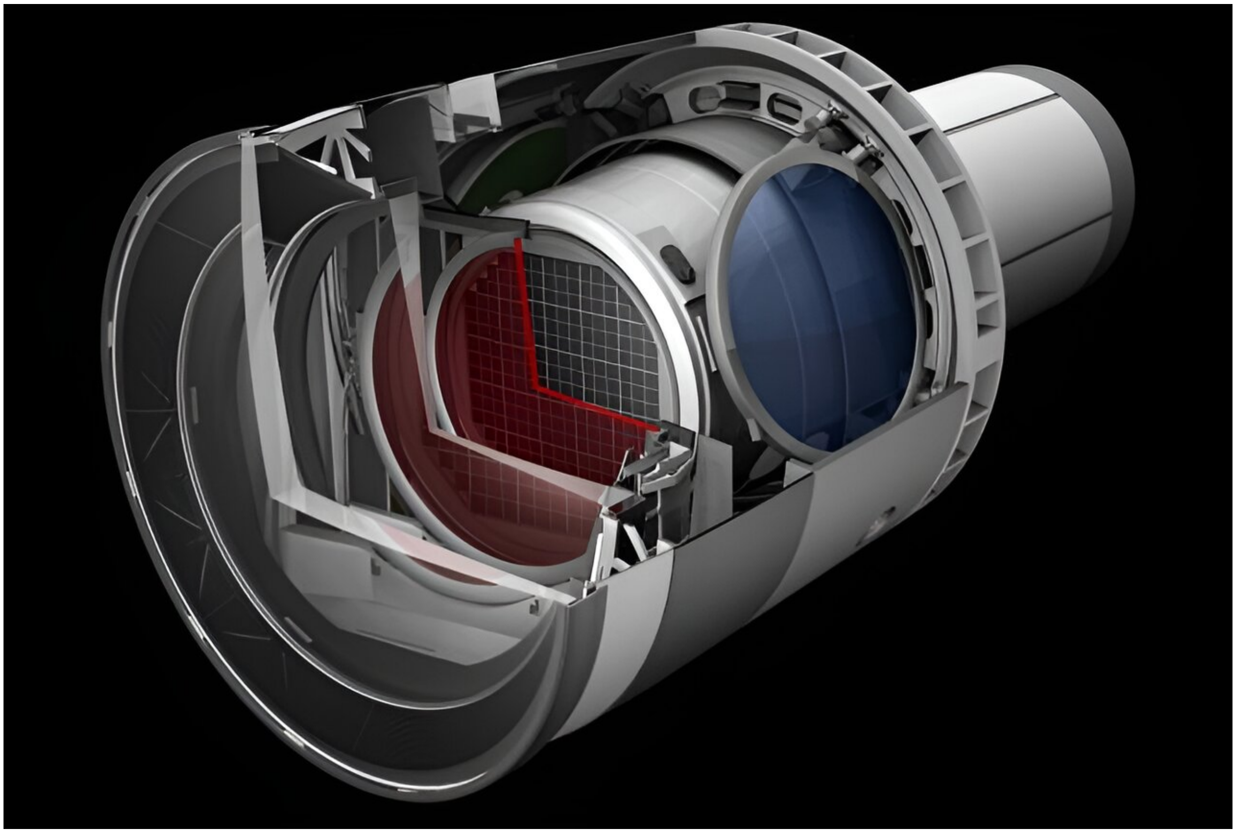
"It serves as an observation generator that simulates a real LSST campaign," Marceta told Universe Today via email, "providing time and coordinates for every LSST field of view (FOV) and exposure time. It also allows for the inclusion of an arbitrary population of moving solar system objects, such as asteroids or comets. It then propagates their motion, determines their positions in the sky, and detects whether some of them appear in the mentioned FOVs."

Marceta, a professor at the University of Belgrade, said that they developed a method to generate a population of interstellar asteroids and utilized the OIF to assess how many of these objects can be detected by LSST under various conditions.

"Given the unconstrained nature of the interstellar objects' population, we considered a wide range of possibilities for critical parameters," he said. "This encompassed size distributions, the range of albedo, and their assumed motions in interstellar space. Taking all these factors into account, we arrived at a range of 0–70 objects per year."

This assumes that at least that many interstellar objects actually exist. Marceta said they assumed a number density of 0.1 object per cubic astronomical unit, a value implied by the detection of 'Oumuamua, "which remains highly uncertain, similar to other parameters associated with this population," he said.

However, because ISOs move so fast, they might more difficult to detect with the Rubin Observatory because of an effect called "trailing loss."



A rendering of the LSST Camera with a cut away to show the inner workings. Credit: LSST.

"It's an effect that occurs when a rapidly moving object is within the telescope's FOV," Marceta explained. "To excite a pixel on the CCD, a certain number of photons must land on it during the exposure time (which is 15 seconds in our simulations). For stationary objects like stars, all photons during the exposure time hit the same area of the CCD. However, for an object that changes its position during the exposure time, the photons land on different pixels as it moves."

Marceta said that even if the total number of photons may be sufficient to excite a pixel, if they are spread across a large number of pixels, it's possible that none of the pixels receive enough photons to exceed the background noise.

While trailed detections on the LSST images can make it easier to link objects into orbits, which could result in the discovery of a new ISO, trailing loss itself is, in fact, an obstacle. It reduces the brightness of an object and can push it below a detection limit.

"The faster the object moves, the greater the number of pixels that receive the photons, making trailing loss more noticeable," he said. "Our simulation shows that interstellar objects can appear in the telescope's field of view with velocities significantly exceeding those of the fastest solar system populations, which makes this issue particularly important."

But of course, this is a chicken-and-the-egg type conundrum. Because of a sample size of only two, scientists can now only make loose predictions of how many interstellar objects Rubin will reveal. Once a larger sample of interstellar objects are able to be counted and analyzed, astronomers will have a much better idea of the population of these objects … which will likely only happen after the Rubin Observatory is up and running.

But Marceta and Seligman are hopeful that Rubin and the LSST will change everything.

"It is possible that the number density of 'Oumuamua-like objects is higher than currently estimated due to a large fraction of interstellar objects currently undetectable due to trailing loss and rapid sky motions," they write.

The more we can find, the better, because some of these will be in the perfect trajectory for an interstellar interceptor mission. Learning details about objects from other solar systems could fundamentally change our view of the universe and our place in it.

More information: Dušan Marčeta et al, Synthetic Detections of Interstellar Objects with The Rubin Observatory Legacy Survey of Space and Time, *arXiv* (2023). DOI: 10.48550/arxiv.2310.17575

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