Citizen scientist spots comet tails streaking past distant star

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Artist's impression of the comet passing a distant star. Credit: Danielle Futselaar

Citizen scientist Thomas Jacobs was the first to spot tell-tale signs that a comet was orbiting a distant star monitored by the Kepler Space Observatory. Professor Saul Rappaport (Massachusetts Institute of Technology; MIT) and his team then collaborated with Jacobs to report the discovery in new research published in *Monthly Notices of the Royal*

Astronomical Society.

The discovery marks the first time that the presence of an object as small as a comet has been inferred by observing dips in the intensity of light from a star. Such dips usually signal crossings of planets or other objects in front of the star, which momentarily block a small fraction of its light. In this case things were different, the researchers were able to pick out the comet's tail, a trail of gas and dust, which blocked about one-tenth of 1 percent of the star's light as the comet streaked by.

"It's amazing that something several orders of magnitude smaller than the Earth can be detected just by the fact that it's emitting a lot of debris," says Saul Rappaport, professor emeritus of physics in MIT's Kavli Institute for Astrophysics and Space Research. "It's pretty impressive to be able to see something so small, so far away."

The data came from NASA's Kepler Space Telescope, a stellar observatory that was launched into space in 2009. For four years, the spacecraft monitored about 200,000 stars for dips in starlight caused by transiting exoplanets. To date, the mission has identified and confirmed more than 2,400 exoplanets, mostly orbiting stars in the constellation Cygnus, with the help of automated algorithms that quickly sift through Kepler's data, looking for the characteristic dips. The smallest exoplanets detected thus far measure about one-third the size of the Earth. Comets, in comparison, span just several football fields, or a small city at their largest, making them incredibly difficult to spot.

All this changed on March 18 this year, when Thomas Jacobs, an amateur astronomer who made it his hobby to comb through Kepler's data, was able to pick out several curious light patterns amid the noise. Jacobs is part of the 'Planet Hunters' citizen scientist project established by Yale University, which enlists amateur astronomers in the search for exoplanets.

The idea was that the human eye might be able to spot things that a computer would miss, Professor Rappaport explains - "I could name 10 types of things these people have found in the Kepler data that algorithms could not find, because of the pattern-recognition capability in the human eye".

In Jacobs' search, he spotted three unusual dips in the light coming from KIC 3542116, a faint star located 800 light years from Earth - he flagged the events and alerted Professor Rappaport, with whom he had collaborated in the past to interpret his findings. A further three transits were subsequently found by Rappaport and the team.

"We sat on this for a month, because we didn't know what it was" Rappaport recalls "- planet transits don't look like this!—Then it occurred to me; 'Hey, these look like something we've seen before...'". In a typical planetary transit, the resulting light curve resembles a 'U', with a sharp dip, then an equally sharp rise, as a result of a planet first blocking a little, then a lot, then a little of the light as it moves across the star. However, the light curves that Jacobs identified appeared asymmetric, with a sharp dip, followed by a more gradual rise.

Rappaport realized that the asymmetry in the light curves resembled disintegrating planets, with long trails of debris that would continue to block a bit of light as the planet moves away from the star. However, such disintegrating planets orbit their star, transiting repeatedly. In contrast, Jacobs had observed no such periodic pattern in the transits he identified. "We thought, the only kind of body that could do the same thing and not repeat is one that probably gets destroyed in the end," says Rappaport. In other words, instead of repeatedly orbiting the star, the objects must have transited, then ultimately flown too close to the star, and vaporised. "The only thing that fits the bill, and has a small enough mass to be destroyed, is a comet."

Rappaport asked Kepler's Lead Data Analyst, Jon Jenkins (NASA Ames Research Center), to weigh in. Jenkins took a critical look at the data and ruled out the possibility of instrumental artifacts or contamination from other stars. "This is a fascinating object, and we had to be absolutely certain we understood the signal before pressing forward with the scientific interpretation," Jenkins said. In this case, it's clear that the signal does, indeed, originate from the KIC 3542116 system. "I'm awed by the sheer diversity and breadth of the discoveries made with Kepler Mission data."

Co-author Andrew Vanderburg of the Harvard-Smithsonian Center for Astrophysics, believes the fact that these six 'exocomets' appear to have transited very close to their star in the past four years raises some intriguing questions - the answers to which could reveal some truths about our own solar system: "Why are there so many comets in the inner parts of these solar systems?" Vanderburg says, "Is this an extreme bombardment era in these systems? The 'Late Heavy Bombardment' was an import stage in the formation of our own solar system when scientists believe a large number of asteroids 'bombarded' the rocky planets, and may have in fact been responsible for first bringing water to Earth. The researchers say that in the future, the MIT-led mission TESS (Transiting Exoplanet Survey Satellite) will continue the type of research done by Kepler "Studying exocomets could give us some insight into how bombardment happens in other solar systems" Vanderburg hypothesizes, which could lead to revelations about the beginnings of life on Earth.

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