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An alien comet from another star is soaring through our solar system

By
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SEWANEE, Tenn. — Something strange is sailing toward us. Something small and cold and extraordinarily fast. No one knows where it came from, or where it is going. But it's not from around here.

This is an interstellar comet — an ancient ball of ice and gas and dust, formed on the frozen outskirts of a distant star, which some lucky quirk of gravity has tossed into our path.

To astronomers, the comet is a care package from the cosmos — a piece of a place they will never be able to visit, a key to all the worlds they cannot directly observe.

It is only the second interstellar interloper scientists have seen in our solar system. And it's the first one they've been able to get a good look at. By tracking the comet's movement, measuring its composition and monitoring its behavior, researchers are seeking clues about the place it came from and the space it crossed to get here. They have already found a carbon-based molecule and possibly water — two familiar chemicals in such an alien object.

As the sun sinks behind the Tennessee mountains, and stars wink into view, astronomer Doug Durig climbs onto the rooftop of his observatory, powers up his three telescopes and angles them skyward.

Every night, the comet grows bigger and brighter in the sky, expelling streams of gas and dust that may offer up clues to its history. On Dec. 8, it will make its nearest approach to Earth, offering researchers an up-close glimpse before it zooms back into the freezing, featureless void.

Far below in the darkness, Durig will be waiting.

An unmarked package from the universe

Each light in the night sky represents a possible solar system. Every star in the universe is, more likely than not, some alien planet's sun.

This is the chief lesson of two decades of studying exoplanets. Scientists have identified thousands of worlds beyond our solar system: gas giants and tiny rocky spheres, worlds lit by dim red suns and ones that orbit the spinning remains of collapsed stars. There are even planets circling medium-sized yellow suns like ours — though nothing found so far can match the breathable atmosphere and deep blue oceans of Earth.

Yet even when viewed through the most powerful telescopes, exoplanets are not discernable as anything more than specks of light. And no human alive has a hope of travelling to another star — merely approaching the nearest one would take 40,000 years.

Scientists' best hope for closely examining another solar system was to wait for a piece of one to come

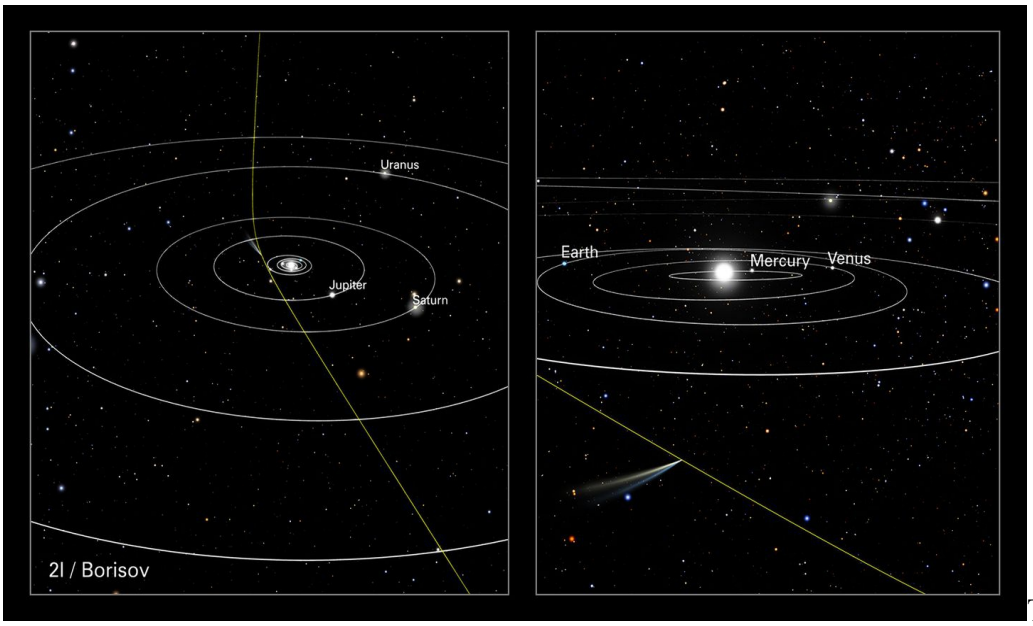
to us.

It was Aug. 30, in the quiet moments before dawn, when a self-taught astronomer in a Crimean mountain village spotted a faint smudge low on the horizon, barely distinguishable against the glittering background of stars.

Gennady Borisov submitted his observations to the Minor Planet Center, the astronomers' clearinghouse for information about small bodies in the solar system, so other scientists could take a look.

One night later, halfway across the planet, the strange report caught Durig's eye.

"I was the second person to observe it," Durig said. "That confirmed the comet was real."



This illustration shows the path of comet 21/Borisov. The comet's straight path across interstellar space is slightly deflected by the gravitational pull of our sun. The panel on the right shows the comet's position relative to Earth when the NASA/ESA Hubble Space Telescope observed it on Oct. 12, when it was 420 million kilometers (almost 261 million miles) from Earth. (NASA, ESA, J. Olmsted, F. Summers (STScI))

Within a couple weeks, scientists had collected enough observations to calculate the comet's orbit. But they did not find the oval path that comets typically make around the sun. Instead, the orbit was hyperbolic — it did not close in on itself. The object was also traveling at the blistering speed of 93,000 miles per hour, far faster than any comets, asteroids or planets orbiting our sun.

"Wow," said Davide Farnocchia, a navigation engineer at NASA's Jet Propulsion Laboratory, who was among the first people to determine the comet came from another star. "I was not expecting to see anything like that."

There has been only one other interstellar object spotted in our solar system: a cigar-shaped rock named 'Oumuamua, a Hawaiian word that translates to "messenger from afar."

But 'Oumuamua was already on its way out of the system when it was discovered in October 2017, and it was so faint scientists were never able to view it as more than a single pixel of light. They were not quite sure what they had seen — was it a metallic, rocky asteroid or an icy**,** dusty comet? And they were unsure whether the detection was just a lucky fluke, never to be repeated, or a harbinger of things to come.

So researchers were thrilled when, less than two years later, another interstellar traveler arrived.

The new comet, which has been named 2I/Borisov (indicating its discoverer and its status as the second known interstellar object) is expected to be within reach of telescopes until fall 2020. At its closest approach, next month, it will be twice as far from Earth as Earth is from the sun.

Though it entered the solar system from the direction of the constellation Cassiopeia, scientists do not know yet where 2I/Borisov came from, or how long it has drifted through the desolation of interstellar space. Given its current speed, it has certainly been traveling for millions, if not billions, of years.

As the object gets closer to the sun's warmth, ices on its surface turn into gas. This creates the characteristic halo-like "coma," which scientists can scrutinize to determine what the comet is made of. Already, 2I/Borisov has been observed more than 2,000 times.

"That's going to be fun, in terms of looking at this object . . . as it comes in from the deep freeze for the very first time," said Michele Bannister, an astronomer at Queens University Belfast. "Let's open it up and see what we have with this particular present from another star."

'Little wanderers roving across the galaxy'

Exoplanet discoveries revealed we live in a crowded cosmos. But they also awakened Earthlings to how lonely we are. Mostplanetary systems discovered in recent decades are wildly unfamiliar, and the most common type of exoplanet — a body larger than Earth, but smaller than Neptune — doesn't exist near our home.

When astronomers had only our own solar system to go by, "it used to seem like planet formation was solved,"said Malena Rice, an astrophysicist at Yale University. "And then all of a sudden there are all these strange systems that don't fit our picture."

Interstellar comets are uniquely useful for confronting this conundrum. They are born of the same swirling disk of gas and dust that produces planets around an infant star. But then they get stranded at the icy edges of solar systems, where they can preserve the early ingredients of planet formation.

Comets in our own solar system have been found to contain some of the basic ingredients for life: water, carbon, even complex organic compounds. Now 2I/Borisov could tell us whether life's essential molecules were among the building blocks of a world beyond our own.

This fall, Bannister's colleague Alan Fitzsimmons produced the first-ever detection of a chemical compound emitted by an interstellar comet. Separating light from 2I/Borisov into its component parts, his team found a signature of cyanogen, a molecule made of a carbon atom and a nitrogen atom bonded together. The gas is common in comets around this sun.

"When I saw that, I shouted in my office . . . something not repeatable in a respectable newspaper," Fitzsimmons recalled.

A few weeks later, astronomer Adam McKay detected oxygen streaming off the comet, an indicator that sunlight is striking water on the surface and breaking up the molecule. If confirmed, this would be the first-ever detection of alien water in our solar system. It is also another sign that 2I/Borisov is much like the comets we know.

"Even in these other systems where their architectures are very different, maybe the underlying physics and chemistry is still pretty similar," said McKay, a research scientist at NASA's Goddard Space Flight Center.

Models of our solar system suggest about 90 percent of the leftover material from planet formation was ejected into interstellar space. The space beyond Neptune still harbors millions of icy bodies, which over millennia can be knocked out of orbit and slung away from the sun.

If any of these scattered fragments happen to be pulled into another system and start to glow in the heat of its star, they will appear as interstellar comets to whoever might be watching.

“There’s a universality to that, which is amazing,” Bannister said. “Our planetary system is woven together with another planetary system by these little wanderers roving across the galaxy.”

The long night

With just an hour to go until daybreak, 2I/Borisov is due to appear above the horizon and make its way across the eastern sky. Durig’s long night is almost over.

Sewanee: The University of the South, the 1,600-student liberal arts college where Durig works, does not have the massive instruments needed to resolve faint night-sky objects. Instead, he must take hundreds of images of the same spot, then use a computer program to layer them so dim lights become clear.

The astronomer checks the focus of his 12-inch Schmidt-Cassegrain telescope and sets it to work, snapping pictures of the place where the interstellar comet is expected to be. He rubs a hand across his eyes, itchy from hours spent beneath the dim red lights he uses to protect his night vision.

It is tiring and often tedious work. Unlike discoverers, follow-up observers do not get to put their names on anything. And unlike researchers working at the world’s largest observatories, it is hard for someone such as Durig to achieve the findings that get published in prestigious journals.

Still, extraordinary discoveries must be confirmed and refined, again and again, by ordinary people. News may be made by breakthroughs, but knowledge is cemented in the follow-ups.

Inside the Cordell-Lorenz Observatory, astronomer Doug Durig waits in darkness for images of the celestial object 2I/Borisov, a comet from another star. (Sarah Kaplan/The Washington Post)

Here in Sewanee’s cramped observatory, cluttered with stacks of observation records and piles of broken equipment he hopes to one day refashion into something usable, “we’re doing essential science,” Durig says. “We’re filling in all the gaps.”

Once his telescope has captured an hour’s worth of snapshots, Durig compiles them into stacks of 100. In the images that emerge, colors are inverted, so stars appear as black smears on a white background. In the lower left is a dark dot encircled in a halo of fuzz.

Durig clicks forward to the next stack, and the dot moves by a centimeter. Another click, and it moves again.

That’s how he knows he is looking at the comet, something swift and surrounded by dust, something

that does not behave like anything else in the sky.

Durig sends his images and a record of the comet's location to the Minor Planet Center — another drop of data in the bucket of scientific knowledge.

Consistent observations like this, conducted by the same people using the same instruments every night, will be even more important once the comet becomes visible in the southern hemisphere, where many of the world's biggest telescopes are positioned. They need to be pointed with extreme precision, so astronomers must have a firm handle on the comet's trajectory and things that might subtly alter it, such as outbursts of gas.

An accurate orbit is also key to astronomers' most ambitious plan for the comet.

"If we can get the best possible trajectory, so we can trace it back with the exact direction it's coming in . . . maybe we can find out what the origin system is," said Farnocchia, the Jet Propulsion Laboratory engineer.

Identifying the comet's parent star would be a tremendous feat, the astronomical equivalent of tracing a message in a bottle back to the person who sent it millions of years ago from billions of miles away. It may not turn out to be possible, most scientists acknowledge.

But maybe that's okay, they say. Because the comet will have already revealed so much else. It will have told us something about the birth of solar systems. It will have connected our home to the workings of the wider galaxy. And now that we have seen it, it is easier to believe that more are out there to be found.

Here on Earth, together in the darkness, Durig and his fellow astronomers will be waiting.