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Hypervelocity stars: Fast-moving exiles of the Milky Way

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Beyond the edge of the Milky Way galaxy, a star flies through space a thousand times faster than a speeding bullet. The voyager is screaming along at 1.5 million miles per hour, or 430 miles per second. At that speed, it is destined to escape the gravitational pull of our galaxy and to travel—exiled for all time—through the blackness of intergalactic space.

How could any star be flung outward at such a speed? Discoverer Warren Brown, an astronomer at the Smithsonian Astrophysical Observatory in Cambridge, Mass., points to the giant black hole at the center of the Milky Way.

"It's paradoxical, but a black hole doesn't always suck in whatever gets close," he explains. "In rare circumstances, a star that's part of a pair can be ripped from its partner and launched through space at an amazing speed."

To make a hypervelocity star, as astronomers call them, a pair of stars orbiting each other must brush close to the giant black hole at the Milky Way's center. One star is captured into orbit around the black hole, while its partner is released and flung into space by the immense gravity of the black hole like a stone from a slingshot.

Astonishing oddball

Although predicted to exist in 1988, the discovery of the first hypervelocity star came as a complete surprise. Brown intended to look for "streams" of stars—groups of stars all moving in the same direction. Star streams form when the Milky Way cannibalizes a smaller galaxy, tearing it apart and absorbing its stars.

While measuring the motions of his tar-

Left: An arrow points to the second of two newly discovered hypervelocity stars in this photograph from the Sloan Digital Sky Survey. Astronomers estimate this star to be moving at 1.43 million miles per hour, a speed that will eventually carry it far beyond the Milky Way Galaxy. It is currently located about 180,000 light-years from Earth.

Opposite: Most hypervelocity stars are destined to drift far beyond their galaxies and into the depths of intergalactic space. This artist's conception shows a hypervelocity star moving into deep space after leaving the Milky Way Galaxy. (Image by Ruth Bazinet)

get stars, Brown spotted an oddball. Its speed was astonishingly fast.

At first, it was hard to believe the surprising result, Brown says. "When I showed the data to [senior Smithsonian astronomer] Margaret Geller, she exclaimed, 'You have a what?'"

After finding the first hypervelocity star, Brown began a systematic hunt for more using the Multiple Mirror Telescope Observatory in southern Arizona. He examined an area of sky 8,000 times larger than the full moon and discovered nine additional hypervelocity stars. Other astronomers joined the hunt, and now about a dozen such stars are known. On average, one star escapes the galactic center of the Milky Way every 100,000 years, so many more hypervelocity stars likely await discovery.

"There's a whole half of the sky we haven't searched yet—the southern sky," Brown adds.

Astronomers estimate that about 1,000 hypervelocity stars are speeding through our galaxy. By comparison, the Milky Way contains about 100 billion stars in total, making the search for hypervelocity stars much more difficult than finding the proverbial "needle in a haystack."

Exchange program

An even greater challenge would be finding stars that have traveled to the Milky Way from neighboring galaxies. For example, the Andromeda spiral galaxy also has a central black hole that could occasionally toss stars across space and into our Milky Way galaxy. However, only long-lived stars can survive the journey.

Closer galaxies offer a better possibility. Earlier this year, astronomers announced the discovery of a hypervelocity star that came from a small, nearby galaxy known as the Large Magellanic Cloud.

"You could say we have an exchange program going," Brown suggests. "Some Milky Way stars travel to other galaxies, while an occasional star from those galaxies finds its way here."

Asked if we should worry about a rogue star blundering through our neighborhood, Brown laughs and shakes his head. "Not at all. There's a lot of empty space between the Milky Way's stars, and very few hypervelocity stars are being thrown outward. The chances of any getting close to us are astronomical."

Although our solar system is safe, any planets orbiting a hypervelocity star would have a rough time. It takes a close pair of stars to create a gravitational slingshot. In such a star system, planets could only form in the outskirts, circling both stars in a wide orbit. As the star system passed by the black hole, those planets would be ripped away and lost to cold, interstellar space.

Back in time

Beyond the amazement factor, hypervelocity stars offer opportunities to learn about our galaxy. The Milky Way's center is obscured by dust and gas, making it difficult for astronomers to study the black hole and surrounding stars. Yet the types of hypervelocity stars that Brown finds tell astronomers about the types of stars orbiting near the central black hole.

By looking for patterns in the locations and ejection times of hypervelocity stars, astronomers also can infer what happened in the galactic center millions of years ago.

As they travel across great distances, hypervelocity stars are influenced by the gravitational pull of the Milky Way's stars, hydrogen gas and unseen "dark matter." By running the motions of these travelers backward in time, astronomers can learn about the galaxy's structure.

"It's another way of studying the shape of the Milky Way and how its constituents are distributed," Brown says.

Each newfound hypervelocity star is as prized as a rare gem. The beauty of these stars lies not in their outward appearance, but in what their sensitive measurements reveal about their dramatic history, and in what they can tell us about our galactic home. For that reason, astronomers will continue to prospect for more hypervelocity stars. ❖