Runaway star – out of the galactic heart of darkness like a bat out of hell

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Hypervelocity star ejected by black hole. Credit: S5 Collaboration

The discovery of the star, known as S5-HVS1, was made by Sergey Koposov from Carnegie Mellon University as part of the Southern Stellar Stream Spectroscopic Survey (S5). Located in the constellation of Grus—the Crane—S5-HVS1 was found to be moving ten times faster

than most stars in the Milky Way.

Astronomers have wondered about high velocity stars since their discovery only two decades ago. S5-HVS1 is unprecedented due to its high speed and close passage to the Earth, "only" 29 thousand light years away. With this information, astronomers could track its journey back right into the centre of the Milky Way, where a 4-million-solar-mass black hole known as Sagittarius A* lurks.

"This is super exciting, as we have long suspected that black holes can eject stars with very high velocities. However, we never had an unambiguous association of such a fast star with the Galactic Centre," said Sergey Koposov, the article's lead author. "We think the black hole ejected the star with a speed of thousands of kilometres per second about five million years ago. This ejection happened at the time when humanity's ancestors were just learning to walk on two feet."

Superfast stars can be ejected by black holes via the Hills Mechanism, proposed by astronomer Jack Hills thirty years ago. Originally, S5-HSV1 lived with a companion in a binary system, but they strayed too close to Sagittarius A*. In the gravitational tussle, the companion star was captured by the black hole, while S5-HVS1 was thrown out at extremely high speed.

"This is the first clear demonstration of the Hills Mechanism in action," said Ting Li from Carnegie Observatories and Princeton University, and leader of the S5 Collaboration. "Seeing this star is really amazing", she added, "as we know it must have formed in the Galactic Centre, a place very different to our local environment. It is a visitor from a strange land."

The discovery of S5-HVS1 was made with the 3.9m Anglo-Australian Telescope (AAT) near Coonabarabran, NSW, Australia, coupled with

superb observations from the European Space Agency's (ESA) Gaia satellite, that allowed the astronomers to reveal the full speed of the star and its journey from the centre of the Milky Way.

"The observations would not be possible without the unique capabilities of the 2dF instrument on the AAT," said Daniel Zucker, an astronomer at Macquarie University in Sydney, Australia, and S5 Executive Committee member. "It's been conducting cutting-edge research for over two decades and still is the best facility in the world for our project."

These results were published in *Monthly Notices of the Royal Astronomical Society*. The S5 collaboration unites astronomers from the United States, United Kingdom, Australia and Chile.

"I am so excited this fast-moving star was discovered by S5," says S5 Executive Committee member Kyler Kuehn, at Lowell Observatory and also affiliated with Australian Astronomical Optics. "While the main science goal of S5 is to probe the stellar streams—disrupting dwarf galaxies and globular clusters—we dedicated spare resources of the instrument to searching for interesting targets in the Milky Way, and voila, we found something amazing for 'free.' With our future observations, hopefully we will find even more!"

More information: Sergey E Koposov et al. Discovery of a nearby 1700 km/s star ejected from the Milky Way by Sgr A*, *Monthly Notices of the Royal Astronomical Society* (2019). DOI: 10.1093/mnras/stz3081

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