UNIVERSITÉ DE GENÈVE

# PRESS RELEASE

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# Gaia spots a large dormant black hole in our Galaxy

A high-mass stellar black hole has been discovered in preliminary data from the Gaia satellite by an international team led by UNIGE astronomers.

**Wading through the inestimable wealth of data from ESA's Gaia mission, a team of scientists, including astronomers from the University of Geneva (UNIGE), uncovered a "sleeping" giant. A large black hole, with a mass of nearly 33 times that of the Sun, was hiding less than 2000 light-years from Earth, in the Aquila constellation. It is the first black hole of stellar origin this big to be spotted so close to Earth. The discovery, published in *Astronomy and Astrophysics*, challenges our understanding of how massive stars develop and evolve.**

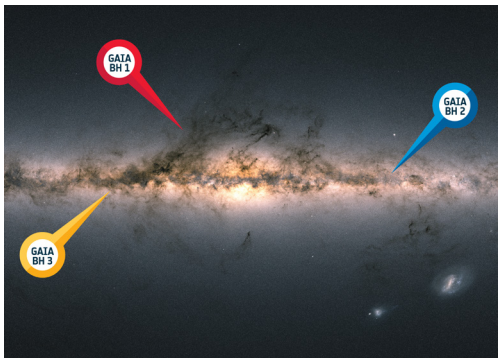
Matter in a black hole is so densely packed that nothing can escape its immense gravitational pull, not even light (hence the name black hole). The great majority of stellar-mass black holes that we know of are gobbling matter from a nearby star companion. The captured material falls at high speed onto the compact object, becoming extremely hot and releasing X-rays. These systems belong to a family of celestial objects named X-ray binaries.

When the black hole companion is not close enough to shed matter on the compact object, no light nor energy is emitted, and the black hole is therefore extremely difficult to spot. Such a "quiet" black hole is called "dormant". Its presence, however, induces a motion on its orbiting companion that could be detected on the sky by a very sensitive astrometric instrument, like the Gaia spacecraft.

## A breakthrough thanks to Gaia's exquisite accuracy

The Gaia mission has been set up to measure the distance to more than two billion stars by screening their motion on the sky with very high accuracy. To prepare the release of the next Gaia catalogue, Gaia Data Release 4 (DR4), scientists within the Gaia Collaboration carry out extensive calculations and tests to check if something is out of the ordinary. Dedicated teams are in place to investigate the "odd" cases and create derived data products.

One such team was founded in 2020 by Laurent Eyer, senior lecturer in the Department of astronomy at UNIGE Faculty of Science, and Tsevi Mazeh, researcher at the University of Tel Aviv, both co-authors of the study. Led by Berry Holl, senior research associate in the Department of astronomy at UNIGE and also a co-author, it was tasked with the careful validation of the results obtained for non-single stars with extreme motions, to check the integrity of potential black holes and avoid the publication of obvious "false detections".




The Gaia BH3 black hole joins the two black holes (Gaia BH1 and Gaia BH2) already detected by the Gaia mission.



**Pictures**

The attention of the team fell on an old giant star, 1926 light-years away from Earth, in the Aquila constellation. By analysing the wobble in the star's path in detail, they found a big surprise: the star was locked in an orbital motion with a dormant black hole of exceptional mass, about 33 times that of the Sun. This is the third dormant black hole found with Gaia and was aptly named Gaia BH3. "The quality of the latest data produced by the consortium has improved so much that we expect to publish quite a number of genuine black holes in the DR4 catalogue!," says Berry Holl excitedly.

**A record-holder in the Galaxy**

The discovery of Gaia BH3 is very exciting because of its mass. Until now, black holes of this mass had only been detected in distant galaxies, relying on gravitational wave observations by the LIGO/Virgo consortium. The typical mass of the known black holes of stellar origin in our galaxy is around 10 times the mass of our Sun. The record was so far held by a black hole in an X-ray binary in the Cygnus constellation (Cyg X-1), whose mass is estimated to be around 20 times that of the Sun.

Astronomers face the pressing question of explaining the origin of black holes as large as Gaia BH3. Current understanding of massive star evolution cannot explain how these types of black holes came to be. Most theories predict that, as they age, massive stars shed a sizable part of their material through powerful winds; ultimately, they explode as a supernova, leaving behind either a neutron star, or a black hole if the core was massive enough at the time of explosion.

"However, building black holes of 30 or more times the mass of our Sun is a real challenge with current evolutionary models; the discovery of Gaia BH3 within our Galaxy is therefore a unique first-time opportunity to study the environment in which these unexpectedly massive stellar black holes reside and to understand their origin," says Nami Mowlavi, senior researcher in the Department of astronomy at UNIGE Faculty of Science, a member of the team and co-author of the paper.

**An intriguing companion**

With an orbit about 16 times the Sun-Earth distance, the companion star of Gaia BH3 is rather uncommon: an old giant star from the Galactic stellar halo, moving in the opposite direction to the stars of the Galactic disk. Its trajectory indicates that this star is probably part of the remains of a small galaxy accreted by the Milky Way more than 8 billion years ago. It may even have originated from a now-disrupted old globular cluster. The star has very few elements heavier than hydrogen and helium, indicating that the progenitor of Gaia BH3 could be a massive star also very poor in heavy elements.

This is remarkable. It supports, for the first time, the idea that the high-mass black holes observed by gravitational wave experiments were produced by the collapse of primaeval massive stars that are poor in heavy elements. These stars might evolve in a different way from the stars we see in the Galactic disk and in the vicinity of the Sun. They might retain most of their mass until the very end, and, once the nuclear fuel in their core finally runs out, collapse to leave high-mass black holes in the firmament.

### A tasty appetiser

The discovery of Gaia BH3 is only the beginning, and much remains to be investigated about its baffling nature. The Gaia Collaboration found this treasure while validating the preliminary Gaia data. Yet, the finding is so exceptional that the Gaia team decided to announce it ahead of the next official data release planned for not earlier than the end of 2025. “I am extremely happy that we are able to share this amazing discovery worldwide!,” says Laurent Eyer. Now that the scientists’ curiosity has been piqued, this black hole and its companion will undoubtedly be the subject of many in-depth studies to come.

## contact

**Berry Holl**
Senior Research Associate
Department of astronomy
Faculty of Science
UNIGE
+41 22 379 22 67
Berry.Holl@unige.ch

**Laurent Eyer**
Senior Lecturer
Department of astronomy
Faculty of Science
UNIGE
+41 22 379 23 61
Laurent.Eyer@unige.ch

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**UNIVERSITÉ DE GENÈVE**
**Communication Department**
24 rue du Général-Dufour
CH-1211 Geneva 4

Tel. +41 22 379 77 17

media@unige.ch
www.unige.ch