Towering balloon-like structures discovered near center of the Milky Way

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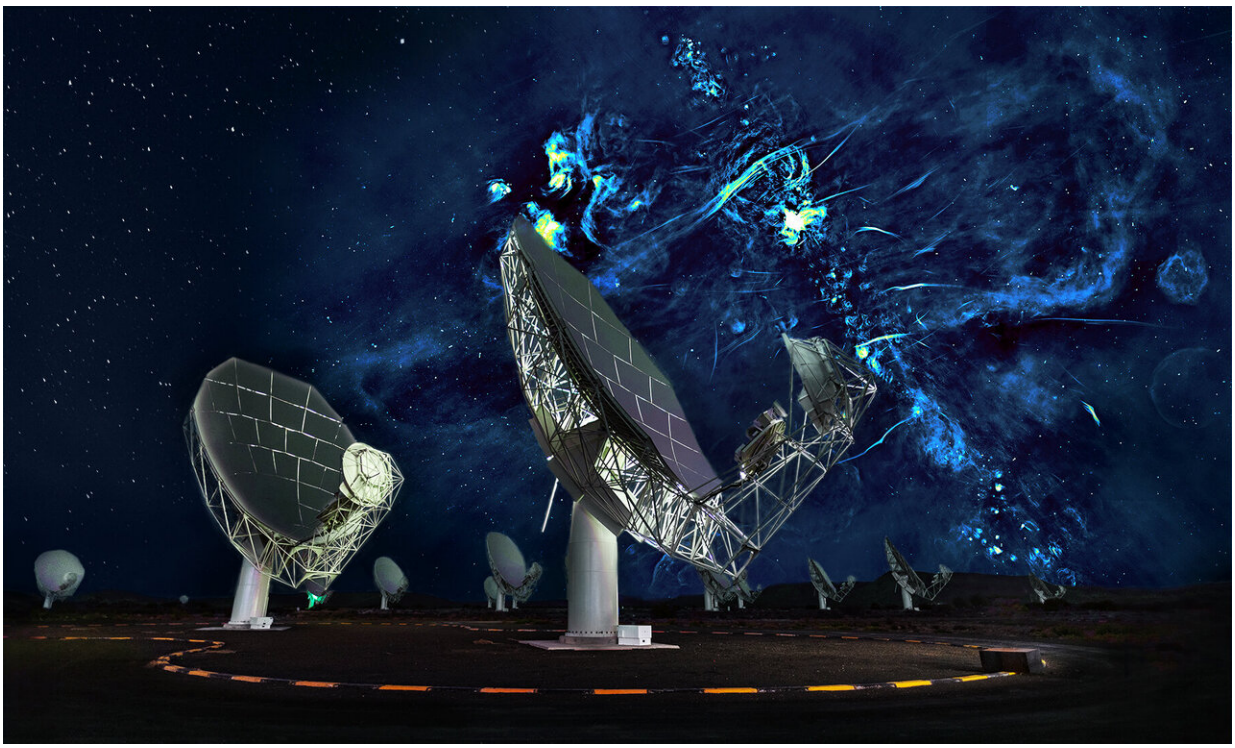


A radio image of the centerof the Milky Way with a portion of theMeerKAT telescope array in the foreground. The plane of the galaxy ismarked by a series ofbright features, exploded stars and regionswhere new stars are being born, and runs diagonally across the imagefrom lower right to top center.The black hole at the centerof theMilky Way is hidden in the brightest of these extended regions.The radio bubbles extend from betweenthetwonearest antennasto the upperright corner.Many magnetized filamentscan be seen runningparallel to the bubbles.In this composite view, the sky to the left of the second nearest antenna is the night sky visible to the unaided eye, and the radio image to the right has been enlarged to highlight its fine features. Credit: SARAO/Oxford/NRAO

An international team of astronomers, including Northwestern University's Farhad Yusef-Zadeh, has discovered one of the largest structures ever observed in the Milky Way. A newly spotted pair of radio-emitting bubbles reach hundreds of light-years tall, dwarfing all other structures in the central region of the galaxy.

The team believes the enormous, hourglass-shaped structure likely is the result of a phenomenally energetic burst that erupted near the Milky Way's supermassive black hole several million years ago.

"The center of our galaxy is relatively calm when compared to other galaxies with very active central black holes," said Ian Heywood of the University of Oxford, first author of study. "Even so, the Milky Way's central black hole can—from time to time—become uncharacteristically active, flaring up as it periodically devours massive clumps of dust and gas. It's possible that one such feeding frenzy triggered powerful outbursts that inflated this previously unseen feature."

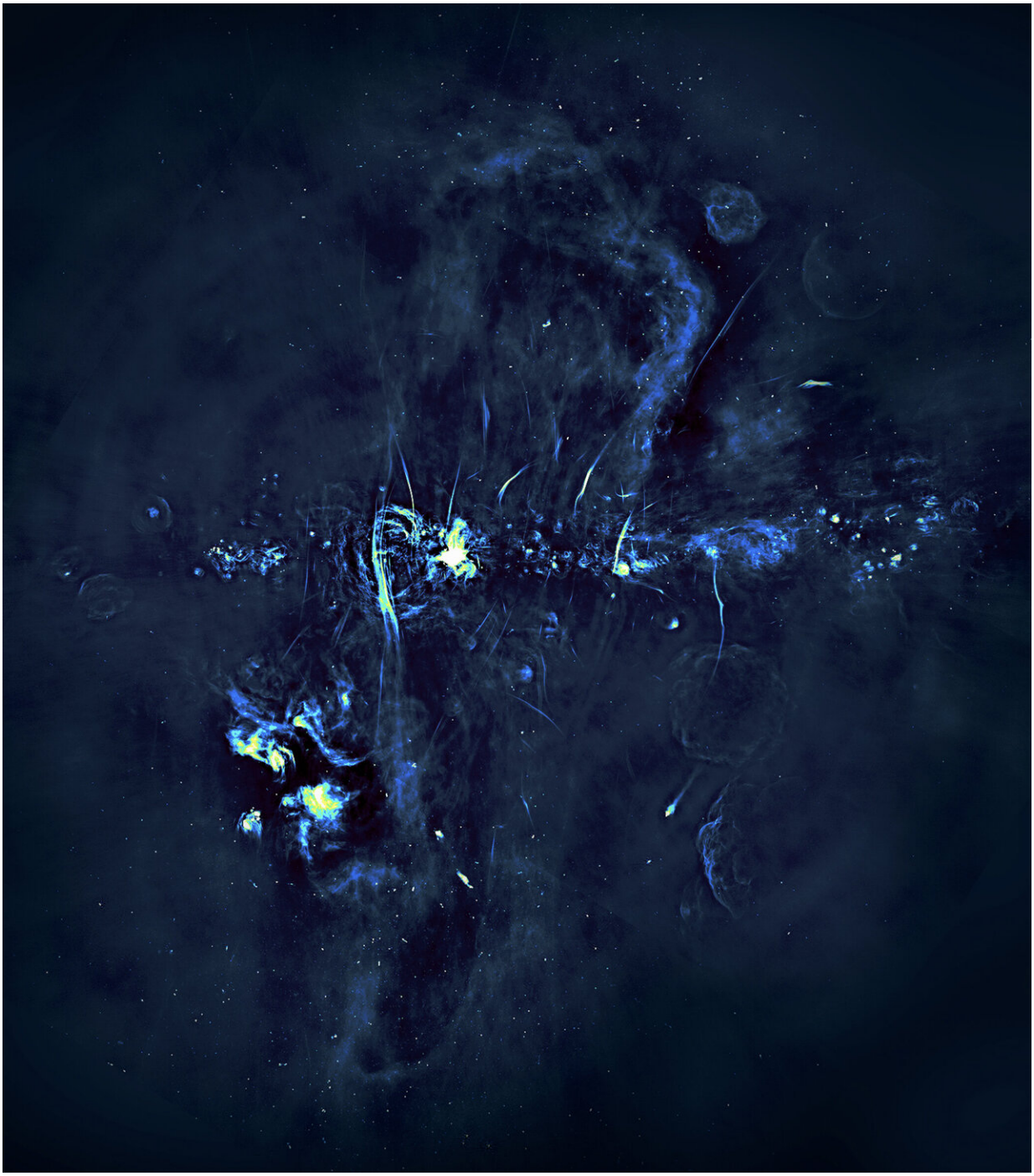
The paper will publish on Sept. 11 in the journal *Nature*. The study's co-authors represent 15 institutions, including Northwestern, Oxford, the South African Radio Astronomy Observatory in Cape Town and the National Radio Astronomy Observatory in Charlottesville, Virginia.

For this work, the team used the South African Radio Astronomy Observatory (SARAO) MeerKAT telescope, the largest science project in Africa. This is the first paper detailing research completed with MeerKAT's full 64-dish array since its launch in July 2018.

Mysteries of the Milky Way

More turbulent and unusually active compared to rest of the Milky Way,

the environment surrounding our galaxy's central black hole holds many mysteries. Northwestern's Yusef Zadeh, a senior author of the paper, has dedicated his career to studying the physical processes that occur in the Milky Way's mystifying center.



A radio image of the central portionsof the Milky Way galaxy.The plane of the galaxy is marked by a series of bright features, exploded stars and regions where new stars are being born, and runs horizontallythrough the image. The black hole at the centerof the Milky Way is hidden in the brightest of these extended regions.The radio bubblesdiscovered by MeerKATextend vertically above and below the plane of the galaxy.Manymagnetized filamentscan be seen running parallel to the bubbles. Credit: SARAO/Oxford

In the early 1980s, Yusef-Zadeh discovered large-scale, highly organized magnetic filaments in the center of the Milky Way, 25,000 light-years from Earth. While their origin has remained an unsolved mystery ever since, the filaments are radio structures stretching tens of light-years long and one light-year wide.

"The radio bubbles discovered with MeerKAT now shed light on the origin of the filaments," Yusef-Zadeh said. "Almost all of the more than 100 filaments are confined by the radio bubbles."

Yusef-Zadeh is a professor of physics and astronomy at Northwestern's Weinberg College of Arts and Sciences and a member of CIERA (Center for Interdisciplinary Exploration and Research in Astrophysics), an endowed research center at Northwestern focused on advancing astrophysics studies with an emphasis on interdisciplinary connections.

The researchers believe that the close association of the filaments with the bubbles implies that the energetic event that created the radio bubbles also is responsible for accelerating the electrons required to produce the radio emission from the magnetized filaments.

Tracing energetic regions

Using MeerKAT, the research team mapped out broad regions in the center of the galaxy, conducting observations at wavelengths near 23 centimeters. Radio emission of this kind is generated in a process known as synchrotron radiation, in which electrons moving at close to lightspeed interact with magnetic fields. This produces a characteristic radio signal that can be used to trace energetic regions in space. The radio light seen by MeerKAT easily penetrates the dense clouds of dust that block visible light from the center of the galaxy.

By examining the nearly identical extent and morphology of the twin bubbles, the researchers think they have found convincing evidence that these features were formed from a violent eruption that over a short period of time punched through the interstellar medium in opposite directions.

"These enormous bubbles have until now been hidden by the glare of extremely bright radio emission from the center of the galaxy," said Fernando Camilo of SARAO in Cape Town and co-author on the paper. "Teasing out the bubbles from the background noise was a technical tour de force, only made possible by MeerKAT's unique characteristics and ideal location. With this unexpected discovery we're witnessing in the Milky Way a novel manifestation of galaxy-scale outflows of matter and energy, ultimately governed by the central black hole."

More information: Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, *Nature* (2019). DOI: 10.1038/s41586-019-1532-5 , nature.com/articles/s41586-019-1532-5

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