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PRESS RELEASE

Sixth BBVA Foundation Astrophysics and Cosmology lecture series

Astrophysicist Michael Kramer explains the project designed to "see" the supermassive black hole at our galaxy's center

- Michael Kramer will visit Madrid on Wednesday, March 21 to give a talk titled "Exploring Einstein's Universe: About Black Holes, Neutron Stars and Gravitational Waves" as part of the the BBVA Foundation lecture series Science of the Cosmos, Science in the Cosmos

- The Director of the Max Planck Institute for Radio Astronomy in Bonn (Germany) is a team member on the Event Horizon Telescope (EHT) project, which linked eight telescopes for a week-long observation of Sagittarius A*, the black hole at the heart of the Milky Way

- In his lecture, Kramer will discuss whether the physical laws that operate on Earth are the same everywhere, even in the vicinity of black holes. "In other words, is Einstein's theory of gravity our final word in the understanding of gravity, or was he wrong?" is the big question the scientist will try to unravel

- From its beginnings in 2011, the Science of the Cosmos, Science in the Cosmos lecture series in the BBVA Foundation has welcomed world authorities in the most active areas of astrophysics and cosmology

Madrid, March 20, 2018.- The year that physics lost Stephen Hawking, one of its leading experts in black holes, could also be the year that humanity finally gets to "see" one. Or, to be more precise, its event horizon, the point of no return for the matter devoured by these cosmic sinkholes that retain even light. Last year, eight radio telescopes from all round the planet, including the 30-meter Pico Veleta telescope in Sierra Nevada (Granada), were trained for a week on the black hole at the core of the Milky Way, known as Sagittarius A*, with results due out some time this year. This is one of the projects currently occupying Michael Kramer, Director of the Max Planck Institute for Radio Astronomy in Bonn (Germany), who will visit the BBVA Foundation's Madrid headquarters on Wednesday, March 21 as the latest speaker in its Science of the Cosmos, Science in the Cosmos lecture series.

The Event Horizon Telescope (EHT) project, Kramer explains, “is trying to take a ‘photo’ of the supermassive black hole in the center of our galaxy.” It will not solve the mystery of what goes on *inside* the black hole, but will at least verify one of the predictions enshrined in current theory: “General Relativity describes gravity as the geometry or curvature of spacetime. In the center of a black hole, spacetime becomes too curved, and our mathematics and physics are incapable of describing such a state,” Kramer explains. “But what we have postulated is that every black hole must have an event horizon, which blocks our view from the outside to the inside and is also the distance from the center where light cannot escape anymore.”

Kramer will discuss these questions in his talk, titled “Exploring Einstein’s Universe: About Black Holes, Neutron Stars and Gravitational Waves.” For the German astrophysicist, “The Universe is full of fascinating objects with conditions that we will never be able to reproduce in terrestrial laboratories.” But through astronomical observations, we can test whether the fundamental laws of nature that we determine here on Earth are the same everywhere – even around black holes. “In other words, is Einstein's theory of gravity our final word with regards to the understanding of gravity,” he asks himself, “or was Einstein maybe wrong?”

Kramer has a distinguished track record when it comes to testing the Theory of General Relativity. He and his team have subjected the theory to its toughest test yet, to see if its predictions can properly describe an object – the double pulsar – that is barely within the grasp of our human imagination. Einstein passed the test, but Kramer would have preferred the opposite outcome. A failure in the predictions of General Relativity “would have been excellent news,” he affirms, “because finding deviations is a hint that there is more to be learned, and that would be very exciting.”

The scientist is frank about his own fascination for pulsars, a kind of cosmic object discovered some fifty years ago, whose first observers speculated that it could be of extraterrestrial origin – only half in jest, they gave it the initials LGM, standing for “little green men.”

“I started work on pulsars for no other reason than that my thesis supervisor was looking for a student in that area,” Kramer recalls now. “But the more I learned the more I was fascinated, and I never left the field. Pulsars are the size of Madrid, but weigh 40% more than the Sun. They are cosmic lighthouses (I always liked lighthouses!) and they send us radiation pulses with the regularity of an atomic clock. They are of great use in physics, because by observing them, we can study many different physical phenomena.” Pulsars are essentially dead stars that at one point exploded as supernovas. In this kind of explosion, the star itself actually implodes – collapses towards its own center – resulting in a dense stellar corpse whose immense gravitational force can end up forming a black hole. Pulsars are, in this respect, the last stage before a black hole: their gravity is extremely strong but not strong enough to swallow light and appear as if they were piercing spacetime in the way that black holes do. However they do have their peculiarities. One is that they spin extremely fast, between tens and thousands of times a second, while emitting a stream of radiation; each time this stream sweeps past the Earth, ground-based telescopes pick up an energy pulse, like the beam of a lighthouse.

So precise is their rotation that millisecond pulsars can measure time more accurately than human-built atomic clocks – that is why when first discovered, in 1967, it was thought that they could be the product of some extraterrestrial civilization. It is this quality that makes them suitable for ultra-precise experiments, like those designed to test the Theory of General Relativity.

Some 1,800 pulsars have been recorded to date, and we know that many of them are circled by a companion star. In 2003 Kramer and other astrophysicists discovered a very special example just 1,500 light years from Earth, because it was not one pulsar, but two: a double pulsar. The two objects orbited each other every 2.4 hours, with the first rotating on its axis every 22.7 milliseconds, and the second with a spin period of 2.77 seconds. This binary system was hard to spot because the bodies would eclipse each other – with only one signal visible – but when its existence was confirmed it marked a huge milestone in astrophysics. At once scientists seized on double pulsars as a way to subject General Relativity to its hardest test yet in the presence of a strong gravitational field.

“We got these tests running just three years after the double pulsar’s discovery,” Kramer relates. “And our results confirmed the validity of General Relativity at the 0.05% level, which is by far the best precision yet achieved for the strong-field regime.”

The two pulsars have been shown to be moving seven millimeters closer every day, due to the energy they lose emitting gravitational waves. Although there is no way to detect these waves directly, we can get an idea of their characteristics by undertaking even more precise pulsar measurements. Kramer and his colleagues are trying to do just that: “We can test many different aspects, among them the characteristics of gravitational waves, the propagation of light in gravitational fields, the fact that clocks go slower near massive bodies, the curvature of spacetime, etc. For each of these effects, general relativity makes a prediction and we can compare those with our data to high precision.” For physicists, it is important to identify phenomena that the theory fails to predict, because they determine in which directions new answers must be sought. “Physicists believed in Newton’s gravity for hundreds of years. Deviations were then observed and eventually Einstein proposed General Relativity. Understanding gravity as described by General Relativity was a revolution that allowed us to find and understand new things, among them black holes.”

For Kramer, the main message to take away from his talk is that "the Universe is a fascinating place, and we have understood a lot already. But there are still challenges ahead. Happily, we live in fortunate times, with great experiments, methods and tools available to help with the task."

Bio notes

Michael Kramer is Director of the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn (Germany) and a member of the Scientific Council of the European Research Council (ERC). He studied physics in Cologne and Bonn, earning a PhD in 1995. After a few years on the MPIfR staff, he moved to the University of California, Berkeley (United States), and from there to the University of Manchester (United Kingdom), where he became Professor of Astrophysics in 2006. In 2009, he was appointed Director back at the MPIfR. His main research interest is the study of fundamental physics using radio astronomy, in particular radio pulsars. A member of the team which received the Descartes Prize of the European Union in 2005, he also won the Marcel-Grossmann Award in 2009 and the Academy Award of the Berlin-Brandenburg Academy of Science in 2010. In 2013 he was awarded the Herschel Medal of the Royal Astronomical Society in the UK.

About Science of the Cosmos, Science in the Cosmos

Since it began in March 2011, the lecture series Science of the Cosmos, Science in the Cosmos has explored some of the main open questions in modern astrophysics. Experts from the top ranks of the world scientific community have shared their vision of the origins of the Universe, the search for life on other planets, how chemical elements are forged in the heart of stars, or the nature of dark matter and energy. The whole of the current series will be available for viewing, along with videos of past editions, on www.fbbva.es and our YouTube channel https://www.youtube.com/user/FundacionBBVA

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