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On behalf of the BlackHoleCam collaboration

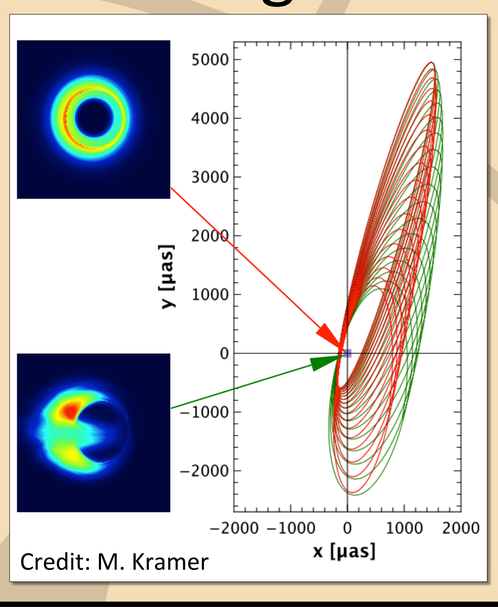
Abstract:

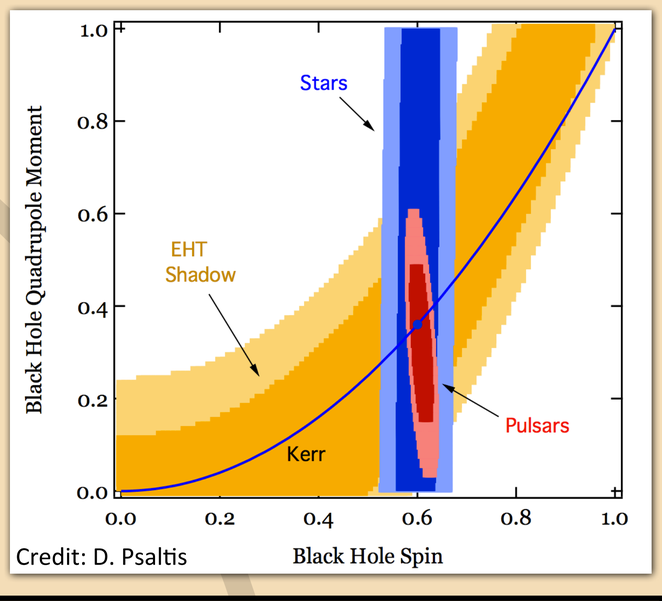
The Department of Astrophysics at Radboud University is, together with the Pulsar Group at MPIfR in Bonn and the Institute of Theoretical Physics at the Goethe University in Frankfurt, one of the three central institutes behind the ERC Synergy program called BlackHoleCam (BHC), an initiative to detect and image the shadow of a black hole using mm-wavelength Very Long Baseline Interferometry (mm-VLBI). The prime target for this search is the supermassive black hole at the Galactic center, called Sagittarius A*. Comparing the interferometric measurements to advanced models of accretion flows and results from pulsar observations at the Galactic center will allow us to improve our understanding of accretion physics, and enable us to test the theory of General Relativity against alternative theories of gravity in regions of extreme spacetime curvature.

Instrumentation

BHC is a major investor in receiver upgrades for stations of the Event Horizon Telescope. The ultimate goal is to realize 64 Gb/s recording bandwidth at all EHT stations, and 128 Gb/s at most. Work is also underway to build a comprehensive and fully automated pipeline for the processing of mm-VLBI data.

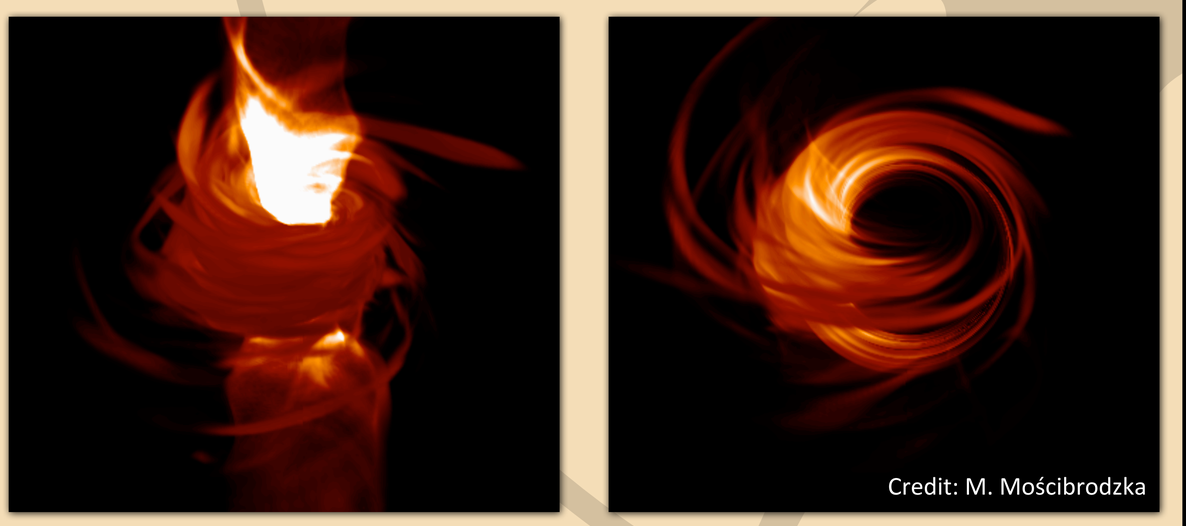
Searching for Pulsars





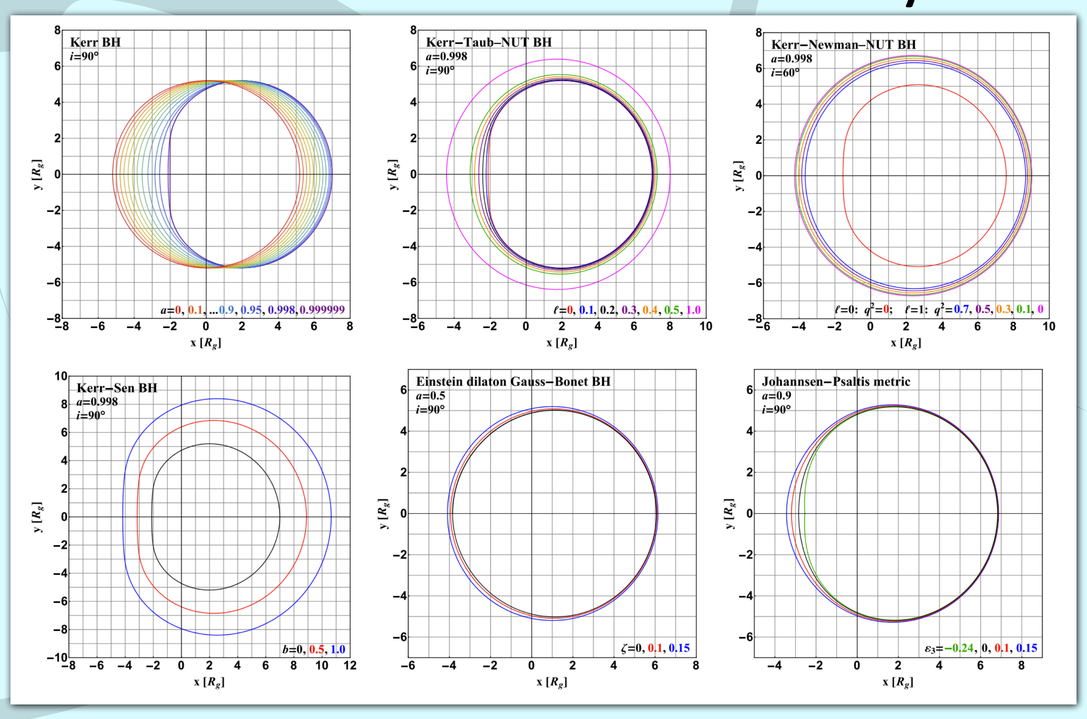
Pulsars orbiting Sagittarius A* with periods shorter than a few years offer excellent opportunities for measuring General Relativistic effects through evolution of their timing and their orbital dynamics. Such measurements allow us for instance to constrain the black hole spin orientation and quadrupole moment of Sgr A*. BHC combines pulsar searches at the Galactic center using the recorded waveforms from EHT observations with development of a framework for theoretical interpretation of these measurements. Illustrated above are the pulsar orbital evolution for different black hole spin orientations (left) and the constraints on spin and quadrupole moment offered by such an orbit (right).

Theory and Modeling



A solid theoretical background is needed to interpret the observations from EHT VLBI campaigns. BHC theorists are producing models and General-Relativistic MagnetoHydroDynamic (GRMHD) simulations to offer a framework within which the mm-VLBI observations can be understood. In the images above, the accretion flow is rendered at two different observing wavelengths - 7 mm ('traditional' VLBI wavelength) and 1.3 mm (EHT wavelength) to illustrate the Sgr A* transition from the optically thick to optically thin regime. In the right image, we see the shadow of the black hole as a dark central feature. Notice that the accretion flow image on the right is dominated by the effects of relativistic boosting and strong gravitational lensing.

Alternatives to General Relativity



The images on the left illustrate the appearance of accretion flows computed using standard GR - however, other theories of gravity are also under investigation in BHC. Alternative theories of gravity give predictions on shadow sizes and shapes that will be measurable in the regime made accessible by the EHT observations. The images above depict projected shadow geometries for different theories of gravity.

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