Team simulates first merger of 3 black holes on a supercomputer

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The same team of astrophysicists that cracked the computer code simulating two black holes crashing and merging together has now, for the first time, caused a three-black-hole collision.

Manuela Campanelli, Carlos Lousto and Yosef Zlochower—scientists in Rochester Institute of Technology's Center for Computational Relativity and Gravitation—simulated triplet black holes to test their breakthrough method that, in 2005, merged two of these large mass objects on a supercomputer following Einstein's theory of general relativity.

The new simulation of multiple black holes evolving, orbiting and eventually colliding confirmed a robust computer code free of limitations. The May issue of *Physical Review D* will publish the team's latest findings in the article "Close Encounters of Three Black Holes," revealing the distinct gravitational signature three black holes might produce. The story will run under the "Rapid Communications" section.

"We discovered rich dynamics leading to very elliptical orbits, complicated orbital dynamics, simultaneous triple mergers and complex gravitational waveforms that might be observed by gravitational wave detectors such as LIGO and LISA," says Lousto, professor in RIT's School of Mathematical Sciences. "These simulations are timely because a triple quasar was recently discovered by a team led by Caltech astronomer George Djorgovski. This presumably represents the first observed supermassive black hole triplet."

The RIT team's triple merger simulates the simplest case of equal masses and nonspinning black holes, a prerequisite for exploring configurations of unequal masses and different spins and

rotations. The center's supercomputer cluster "newHorizons" processed the simulations and performed evolutions of up to 22 black holes to verify the results.

"Twenty-two is not going to happen in reality, but three or four can happen," says Yosef Zlochower, an assistant professor in the School of Mathematical Sciences. "We realized that the code itself really didn't care how many black holes there were. As long as we could specify where they were located—and had enough computer power—we could track them."

Specially designed high-performance computers like newHorizons are essential tools for scientists like Campanelli's team who specialize in computational astrophysics and numerical relativity, a research field dedicated to proving Einstein's theory of general relativity. Only supercomputers can simulate the force of impact necessary to generate gravity waves—warps in space-time that might provide clues to the origin of the universe.

Scientists expect to measure actual gravity waves for the first time within the next decade using the ground-based detector known as the Laser Interferometer Gravitational Wave Observatory (LIGO) and the future NASA/European Space Agency space mission Laser Interferometer Space Antenna (LISA).

"In order to confirm the detection of gravitational waves, scientists need the modeling of gravitational waves coming from space," says Campanelli, director of RIT's Center for Computational Relativity and Gravitation. "They need to know what to look for in the data they acquire otherwise it will look like just noise. If you know what to look for you can confirm the existence of gravitational waves. That's why they need all these theoretical predictions."

Adds Lousto: "Gravity waves can also confirm the existence of black holes directly because they have a special signature. That's what we're simulating. We are predicting a very specific signature of black hole encounters. And so, if we check that, there's a very strong evidence of existence of black holes."

Source: Rochester Institute of Technology

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