First gravitational waves form after 10 million years

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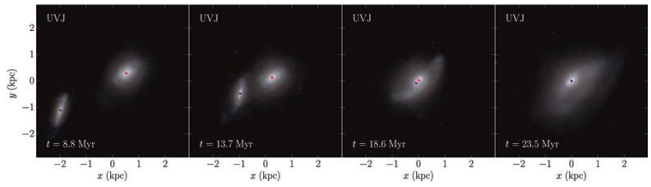

This simulation shows how two galaxies merge over a period of 15 millionen years. The red and the blue dots illustrate the two black holes. Credit: Astrophysical Journal

If two galaxies collide, the merging of their central black holes triggers gravitational waves, which ripple throughout space. An international research team involving the University of Zurich has now calculated that this occurs around 10 million years after the two galaxies merge – much faster than previously assumed.

In his General Theory of Relativity, Albert Einstein predicted gravitational waves over a century ago; this year, they were detected directly for the first time: The American Gravitational Wave Observatory LIGO recorded such curvatures in space from Earth, which were caused by the merging of two massive black holes. And the research on gravitational waves – and thus the origin of the universe – continues: From 2034 three satellites are to be launched into space in a project headed by the European Space Agency (ESA) to measure gravitational waves at even lower frequency ranges from space using the Evolved Laser Interferometer Space Antenna (eLISA).

Until now, however, it was not possible to conclusively predict the point at which gravitational waves are triggered and spread throughout space when galaxies merge. An international team of astrophysicists from the University of Zurich, the Institute of Space Technology Islamabad, the University of Heidelberg and the Chinese Academy of Sciences has now calculated this for the first time using an extensive simulation.

Much faster than previously assumed

Every galaxy has a supermassive black hole at its core, which can exhibit millions or even billions of solar masses. In a realistic simulation of the universe, the merging of two roughly 3-billion-year-old galaxies lying relatively close to one another was simulated. With the aid of supercomputers, the researchers calculated the time the two central black holes with around 100 million solar masses needed to emit strong gravitational waves after the galaxies collided.

"The result is surprising," explains Lucio Mayer from the Institute for Computational Science of the University of Zurich: "The merging of the two black holes already triggered the first gravitational waves after 10 million years – around 100 times faster than previously assumed."

Year-long supercomputer calculation

The computer simulation, which took more than a year, was conducted in China, Zurich and Heidelberg. The project required an innovative computational approach with various numerical codes on different supercomputers. In the process, each supercomputer was responsible for calculating a certain phase of the orbital convergence of the two massive black holes and their parent galaxies.

Compared to previous models, the relation between the orbits of the central black holes and the realistic structure of the parent galaxies was factored into the present simulation. "Our calculations therefore allow a robust forecast for the merging rate of supermassive black holes in the early stage of the universe," explains Mayer. "They may help assess

the gravitational waves eLISA is bound to find in the near future more effectively."

More information: Swift Coalescence of Supermassive Black Holes in Cosmological Mergers of Massive Galaxies. *Astrophysical Journal*, 2. September 2016. arxiv.org/abs/1604.00015 , iopscience.iop.org/article/10. … 7/0004-637X/828/2/73

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