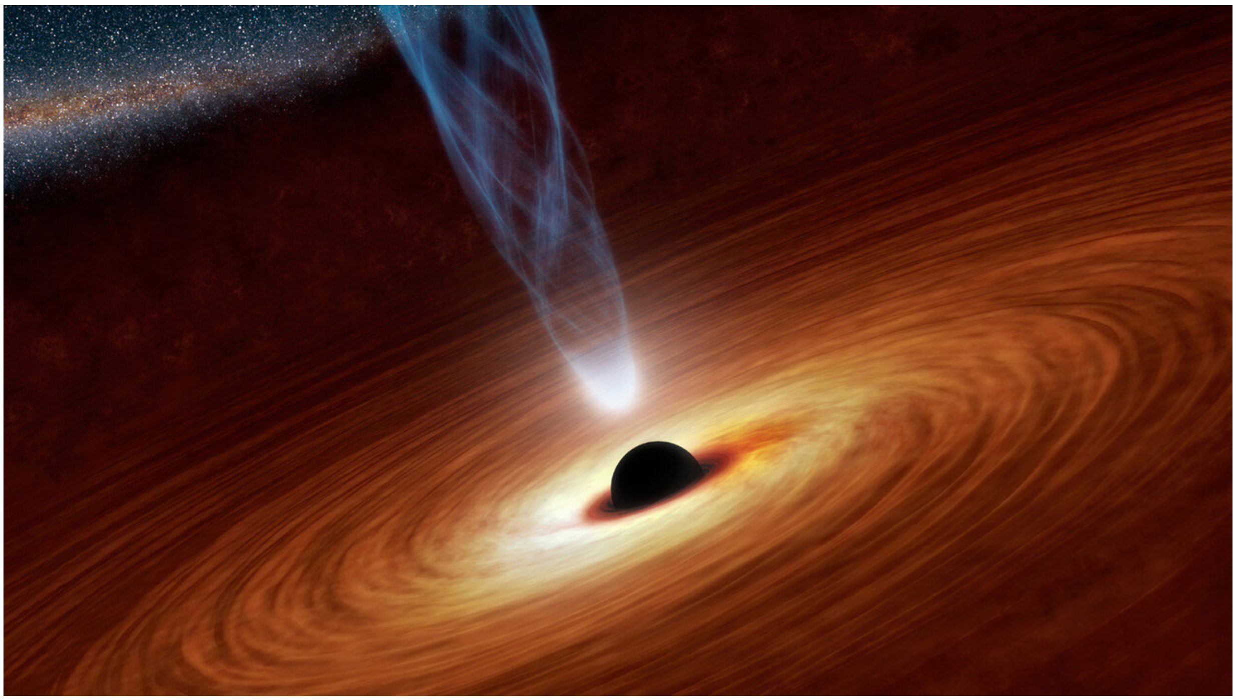
Detecting colliding supermassive black holes: The search continues

September 10 2020



Artist's illustration of a supermassive black hole. Credit: NASA/JPL/CALTECH

In a new study, researchers have developed an innovative method to detect colliding supermassive black holes. The study has just been published in the *Astrophysical Journal* and was led by postdoctoral researcher Xingjiang Zhu from the ARC Center of Excellence for Gravitational Wave Discovery (OzGrav) at Monash University.

At the center of every galaxy in the universe, there is a supermassive black hole millions to billions times the mass of the sun. Big galaxies are assembled from smaller galaxies merging together, so collisions of supermassive black holes are expected to be common in the cosmos. But merging supermassive black holes remain elusive: No conclusive evidence of their existence has been found so far.

One way to look for these mergers is through their emission of gravitational waves—ripples in the fabric of space and time. A distant merging pair of supermassive black holes emit gravitational waves as they spiral in around each other. Since the black holes are so large, each wave takes many years to pass by Earth. Astronomers have used a technique known as pulsar timing array to observe gravitational waves from supermassive binary black holes—so far to no avail.

In parallel, astronomers have been looking for the collision of supermassive black holes with light. A number of candidate sources have been identified by looking for regular fluctuations in the brightness of distant galaxies called quasars. Quasars are extremely bright, believed to be powered by the accumulation of gas clouds onto supermassive black holes.

If the center of a quasar contains two black holes orbiting around each other (instead of a single black hole), the orbital motion might change the gas cloud accumulation and lead to periodic variation in its brightness. Hundreds of candidates have been identified through such searches, but astronomers are yet to find the smoking-gun signal.

"If we can find a pair of merging supermassive black holes, it will not only tell us how galaxies evolved, but also reveal the expected gravitational-wave signal strength for pulsar watchers," says Zhu.

The OzGrav study seeks to settle the debate, determining if any of the identified quasars are likely to be powered by colliding black holes. The verdict? Probably not.

"We've developed a new method allowing us to search for a periodic signal and measure quasar noise properties at the same time," says Zhu. "Therefore, it should produce a reliable estimate of the detected signal's statistical significance."

Applying this method to one of the most prominent candidate sources, called PG1302-102, the researchers found strong evidence for periodic variability; however, they argued that the signal is unlikely to be caused by a pair of black holes en route to collision. Instead, they found that the commonly assumed model, describing the fluctuations in the light from hot gas, is flawed.

"Our results are showing that quasars are complicated," says collaborator and OzGrav Chief Investigator Eric Thrane. "We are confident that this new method will help us search for supermassive black hole collisions by better understanding quasars as well as distinguishing possible signals."

More information: Xing-Jiang Zhu et al. Toward the Unambiguous Identification of Supermassive Binary Black Holes through Bayesian Inference, *The Astrophysical Journal* (2020). DOI: 10.3847/1538-4357/abac5a , arxiv.org/abs/2004.10944

Provided by ARC Centre of Excellence for Gravitational Wave Discovery