Astronomers spot signs of supermassive black hole mergers

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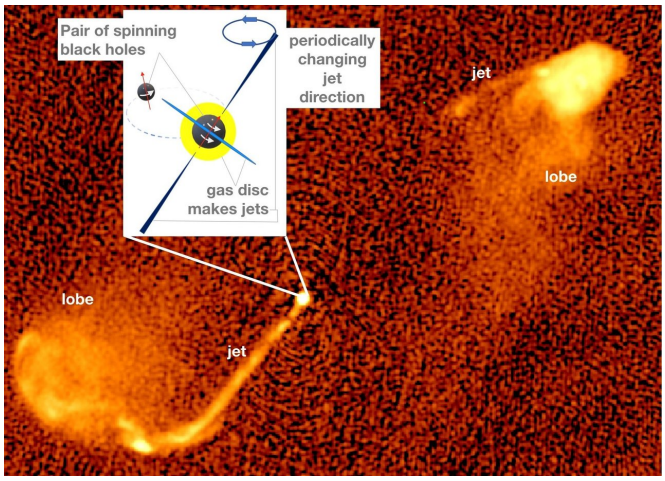

Jets from double black holes change direction continuously. The effect can explain features in this 5 GHz radio map of 3C 334 and many powerful radio sources in the sky. The jet emanates from the nucleus of a galaxy (its stars are not visible at radio frequencies) about 10 billion light years from our own. The image spans five million light years from left to right. The peculiar structure of the jets signifies a periodic change of the direction of the jet (precession), an effect that is predicted for jets from black hole pairs. The inset diagram schematically illustrates the physical processes in the black hole pair. Jets may form in gas discs around black holes. The direction of the jets is tied to the spin of the black hole. The spin axis is shown as a red arrow. The latter changes direction periodically due to the presence of the second black hole. Credit: M. Krause / University of Hertfordshire

New research, published today in the journal *Monthly Notices of the Royal Astronomical Society*, has found evidence for a large number of double supermassive black holes, likely precursors of gigantic black hole merging events. This confirms the current understanding of cosmological evolution—that galaxies and their associated black holes merge over time, forming bigger and bigger galaxies and black holes.

Astronomers from the University of Hertfordshire, together with an international team of scientists, have looked at radio maps of powerful jet sources and found signs that would usually be present when looking at black holes that are closely orbiting each other.

Before black holes merge they form a binary black hole, where the two black holes orbit around each other. Gravitational wave telescopes have been able to evidence the merging of smaller black holes since 2015, by measuring the strong bursts of gravitational waves that are emitted when binary black holes merge, but current technology cannot be used to demonstrate the presence of supermassive binary black holes.

Supermassive black holes emit powerful jets. When supermassive binary black holes orbit it causes the jet emanating from the nucleus of a galaxy to periodically change its direction. Astronomers from the University of Hertfordshire studied the direction that these jets are emitted in, and variances in these directions; they compared the direction of the jets with the one of the radio lobes (that store all the particles that ever went through the jet channels) to demonstrate that this method can be used to indicate the presence of supermassive binary black holes.

Dr. Martin Krause, lead author and senior lecturer in Astronomy at the University of Hertfordshire, said: "We have studied the jets in different conditions for a long time with computer simulations. In this first systematic comparison to high-resolution radio maps of the most powerful radio sources, we were astonished to find signatures that were compatible with jet precession in three quarters of the sources."

The fact that the most powerful jets are associated with binary black holes could have important consequences for the formation of stars in galaxies; stars form from cold gas, jets heat this gas and thus

suppress the formation of stars. A jet that always heads in the same direction only heats a limited amount of gas in its vicinity. However, jets from binary black holes change direction continuously. Therefore, they can heat much more gas, suppressing the formation of stars much more efficiently, and thus contributing towards keeping the number of stars in galaxies within the observed limits.

More information: Martin G H Krause et al, How frequent are close supermassive binary black holes in powerful jet sources?, *Monthly Notices of the Royal Astronomical Society* (2018). DOI: 10.1093/mnras/sty2558