# Astrophysicists prepare for age of multi-messenger astronomy, build galaxy catalog to study black holes

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Led by postdoctoral fellow researcher Maria Charisi, a team of international researchers known as the NANOGrav collaboration has

created a catalog of 45,000 galaxies to detect gravitational waves created by pairs of black holes known as binaries. Using pulsars—the most precise clocks of the sky—a galactic scale detector dubbed a pulsar timing array and infrared data from across the sky, Charisi used the catalog to input hypothetical binaries to measure differences in the masses of the two black holes or their distance from each other within a galaxy. "Since we haven't found gravitational waves with pulsar timing arrays yet, we can play with our binary parameters and a range of gravitational wave frequencies to find the limits of the sizes of black hole binaries in specific galaxies," Charisi said.

From this work, astrophysicists can rule out the existence of certain types of binaries in several nearby galaxies. Within our own galaxy, scientists know a central supermassive black hole exists, but not if there is a smaller companion forming a binary. Although pulsar timing arrays cannot constrain a binary in our Milky Way, the experiment is so sensitive that these limits are similar to limits in our own galaxy obtained with other methods.

This is the first time that pulsar timing array data has been explored with the accompanying galaxy catalog. By calculating the limits of black hole binaries in nearby galaxies, Charisi, Stephen Taylor, assistant professor of physics and astronomy, and their international colleagues are preparing for an age of multimessenger astronomy. As black hole binaries interact together and within their galactic environment consisting of gas and stars, scientists will be able to interpret multimessenger signals full of rich information about the composition and behavior of galaxies. "We have never seen a black hole binary before, so we know very little at present," Taylor said. "There is much theoretical debate about how a binary evolves, and seeing one will be the Rosetta stone of our field. We are preparing for this moment."

As experiment becomes more sensitive with more observations, Charisi

and Taylor expect to probe more galaxies, looking at scenarios from even larger samples. Ultimately with this data and upon the first detection of gravitational waves, scientists will be able to pinpoint the galaxy from which the signals came.

**More information:** Zaven Arzoumanian et al, The NANOGrav 11 yr Data Set: Limits on Supermassive Black Hole Binaries in Galaxies within 500 Mpc, *The Astrophysical Journal* (2021). DOI: 10.3847/1538-4357/abfcd3

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