Galaxy may hold hundreds of rogue black holes

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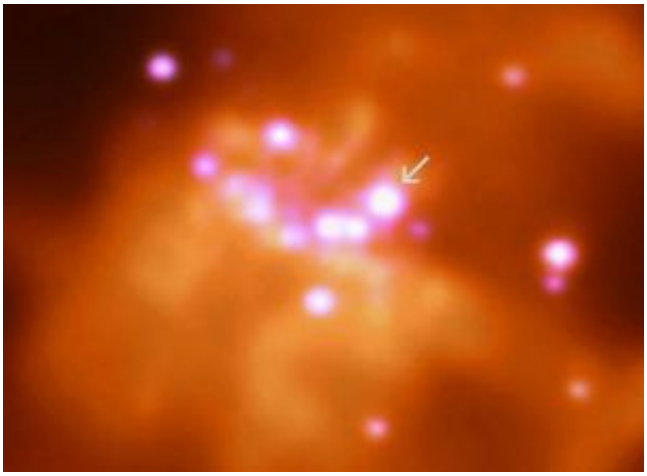

The arrow points to a candidate intermediate mass black hole in a Hubble space telescope image of a globular cluster in the M20 galaxy. Credit: Space Telescope Science Institute

If the latest simulation of what happens when black holes merge is correct, there could be hundreds of rogue black holes, each weighing several thousand times the mass of the sun, roaming around the Milky Way galaxy.

“Rogue black holes like this would be very difficult to spot,” says Vanderbilt astronomer Kelly Holley-Bockelmann, who is presenting the results of the supercomputer simulation at a meeting of the American Astronomical Society on Jan. 9 in Austin, Texas. Much of the research

was done at Penn State University in collaboration with Deirdre Shoemaker and Nicolas Yunes before Holley-Bockelmann moved to Vanderbilt. Kayhan Gultekin at the University of Michigan also participated in the study.

“Unless it's swallowing a lot of gas, about the only way to detect the approach of such a black hole would be to observe the way in which its super-strength gravitational field bends the light that passes nearby. This produces an effect called gravitational lensing that would make background stars appear to shift and brighten momentarily,” she says.

The research focused on modeling "intermediate mass" black holes, whose very existence is controversial. Astronomers have ample evidence that small black holes less than 100 solar masses are produced when giant stars explode. There is similar evidence that “super-massive” black holes weighing the equivalent of millions to billions of solar masses sit at the heart of many galaxies, including the Milky Way. In addition, theoreticians have predicted that globular clusters – ancient, gravitationally bound groups of 100,000 to a million stars – should contain a third class of black holes, called intermediate mass black holes, that weigh a few thousand solar masses. But so far there have only been two tentative observations of objects of this sort.

In the past two years, scientists have succeeded in numerically simulating black hole mergers that incorporate Einstein’s theory of relativity. One of the big surprises to come from this effort is the prediction that when two black holes that are rotating at different speeds or are different sizes combine, the newly merged black hole receives a big kick due to conservation of momentum, pushing it away in an arbitrary direction at velocities as high as 4,000 kilometers per second.

“This is much higher than anyone predicted. Even the average kick velocity of 200 kilometers per second is extremely high when compared

to the escape velocities of typical astronomical objects," says Holley-Bockelmann. "We realized that basically any black hole merger would kick the new remnant out of a globular cluster, because the escape velocity is less than 100 kilometers per second."

Using the facilities of Vanderbilt's Advanced Center for Computation, Research and Education, Holley-Bockelmann's team ran a number of simulations of the growth of intermediate mass black holes as they combine with a number of stellar-sized black holes, which are plentiful in globular clusters, paying close attention to the kick they received after each merger.

"We used different assumptions for the initial black hole mass, for the range of stellar black hole masses within a globular cluster, and assumed that the spins and spin orientations were distributed randomly. With our most conservative assumptions, we found that, even if every globular cluster started out with an intermediate-sized black hole, only about 30 percent retain them through the merger epoch. With our least conservative assumptions, less than 2 percent of the globular clusters should contain intermediate mass black holes today," she says.

If the roughly 200 globular clusters in the Milky Way have indeed spawned intermediate-sized black holes, this means that hundreds of them are probably wandering invisibly around the Milky Way, waiting to engulf the nebulae, stars and planets that are unfortunate enough to cross their paths.

Fortunately, the existence of a few rogue black holes in the neighborhood does not present a major danger. "These rogue black holes are extremely unlikely to do any damage to us in the lifetime of the universe," Holley-Bockelmann stresses. "Their danger zone, the Schwarzschild radius, is really tiny, only a few hundred kilometers. There are far more dangerous things in our neighborhood!"

Source: Vanderbilt University