Article heading : NASA’s Hubble, Chandra Spot Rare Type of Black Hole Eating a Star

NASA’s Hubble Space Telescope and NASA’s Chandra X-ray Observatory have teamed up to identify a new possible example of a rare class of black holes. Called NGC 6099 HLX-1, this bright X-ray source seems to reside in a compact star cluster in a giant elliptical galaxy.

Just a few years after its 1990 launch, Hubble discovered that galaxies throughout the universe can contain supermassive black holes at their centers weighing millions or billions of times the mass of our Sun. In addition, galaxies also contain as many as millions of small black holes weighing less than 100 times the mass of the Sun. These form when massive stars reach the end of their lives.

Far more elusive are intermediate-mass black holes (IMBHs), weighing between a few hundred to a few 100,000 times the mass of our Sun. This not-too-big, not-too-small category of black holes is often invisible to us because IMBHs don’t gobble as much gas and stars as the supermassive ones, which would emit powerful radiation. They have to be caught in the act of foraging in order to be found. When they occasionally devour a hapless bypassing star — in what astronomers call a tidal disruption event— they pour out a gusher of radiation.

The newest probable IMBH, caught snacking in telescope data, is located on the galaxy NGC 6099’s outskirts at approximately 40,000 light-years from the galaxy’s center, as described in a new study in the Astrophysical Journal. The galaxy is located about 450 million light-years away in the constellation Hercules.

Astronomers first saw an unusual source of X-rays in an image taken by Chandra in 2009. They then followed its evolution with ESA’s XMM-Newton space observatory.

“X-ray sources with such extreme luminosity are rare outside galaxy nuclei and can serve as a key probe for identifying elusive IMBHs. They represent a crucial missing link in black hole evolution between stellar mass and supermassive black holes,” said lead author Yi-Chi Chang of the National Tsing Hua University, Hsinchu, Taiwan.

X-ray emission coming from NGC 6099 HLX-1 has a temperature of 3 million degrees, consistent with a tidal disruption event. Hubble found evidence for a small cluster of stars around the black hole. This cluster would give the black hole a lot to feast on, because the stars are so closely crammed together that they are just a few light-months apart (about 500 billion miles).

The suspected IMBH reached maximum brightness in 2012 and then continued declining to 2023. The optical and X-ray observations over the period do not overlap, so this complicates the interpretation. The black hole may have ripped apart a captured star, creating a plasma disk that displays variability, or it may have formed a disk that flickers as gas plummets toward the black hole.

“If the IMBH is eating a star, how long does it take to swallow the star’s gas? In 2009, HLX-1 was fairly bright. Then in 2012, it was about 100 times brighter. And then it went down again,” said study co-author Roberto Soria of the Italian National Institute for Astrophysics (INAF). “So now we need to wait and see if it’s flaring multiple times, or there was a beginning, there was peak, and now it’s just going to go down all the way until it disappears.”

The IMBH is on the outskirts of the host galaxy, NGC 6099, about 40,000 light-years from the galaxy’s center. There is presumably a supermassive black hole at the galaxy’s core, which is currently quiescent and not devouring a star.

Black Hole Building Blocks
The team emphasizes that doing a survey of IMBHs can reveal how the larger supermassive black

holes form in the first place. There are two alternative theories. One is that IMBHs are the seeds for building up even larger black holes by coalescing together, since big galaxies grow by taking in smaller galaxies. The black hole in the middle of a galaxy grows as well during these mergers. Hubble observations uncovered a proportional relationship: the more massive the galaxy, the bigger the black hole. The emerging picture with this new discovery is that galaxies could have “satellite IMBHs” that orbit in a galaxy’s halo but don’t always fall to the center.

Another theory is that the gas clouds in the middle of dark-matter halos in the early universe don’t make stars first, but just collapse directly into a supermassive black hole. NASA’s James Webb Space Telescope’s discovery of very distant black holes being disproportionately more massive relative to their host galaxy tends to support this idea.

However, there could be an observational bias toward the detection of extremely massive black holes in the distant universe, because those of smaller size are too faint to be seen. In reality, there could be more variety out there in how our dynamic universe constructs black holes. Supermassive black holes collapsing inside dark-matter halos might simply grow in a different way from those living in dwarf galaxies where black-hole accretion might be the favored growth mechanism.

"So if we are lucky, we’re going to find more free-floating black holes suddenly becoming X-ray bright because of a tidal disruption event. If we can do a statistical study, this will tell us how many of these IMBHs there are, how often they disrupt a star, how bigger galaxies have grown by assembling smaller galaxies.” said Soria.

The challenge is that Chandra and XMM-Newton only look at a small fraction of the sky, so they don’t often find new tidal disruption events, in which black holes are consuming stars. The Vera C. Rubin Observatory in Chile, an all-sky survey telescope from the U.S. National Science Foundation and the Department of Energy, could detect these events in optical light as far as hundreds of millions of light-years away. Follow-up observations with Hubble and Webb can reveal the star cluster around the black hole.

The Hubble Space Telescope has been operating for more than three decades and continues to make ground-breaking discoveries that shape our fundamental understanding of the universe. Hubble is a project of international cooperation between NASA and ESA (European Space Agency). NASA’s Goddard Space Flight Center in Greenbelt, Maryland, manages the telescope and mission operations. Lockheed Martin Space, based in Denver, also supports mission operations at Goddard. The Space Telescope Science Institute in Baltimore, which is operated by the Association of Universities for Research in Astronomy, conducts Hubble science operations for NASA.