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Lurking at the center of our very own Milky Way galaxy is a supermassive black hole. In fact, supermassive black holes are thought to exist at the center of most, if not all, large galaxies. Recently, however, scientists have discovered an example of this kind of astronomical arrangement in the place they least expected: at the heart of one of the smallest dwarf galaxies ever encountered. Using the Hubble Telescope and the Gemini North 8-meter optical and infrared telescope, researcher Anil Seth and his team of astronomers from the University of Utah observed dwarf galaxy M60-UCD1 and collected data that allowed them to calculate the mass of the black hole at its center. M60-UCD1 itself is estimated to contain 140 million stars inside a 300 light-year diameter (Chou, F., Weaver, D., & Villard, R. 2014). In contrast, the Milky Way is approximately 100,000 light years in diameter and is home to between 100 and 300 billion stars (Djorkovski, G. 2004). Even though the Milky Way is 500 times larger and 1,000 times more massive than M60-UCD1, the ultra-compact dwarf galaxy's supermassive black hole has a mass of 21 million suns, while the Milky Way's black hole only measures up to a (relatively) puny 4 million suns. The Milky Way's black hole constitutes less than 0.01 % of its galaxy's total mass, while M60-UCD1's black hole accounts for 15 % (Chou, F., Weaver, D., & Villard, R. 2014).

The Gemini Observatory on Mauna Kea, Hawai'i, at sunset. The 8-meter optical telescope Gemini North, housed here, was used along with the Hubble Space Telescope in the detection of M60-UCD1's black hole.

This discovery implies that supermassive black holes may exist in even more galaxies than previously thought, and has also forced astronomers to reevaluate their predictions regarding the formation of dwarf galaxies. Dwarf galaxies were previously thought to arise independently from other galaxies through the birth of isolated stars, but this new information suggests that dwarf galaxies are instead the remnants of larger galaxies that were torn apart during spectacular collisions with other large galaxies. According to Seth, "We simply don't know of any other way you could make a black hole so big in an object this small" (Chou, F., Weaver, D., & Villard, R. 2014).

Of these two implications, it will be easier to collect evidence for the existence of more dwarf-galaxy black holes than it will be to prove that dwarf galaxies were created by the collisions of larger galaxies. However, this relative comparison belies the true difficulty in detecting black holes: they remain purely theoretical objects that are, as far as we know, impossible to observe directly. Their existence is predicted by Einstein's theory of relativity, and their presence in a given location can be inferred by observing the behavior of nearby matter. Current methods use a black hole's gravitational influence to "visualize" it: stars are observed orbiting around a circular region of space that appears empty to traditional techniques, and so the center of the orbit presumably contains a black hole (NASA 2014b). Another method involves the measurement of the high-energy radiation, mostly in the form of X-rays, emitted by a black hole as nearby matter falls inexorably into it in a process known as accretion (NASA 2014a).

New efforts are being made to detect "rogue" black holes, which are found scattered all across a galaxy rather than only at its center. It is possible that the Milky Way contains hundreds of these rogue black holes that were originally native to the dwarf galaxies that are predicted to have collided in the formation of our galaxy. Since these black holes are not located centrally, it is difficult to pinpoint a region within the vast expanse of the Milky Way in which to search for them. Astrophysicist Avi Loeb of Harvard University, however, has proposed a new way to identify these most elusive of black holes. When black holes pass through the disks of gas that fill the space between the stars in the Milky Way, they produce a bow shock, similar to a sonic boom, that accelerates electrons to high energies, causing emission of radio waves that can be detected by current radio observatories. Once a rogue black hole is initially located based on these emissions, the other methods previously described can be used to confirm its presence and mass. The discovery of such rogue black holes in our own galaxy would provide evidence for the collision-based mechanisms now thought to underlie the formation of dwarf galaxies as well as the Milky Way.

While many would probably agree that the information yielded from research on black holes is fascinating, one might reasonably wonder why resources are being devoted to the study of subjects that are theoretical, unobservable, distant, and perhaps irrelevant for our lives on Earth. There are at least two practical reasons why this type of basic research should continue. While basic research is not directed at solving particular practical problems, but rather is often a product of curiosity alone and seeks only to advance fundamental knowledge, the technology developed to enable it nonetheless often finds many practical applications. For example, wireless networking, modern medical imaging techniques, radar technology, and cloud computing all exist because of basic astronomical research. Furthermore, any fundamental discoveries about black hole physics could themselves reveal new possibilities for technologies that could not even have been imagined before. Black holes are incredibly efficient at harnessing energy, converting about 7 % of the mass they consume into energy (in comparison, nuclear fusion only converts about 0.3 % of mass into energy) (Lawrence Livermore National Laboratory 2007) (McClintock, J. & Remillard, R. 2004). Researchers Louise Crane and Shawn Westmoreland from Kansas State University argue that it is "clearly extremely ambitious, but [not] impossible" to harness this efficiency someday by creating an artificial black hole generator to provide energy for power plants or even spacecraft (Crane, L. & Westmoreland, S. 2009). Whether this fantastical technology will ever come to fruition remains to be seen, but it is clear that the natural phenomena must be understood through basic research before there is even a chance.

An equally compelling, albeit less pragmatic, motive for black hole research again ties back to the fact that such research is basic research. At its heart, science seeks to understand how the universe works. Black holes provide clues about how galaxies are formed and have even spawned new predictions about the origins of the universe at large. Humans are innately curious about the world around them; we have always looked to the stars and had a certain fascination with the unknown. Basic research—including on black holes—is thus not only a practical matter, but an activity that lies at the core of what it means to be human.

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