Four questions: Here there be monsters

April 18 2019, by Daniel Stolte

dam Block's photo of the Messier 87 galaxy. Credit: Adam Block

On April 10, the world got to see the first image taken of a black hole in space, taken by the Event Horizon Telescope, a worldwide collaboration of astronomers and astrophysicists including a substantial team at the University of Arizona.

Adam Block, astrophotographer and operations specialist at the UA's Steward Observatory, took an image of Messier 87, the galaxy where astronomers took the first image of a black hole, as it would present itself to the eyes of a space-faring visitor. The image is one of very few showing the extensive glow caused by the roughly one trillion stars that call the M87 galaxy home, yet at the same time detailing the monstrous jet emanating from the supermassive black hole at its center – a feat difficult to achieve in the same image because of the vastly different exposure times required.

"When I take a picture like this one, every pixel only sees a tiny little piece of sky," Block said. "With the telescope I used (the Schulman Telescope at the Mount Lemmon SkyCenter) the resolution is 0.33 arcseconds per pixel, but with the EHT, they were able to resolve 40 micro arcseconds. If you could slice up one of the pixels in my image into 10,000 bits, the area around the supermassive black hole that EHT was able to resolve would be a single one of them. That gives you some idea of the amazing resolving power that the EHT collaboration was able to achieve. Going forward, EHT is going to observe at shorter wavelengths, and that will give them higher resolution."

UANews spoke to Block about his M87 photo, and the information it provides about the now-famous galaxy.

Why was the Event Horizon Telescope pointed at a galaxy 55 million light-years away?

Block: The supermassive black hole that was observed with the Event Horizon Telescope is in the center of a giant galaxy called M87, and that is exactly the kind of galaxy where we would expect to find a monster. We are looking at a massive, elliptical galaxy, not a spiral galaxy like our Milky Way. Even though it's just a little bigger in diameter than the Milky Way, because it is football-shaped, M87 is hundreds of times more massive. M87 probably is the biggest galaxy in the Virgo cluster. In fact, it is one of the most massive galaxies in the local universe.

A crop of the above image shows M87's jet in greater detail. The part of the jet that's visible in the optical light spectrum is about 8,000 light-years long. Credit: Adam Block

M87 also sits at the center of the Virgo cluster, an accumulation of about 2,000 galaxies that is the nearest large cluster of galaxies to us. Our Milky Way, on the other hand, is in a fairly quiet part of the local universe, a cosmic cul-de-sac, if you will. It's as if we were at the suburbs, and we'd be looking at that bright glow on the horizon, that big city closest to our quiet little town.

When a galaxy is in the center of a cluster, it tends to interact much more frequently with other galaxies. We think M87 grew so large because it has absorbed other galaxies over time, and that's important, because that's how you grow a supermassive black hole. If you don't have all this activity of galaxies colliding with other galaxies, you don't have enough raw material, and if there isn't a lot of material falling into the black hole, you don't see anything. The black hole in M87 is feeding, and that's why we see it.

In 2010, you took an image of M87 that was selected by NASA as the "Astronomy Picture of the Day." What does that image tell us about the galaxy and its supermassive black hole?

Block: The image is quite zoomed in. If you zoomed out and looked at it at a progressively wider field of view, you'd see more and more galaxies, all members of the Virgo cluster. Those fuzzy little spots surrounding the M87 galaxy all look like stars, but almost all of those are ancient, globular star clusters. There is no star formation taking place here, because for that you need cold clouds of gas that can collapse, but that requires a bit of a quieter area. In M87, where you have stars whipping around due to the interactions with other galaxies and the black hole itself injecting energy into the surroundings, that activity contributes to star formation being shut off.

According to one hypothesis, all those globular clusters of stars we see around M87 could be the remnants of small dwarf galaxies that M87 swallowed eons ago. So, all those little dots could literally be the leftover scraps showing the history of M87 growing. The picture is hinting at all of this monstrous galactic hunger, and of course that lends credence to the idea of the formation of the supermassive black hole.

We also see the jet of high-energy particles shooting out of what is believed to be the supermassive black hole at its center – a testament to how big M87 is as a place. The accretion disc swirling around the black hole emits light across the entire electromagnetic spectrum, from gamma rays to radio waves, which is what EHT detected. In fact, M87 is the brightest radio source in that direction in the sky. All that mass and all that astrophysical activity is what made it possible for a supermassive black hole to exist in a way that made it observable. We are very fortunate in that sense, and all those things are part of the story of M87, making it one of the best places that astronomers wanted to look for something as remarkable as a black hole.

Artist impression of a black hole with an accretion disk and jet. Credit: Mark Garlick

The jet is a very concrete consequence of having a black hole there, and it has its own characteristics. Astrophysicists think the jet consists of high-energy particles shooting out from the superheated gas and dust in the accretion disk around the black hole. Much of it is literally light – photons – but also ionized gas and electrons. The jet is what we call collimated – meaning it is focused, like a laser beam, and relativistic, which means that particles, superheated plasma and gas are moving out at velocities near the speed of light. The jet is directed toward our line of sight, and from our perspective, when you look at the light, it looks like it's moving faster. But it only appears as if it was traveling faster the speed of light. It's a relativistic effect following directly from Einstein's Theory of General Relativity.

The now famous image of M87's supermassive black hole captured it as it appeared 55 million years ago. What would it look like today?

Block: For all intents and purposes, black holes are almost like permanent structures of the cosmos in any reasonable time you can think about. Stephen Hawking proposed that black holes can 'leak' a little bit of energy, but that effect would be so small that it would take many times the current age of the universe for them to fade out of existence. Whether we see them or not only has to do with whether they're eating something. If they're just out there without consuming any matter, we can't see them. The black hole in M87 is definitely still there, and although the information you see in the picture is 55 million years old, the stars in that galaxy have been around for billions of years. The jet has been doing this for a very long time. These are very big objects, and the universe proceeds along times that are much different from our lifetimes, so everything moves very slowly. If we could travel to M87 now, we wouldn't see anything much different.

What excites you most about the image of M87's black hole?

Block: Until last week, pictures of unicorns and pictures of black holes were basically in the same category; and now, black holes move into reality.

Provided by University of Arizona