Hanny’s Voorwerp

In 2007, Hanny van Arkel, a young Dutch school teacher with an interest in astronomy, was classifying galaxies as part of the Galaxy Zoo project. Galaxy Zoo invites the public to take part in “citizen science” astronomical research by examining and categorizing galaxies using online imagery (see Galaxy Zoo Sidebar). As she viewed a spiral galaxy called IC 2497, she noticed what appeared to be a strangely shaped smudge below it. The anomaly seemed to be a solitary blue object floating near the normal-looking spiral galaxy.

Although she thought that the mysterious smudge might be an irregular galaxy, it appeared to be too blue, and too oddly shaped. She decided to post a question about it to the online Galaxy Zoo forum. No one, not fellow citizen classifiers nor professional astronomers, had an answer for her. A fellow Galaxy Zoo participant, who knew Hanny was Dutch, learned that the Dutch word for “object” was “voorwerp” and coined the term Hanny’s Voorwerp.

Since van Arkel’s discovery, puzzled astronomers have used an arsenal of telescopes—including X-ray and radio observatories—to help unravel its mysterious nature. They found that in spite of its appearance, Hanny’s Voorwerp is not just an isolated cloud of gas floating in space. Instead, the glowing nebula is part of a long, twisting rope of gas, or tidal tail, about 300,000 light-years long that wraps around the galaxy IC 2497. Nothing quite like it has ever been seen before.

Surprisingly, the only optically visible part of the tidal tail is Hanny’s Voorwerp. The favored explanation for this is that the voorwerp was illuminated in the past by a searchlight-like beam of light that once emanated from IC 2497’s core. Such a beam could have been emitted if the core of IC 2497 became a quasar—a bright, compact, and highly energetic object that is powered by a massive and active black hole. An encounter with another galaxy could have fed the black hole and produced the quasar, while pulling the gaseous tidal tail from IC 2497. The voorwerp would then be a massive “light echo” caused by the quasar’s beam striking the tail’s gas. Because of the distance between the center of the galaxy and the voorwerp, light from the quasar would have taken 70,000 years to reach the gaseous object.

Hanny’s Voorwerp is the size of the Milky Way galaxy, and its bright green color comes from glowing oxygen. This Hubble view reveals a pocket of star clusters, the yellowish-orange area at the tip of the Voorwerp. What appears to be a gaping hole actually may be a shadow cast by an object in the illuminating quasar’s light path. This feature gives the illusion of a cavity about 20,000 light-years wide.
The quasar in IC 2497 must have been bright. If it were still active, it would be visible from Earth with binoculars. However, the quasar must have turned off no more than 70,000 years ago, though its light continued to travel through space. Such start-ups and shut-downs are typical of quasars. But Hanny's Voorwerp and IC 2497 suggest that a quasar's energy output can shut down on timescales of mere millions of years—well less than the 100 million years theorized.

To further investigate this intriguing object, astronomers pointed Hubble's sensitive cameras and imaging spectrograph at Hanny's Voorwerp in the spring of 2010. In the sharpest view yet of the voorwerp, Hubble uncovered star birth in a region of the object facing IC 2497. Previous radio observations showed an outflow of gas arising from the galaxy's core. The Hubble images revealed that this outflowing gas is interacting with a small region of Hanny's Voorwerp, causing it to collapse and form new stars. The youngest stars are only around two million years old. These star clusters are localized and confined to an area that is only a few thousand light-years wide. These stars are so dim that they were previously invisible to other telescopes—lost in the brilliant light of the surrounding gas. The new Hubble images and spectra of the galaxy's dusty core also showed a bubble of gas expanding from one side of the core, perhaps evidence of the sputtering quasar's final gasps.

The quasar's outburst also seems to have cast a shadow on the nebulous object. This shadow gives the illusion of a gaping hole about 20,000 light-years wide in the voorwerp. Hubble reveals sharp edges around the apparent opening of the “hole” but no other unusual features in the gas. This suggests to astronomers that an object close to the quasar may have blocked some of the light and projected a shadow on the voorwerp, similar to dirt on a lens casting a shadow on a movie screen.
Galaxy Zoo

Astronomer Kevin Schawinski was investigating what appeared to be blue elliptical galaxies—ultimately sorting his images into two categories: spirals and ellipticals. He had classified about 50,000 of them in five days when he realized there must be a more efficient, less arduous way. He needed help, but no computer programs were sophisticated enough to accomplish this as accurately as the human brain. In discussing this dilemma with a fellow astronomer, Chris Lintott, they devised the idea of asking for help online and thus created “Galaxy Zoo.”

Galaxy Zoo is an online astronomy project that invites members of the worldwide public to assist in classifying galaxies. An example of “citizen science,” it enlists people of all ages without any scientific background to help in astronomical research. The effort is now part of a larger group of similar projects collectively called the “Zooniverse.”

The original Galaxy Zoo was launched in July 2007 using the Sloan Digital Sky Survey, a data set of approximately one million galaxies. With so many galaxies, the team thought that it might take at least two years for participants to work through them all. Within 24 hours of launch, the site was receiving 70,000 classifications an hour, and more than 50 million classifications were received during its first year from almost 150,000 people.

Having multiple assessments of the same object is important, as it allows scientists to determine the reliability of its classification. The task of the first Galaxy Zoo was to split the galaxies into ellipticals and spirals and—if the galaxy was a spiral—record the direction of the arms. When Galaxy Zoo 2 was designed, its developers took 250,000 of the best and brightest images from the original sample of galaxies and asked its citizen science team to answer more detailed questions about them. In the 14 months that the site was up, Galaxy Zoo 2 users helped make more than 60 million classifications. The Galaxy Zoo 2 database is already helping scientists to understand how galaxies form and evolve.

In the latest version of Galaxy Zoo, called Hubble Zoo, the public is asked to assess hundreds of thousands of galaxies captured in long-exposure images of deep space by Hubble.

A sample tutorial from GalaxyZoo.org (used with permission) is shown below.

Q: Is there a sign of a bar feature through the center of the galaxy?

Some galaxies have a straight, often fairly short, bar at their center. For spirals, the arms will sometimes start from the end of the bar. Only answer “Bar” here if you see a bar feature, not just a rounded bulge.
This near-infrared view was taken with Hubble’s Wide Field Camera 3. A faint outline of the mysterious voorwerp (which is brighter in green, visible-light wavelengths) can be seen below the large galaxy IC 2497 near the center.
Hanny van Arkel

Undoubtedly the most famous Galaxy Zoo participant, a 28-year-old Dutch schoolteacher named Hanny van Arkel lives with her German shepherd, Janey, in Heerlen, a municipality located in the southeastern tip of the Netherlands. In August 2007, this amateur guitarist was browsing the website of Brian May—the guitarist for the British rock band Queen who also happens to have a doctorate in astrophysics—when she read his post about Galaxy Zoo. It immediately appealed to her, and she signed up.

After about a week of classifying, a spiral galaxy appeared on her screen and Van Arkel quickly identified it as “anticlockwise.” Once she entered her selection, another image popped up. At that point she hesitated, realizing she had seen something else a bit odd about the previous image. When she clicked the “back” button, Hanny saw that the spiral galaxy had a companion, although she could not determine what it was. A blue smudge with remarkable form, it failed to match any galaxy types described in the Galaxy Zoo classification tutorial.

She went to the online forum for the volunteers of Galaxy Zoo and posted the picture and the question, “What’s the blue stuff below? Anyone?” No one knew, so she contacted members of the professional astronomy team. Again, no one had an answer. A member who knew she was Dutch learned the Dutch word for object was voorwerp. “Hanny, here’s your voorwerp,” he wrote to her, and the term was coined.

In January 2008, the “Zookeepers” began investigating the mysterious blue cloud, and Hanny’s life changed forever. She was interviewed for radio and television shows all over the world and now gives lectures about the voorwerp. Hanny’s Voorwerp has made her famous, and her many media appearances make her an excellent ambassador of astronomy and of “citizen science” in general. Van Arkel now teaches biology, Dutch, and English at the Citaverde College in Heerlen. She writes about her adventures on www.hannysvoorwerp.com.

Hanny van Arkel, a Dutch schoolteacher, has become a worldwide celebrity representative of “citizen science” through her curiosity-inspired astronomical discovery as a member of the Galaxy Zoo project. (Photo credit: Ulf Lüdeke)
The very existence of the tidal tail suggests that IC 2497 may have merged with another galaxy about a billion years ago. The Hubble images show in exquisite detail that the spiral arms are twisted, which is additional evidence of a recent, perturbing gravitational influence. Dr. William Keel, leader of the Hubble study, proposed a scenario where the merger expelled the long streamer of gas from the galaxy and funneled gas and stars into the center, which fed the black hole. The engorged black hole then powered the quasar, from which emanated two oppositely directed cones of light. One light beam illuminated part of the tidal tail, creating what is now called Hanny’s Voorwerp. When the quasar later shut down, it left behind the ordinary-looking galaxy core we observe today. In the future, if more material is drawn into the black hole, the quasar could light up again.

Hanny’s Voorwerp and spiral galaxy IC 2497 are located in the constellation Leo Minor, approximately 680 million light-years from Earth, so the events we are seeing actually happened 680 million years ago.

When it was discovered, the voorwerp was the only object of its type known to astronomers. Smaller light-echoes had been seen around supernovas, but never on this scale. Though pieces of the object had been included in a software-produced object catalog from a previous telescopic survey, its significance only became known when it was brought to the attention of Galaxy Zoo team members by van Arkel.
Now, thanks to the citizen scientists of Galaxy Zoo, nineteen other objects, similar but smaller and dimmer than Hanny’s Voorwerp, have been identified. *Hubble* is scheduled to examine seven of the most interesting ones in 2012. This should greatly enhance astronomers’ understanding of this new class of objects, the life cycles of black holes, and how black holes evolve into quasars.

**Further Reading**


Dr. William Keel, a professor of astronomy at the University of Alabama, has been a regular observer with the *Hubble Space Telescope*. He has also observed with numerous ground-based telescopes and used data from a dozen other spacecraft that spanned the spectrum from the infrared to the X-ray regimes. A member of the Galaxy Zoo project, he studies such topics as the effects of interactions on galaxies, the history of galaxy mergers, the triggering of star formation, and nuclear activity in galaxies. Born in Jackson, Mississippi, he holds a bachelor’s degree in physics and astronomy from Vanderbilt University, and a doctorate in astronomy from the University of California at Santa Cruz. He has published two books, *The Road to Galaxy Formation* and *The Sky at Einstein’s Feet*, and he is currently writing a history of space astronomy. *(Photo credit: Jeff Hanson)*