Measuring the Galactic Merger Rate

Taken from: Hubble 2011: Science Year in Review


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Measuring the Galactic Merger Rate

Astronomers consider the galactic merger rate one of the fundamental measures of galaxy evolution. It tells them how galaxies grow over time through encounters with other galaxies. Past measurements of this number have yielded a wide range of results. *Hubble* deep-field surveys have indicated that anywhere from 5 to 25 percent of the galaxies manifest signs of possible mergers. Recently, scientists have evaluated 9 billion years of *Hubble* survey data in conjunction with new computer models of mergers to gain a significantly better understanding of this important parameter.

Maryland-based astronomer Jennifer Lotz led a team that studied galaxy interactions at different distances, allowing them to isolate and compare varying merger rates over time. Accurate values for these rates bring clarity to understanding the forces that drive galaxy assembly, including the pace of star formation and the accretion of gas onto supermassive black holes at the centers of galaxies.

Accurately identifying mergers is difficult. Galaxies of various morphologies and sizes interact very differently. Previous studies that looked for close pairs of galaxies that appeared to be colliding yielded much lower numbers for mergers than those studies that searched for galaxies with disturbed shapes.

To identify how many encounters occurred in a given sample, Lotz needed a good understanding of what to examine, including how long merging galaxies appear disturbed before returning to a more normal appearance. Lotz and her team employed highly detailed computer simulations to help make sense of the *Hubble* images. In a time-consuming process, the team tried to account for a broad variety of merger possibilities that ranged from galaxy pairs with equal masses to interactions between giant galaxies and dwarfs. The team also analyzed different orbits for the galaxies, different relative orientations to one another, and possible impact trajectories. In all, the group produced 57 different merger scenarios and studied the mergers from 10 different viewing angles. The simulations modeled each colliding-galaxy pair over two billion to three billion years, beginning with their first encounter and continuing until their union was completed.

**ESO 593-8** is an impressive pair of interacting galaxies found in the constellation Sagittarius and located approximately 650 million light-years from Earth. The two components will probably merge to form a single galaxy in the future. The dusty pair is adorned with a number of a number of bright, blue star clusters.
Lotz compared her computer-generated images with pictures of thousands of galaxies taken from some of Hubble’s largest surveys, including the All-Wavelength Extended Groth Strip International Survey, the Cosmological Evolution Survey, and the Great Observatories Origins Deep Survey, as well as mergers identified by the Deep Extragalactic Evolutionary Probe 2 survey with the W. M. Keck Observatory in Hawaii. The process of locating mergers among dwarf galaxies was particularly challenging because of the dim appearance and small size of these galaxies. She and other groups had identified about a thousand merger candidates from these surveys and found very different merger rates initially. When the astronomers applied what they learned from the simulations to the Hubble surveys in their study, they derived much more consistent results.

The team found that during the past nine billion years, each large galaxy, on average, merged once with one of similar size. Small galaxies collided with larger ones more frequently. In one of the first measurements of collisions between dwarf and...
This Hubble image reveals an interacting pair of spiral galaxies known as UGC 8335. Gravitational attraction has joined the two with an interconnecting bridge of material and has also pulled curved tails of gas and stars from their outer disks. Both galaxies show dust lanes in their centers; these areas are often associated with clusters of new stars. UGC 8335 is located in the constellation Ursa Major, the Great Bear, and is approximately 400 million light-years from Earth.
This Hubble image shows a small portion of the Extended Groth Strip, a photo survey conducted in a region of the constellation Ursa Major. Fresh analysis of the data is yielding clues about the universe’s early development, including information about galactic merger rates.
massive galaxies in the distant universe, Lotz’s team found these mergers happened three times more often than encounters between two massive galaxies. Overall, the team’s measured galactic merger rate during the last 8 billion to 9 billion years is consistent with, and falls between, the 5 and 25 percent values previously published.

Lotz’s next goal is to analyze galaxies that interacted even longer ago—about 11 billion years—when star formation across the universe peaked. She is interested to see if the merger rate rises along with the star formation rate. A link between the two would mean galaxy encounters incite rapid star birth, a theory that has some supporting data but needs additional validation.

Further Reading


Dr. Jennifer M. Lotz was born in Boulder, Colorado and graduated from high school in Carlisle, Pennsylvania. After completing internships at the Maria Mitchell Observatory and the Harvard-Smithsonian Center for Astrophysics, she received her bachelor of arts degree in physics and astronomy from Bryn Mawr College in Pennsylvania. She completed her doctorate in astrophysics at Johns Hopkins University in 2003. As a postdoctoral fellow, she worked at the University of California, Santa Cruz and was a Leo Goldberg Fellow at the National Optical Astronomy Observatory. She recently returned to Baltimore, Maryland as an assistant astronomer at the Space Telescope Science Institute, working on preparations for the James Webb Space Telescope. Her research uses both *Hubble* images and theoretical simulations to understand the evolution of galaxies and galaxy mergers.