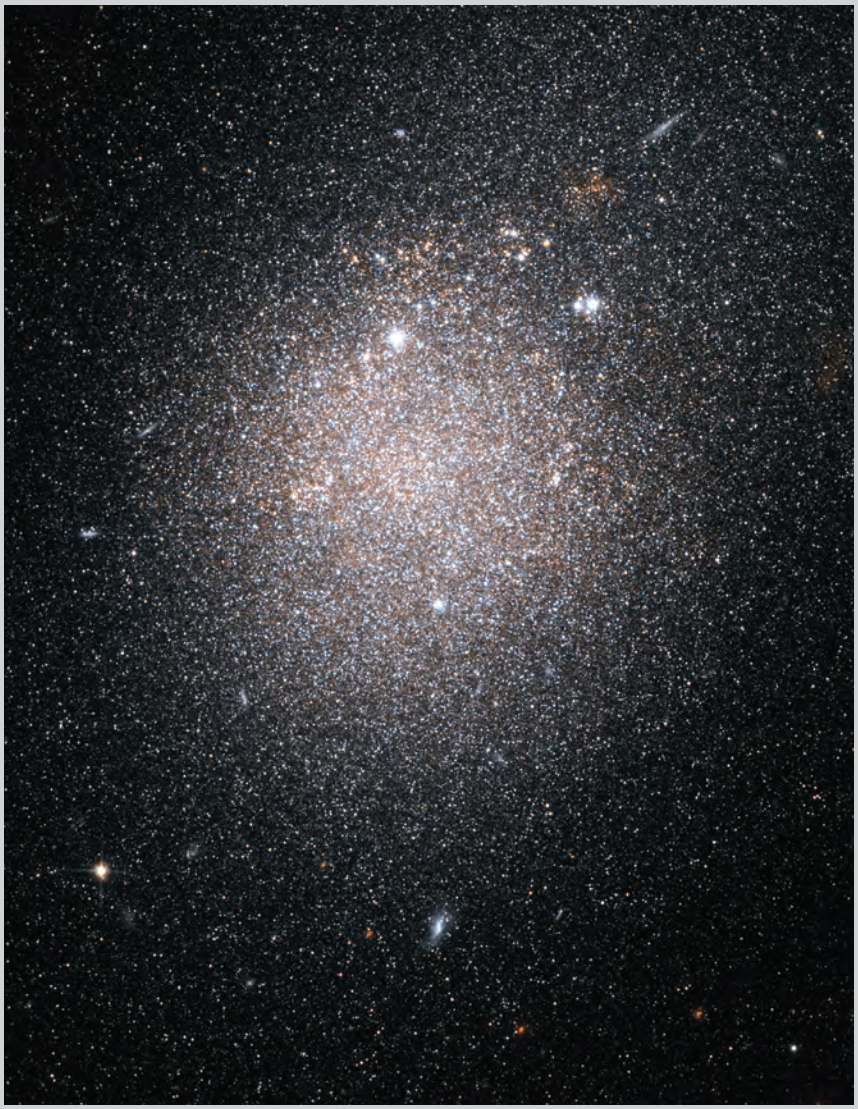
Starbursts in Dwarf Galaxies

Dr. Kristen McQuinn, *kmcquinn@astro.umn.edu*

Bursts of star formation in a galaxy occur rapidly, lighting up local pockets for a relatively short period of time before dissipating. These "starbursts" begin when an external event compresses areas of the galaxy's gas, leading to the gravitational collapse of clouds that form many stars at nearly the same time. The outside triggering event might be a supernova, for example, generating strong shockwaves that push the gases together.

But these short, highly localized starbursts appear to be part of a larger story. An analysis of archival images of dwarf galaxies taken by the *Hubble* suggests that starbursts sweep across an entire galaxy; their full run lasting up to 80 times longer than astronomers had previously thought for individual, localized events. The longer duration may affect how dwarf galaxies change over time, and influence galactic evolution as a whole.



NCG 4163 is a dwarf galaxy found in the constellation of Canes Venatici. It is classified as a "starburst galaxy" because of its significantly elevated star formation rate compared with other similar galaxies. NGC 4163 is located at a distance of 9.5 million light-years from the solar system.

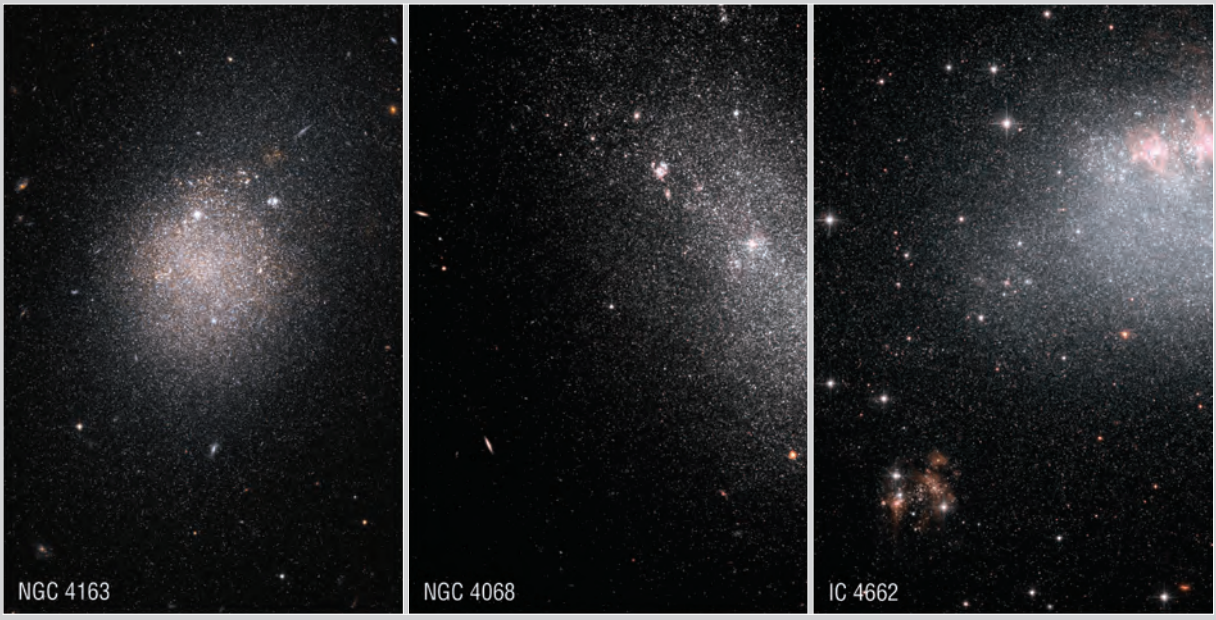
The analysis, led by Kristen McQuinn of the University of Minnesota in Minneapolis, shows that starburst activity in a dwarf galaxy occurs on a galaxy-wide scale. Pockets of intense star formation propagate throughout the galaxy like bursts along a string of firecrackers. According to McQuinn and her team, the duration of all the starburst events in a single dwarf galaxy can extend 200 million to 400 million years. This timescale is longer than the 5 million to 10 million years proposed by astronomers who have studied star cluster formation in dwarfs—they were looking only at individual clusters, and not whole galaxies. A typical dwarf galaxy is 10,000 to 30,000 light-years wide, about a third the size of the Milky Way. Since dwarfs are considered by many astronomers to be the building blocks of the large galaxies seen today, the length of starburst activity is important for understanding how galaxies evolve.

The researchers analyzed archival Advanced Camera for Surveys data of three dwarf galaxies: NGC 4163, NGC 4068, and IC 4662. Their distances range from 8 million to 14 million light-years. The trio is part of a survey of starbursts in 18 nearby dwarf galaxies. *Hubble*'s superb resolution allowed McQuinn's team to pick out individual stars in the galaxies and measure their brightnesses and colors, two important characteristics used to determine stellar ages. By establishing the ages of the stars, the astronomers could reconstruct the starburst history in each galaxy.

Two of the galaxies, NGC 4068 and IC 4662, show active, brilliant starburst regions in the *Hubble* images; this activity is occurring "now." However, the most recent starburst in the third galaxy, NGC 4163, occurred 200 million years ago and has faded from its original brightness. The team looked at regions of high and low densities of stars, and pieced together a picture of the starburst activity in all three galaxies. In the past, the galaxies were producing approximately eight stars every thousand years—a low-to-average rate. Then something happened, perhaps an encounter with another galaxy, which increased this rate by a factor of 5 to 40 new stars per thousand years—a lot for a small galaxy.

About 300 million to 400 million years ago star formation occurred in the outer areas of these galaxies. It then migrated inward as explosions of massive stars triggered new star formation in adjoining regions. Starbursts are still occurring in the inner parts of NGC 4068 and IC 4662. The total duration of starburst activity depends on many factors, including the amount of gas in a galaxy, the distribution and density of the gas, and the event that triggered the starburst. A merger or an interaction with a large galaxy, for example, could create a longer starburst event than an interaction with a smaller system.

Starbursts are commonly seen in distant, hence older, galaxies. In that epoch, galaxies had more gas with which to make stars, and interactions between galaxies occurred more frequently, because the expanding universe was younger, smaller, and denser. McQuinn plans to expand her study to a larger sample of more than 20 nearby galaxies. Studying these galaxies, she can view the starburst process in great detail. This research will help astronomers to better interpret the more distant observations.



These images show myriad stars residing in the central regions of the three dwarf galaxies NGC 4163, NGC 4068, and IC 4662. The bluish dots are younger stars; the reddish dots, older stars. The irregularly shaped red blobs in the images of NGC 4068 and IC 4662 are regions of current starburst activity—areas of intense star formation. These sites are bathed in ionized hydrogen gas, which glows red. Starbursts continue up to 80 times longer than first thought, and can last 200 million to 400 million years. These galaxies show that starbursts are not isolated events, but sweep across a galaxy.

Further Reading

"Astronomy: Twinkle Twinkle, Lots of Stars," *Nature*, **459**, 810, 2009.http://www.nature.com/nature/journal/v458/n7240/full/458810c.html

"Dwarf Galaxies Prove Persistent," *Astronomy & Geophysics*, **50**, 3.07, 2009. http://www3.interscience.wiley.com/cgi-bin/fulltext/122414125/HTMLSTART

McQuinn, K.B.W., et al., "The True Durations of Starbursts: Hubble Space Telescope observations of three nearby dwarf starburst galaxies," *The Astrophysical Journal*, **695**, 561–573, 2009.

"Starbursts in Dwarf Galaxies are a Global Affair," 2009. http://www.physorg.com/news160318098.html

Tolstoy, E., et al., "Star-Formation Histories, Abundances, and Kinematics of Dwarf Galaxies in the Local Group," *Annual Review of Astronomy and Astrophysics*, **47**, 371–425, 2009.

Update

McQuinn and her team extended their analysis to 20 nearby dwarf galaxies and found that the starburst durations range from 450–650 Myr in 15 of the galaxies and up to 1.3 Gyr in four galaxies. These longer durations are comparable to or longer than the rotational period of each system, suggesting that these starbursts have an important impact on the evolution of the host galaxies. While five of the galaxies presented fossil bursts, 15 show ongoing bursts and thus the final durations may be longer than reported. One galaxy shows a burst just beginning over the last 20 Myr. The bursts are responsible for creating between 3%–26% of the host galaxy's stellar mass. With few exceptions, the bursts are not centrally concentrated, but distributed across the disks of the systems. All observations used in the study were archival and originally obtained from either the *Hubble* ACS or WFPC2 instruments.

Additional References

McQuinn, K.B.W., "The Nature of Starbursts. I. The Star Formation Histories of Eighteen Nearby Starburst Dwarf Galaxies," *The Astrophysical Journal*, **721**, 297–317, 2010.

McQuinn, K.B.W., "The Nature of Starbursts. II. The Duration of Starbursts in Dwarf Galaxies," The Astrophysical Journal, **724**, 49–58, 2010.

Dr. Kristen McQuinn researches how small "dwarf" galaxies in the local universe evolve due to intense bursts of star formation that last hundreds of millions of years. Born in Bethpage, New York, her interest in physics was cultivated by her high school physics teacher and led to her studying physics and mechanical engineering at Lehigh University. She earned her B.S. in 1990, and after a decade in business, she returned to academics to earn her M.S. in astrophysics in 2001 at Boston University. McQuinn received her Ph.D. from the University of Minnesota, where she is currently a post-doctorate fellow. Her research includes data from three of NASA's space telescopes. In addition to her research, she is active in her community by bringing science and astronomy lessons to local elementary schools.