Galaxy seen shuddering from ancient collision

High-resolution portrait of Andromeda reveals patterns of star formation.

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Thousands of Hubble Space Telescope exposures went into creating this image, which can also be seen in a zoomable version here.

Using thousands of exposures from the Hubble Space Telescope, astronomers have created the sharpest and deepest image ever assembled of the Andromeda galaxy. The 100,000-pixel-wide composite picture suggests that the galaxy was clobbered in a major collision with another galaxy some 2 billion years ago, says one of the authors of the study.

The mosaic, which covers about one-quarter of the Milky Way's nearest twin, shows evidence of a galaxy-wide wave of star birth that could have been triggered by such an ancient impact, astronomer Benjamin Williams of the University of Washington in Seattle told *Nature*.

The project, known as the PHAT (Panchromatic Hubble Andromeda Treasury), used all three of Hubble's cameras and combined 7,398 ultraviolet, visible-light and infrared exposures taken between July 2010 and October 2013. It was presented at a meeting of the American Astronomical Society in Seattle on 5 January.

Assembling a similar portrait of the Milky Way would be impossible because observations of our home Galaxy are obscured by dust and confounded by stars that lie along the same line of sight but at different distances from Earth, says team leader Julianne Dalcanton, also an astronomer at the University of Washington. The high-resolution views of Andromeda, which lies a relatively nearby 779,000 parsecs (2.5 million light years) from Earth, therefore afford one of the best opportunities to learn about the evolution of a spiral galaxy like the Milky Way, she adds.

Insights from a neighbour

To refine models of star formation and stellar evolution, astronomers have until now relied in large part on two satellite galaxies of the Milky Way known as the Magellanic Clouds, says astronomer Charles Conroy of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, who is not part of the PHAT team. But, he says, these galaxies are much less massive than the Milky Way, and their stars have, on average, a different composition. By contrast, Andromeda is an excellent analogue for the Milky Way. "By studying Andromeda, we really will gain tremendous insight into how stars form and evolve in our backyard," he says.

PHAT is the most detailed survey of individual stars — 117 million in all — in a galaxy beyond the Milky Way, covering a region spanning 18,700 parsecs (61,000 light years) end to end. Because the infrared images reveal emission from dust, which is a tracer of the gas that provides the raw material for making stars, the images also provide new information on star formation in the galaxy, she adds.

"What's really fantastic about this work is that it is done on small spatial scales, so it's

the most finely spatially resolved star-formation history of Andromeda to date," says Alexia Lewis of the University of Washington. Using the information on dust and the colours of the stars, which together reveal accurate ages of the individual stars, Lewis reconstructed the last half-billion years of star-formation history of the imaged section of Andromeda (see video).

"You can actually see how the star formation moves through the galaxy and changes strength with time," says Dalcanton.

The biggest surprise in Lewis's video is that a well-documented ring of star formation in Andromeda, thought to be a fleeting feature, has persisted over the past 400 million to 500 million years. Star formation occurs in regions that have a supply of molecular gas; once that gas is depleted, star birth stops, Lewis notes. The longevity of the ring-like feature, dubbed the 10-kiloparsec ring, indicates either that the region had an unusually large supply of such gas to begin with, or that some mechanism is continually funnelling fresh gas into the ring, she says. Either way, "It's a puzzle," says Dalcanton.

But the survey also hints at an even older, galaxy-wide wave of starbirth, says Williams. Other researchers had found evidence of such a wave in the outskirts of one section of Andromeda's disk[1], but "no one would have guessed it was galaxy-wide", he says.

The PHAT survey lets astronomers "trace back a significant structural element of Andromeda, which in turn suggests a major event in that galaxy billions of years ago", says Conroy. "All of this is enabled, fundamentally, by resolving a galaxy into its constituent stars."

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References

1. Bernard, E. J. *et al. Mon. Not. R. Astron. Soc.* **446**, 2789–2801 (2015).