New tidal streams found in Andromeda reveal history of galactic mergers

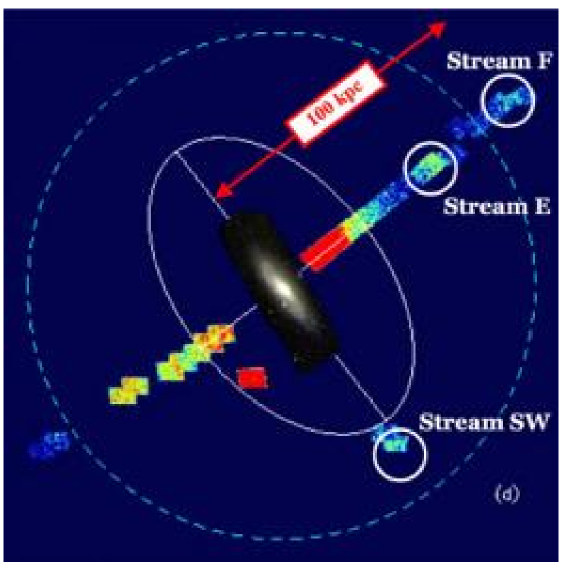
January 7 2010, By Tim Stephens

The traditional view of the Andromeda galaxy (above) shows only its bright bulge and inner disk, extending to about 65,000 light years from the galaxy's center. The stellar halo in which new tidal streams were found extends more than 500,000 light years from the center. The image below is a false-color map of the density of red giant stars in Andromeda, showing the newly discovered tidal streams in the stellar halo, with the traditional view of the galaxy in the central inset. Images courtesy of P. Guhathakurta.

(PhysOrg.com) -- An international team of astronomers has identified two new tidal streams in the Andromeda galaxy, the remnants of dwarf galaxies consumed by our large galactic neighbor. Analysis of the stars in Andromeda's tidal streams and other components of its extended halo is yielding new insights into the processes involved in the formation and evolution of massive galaxies, said Puragra Guhathakurta, professor of astronomy and astrophysics at the University of California, Santa Cruz.

Guhathakurta's team presented the latest results from studies of the newly discovered tidal streams on Thursday, January 7, at the 215th meeting of the American Astronomical Society in Washington, D.C.

In the currently favored "Lambda Cold Dark Matter" paradigm of structure formation in the universe, the outer halos of large galaxies like our Milky Way galaxy and the neighboring Andromeda galaxy (also known as M31) are built up through the merger and dissolution of smaller "dwarf" satellite galaxies. "This process of galactic cannibalism is an integral part of the growth of galaxies," Guhathakurta said.



The smooth, well-mixed population of halo stars in these large galaxies represents the aggregate of the dwarf galaxy victims of this cannibalism process, while the dwarf galaxies that are still intact as they orbit their large parent galaxy are the survivors of this process.

"The merging and dissolution of a dwarf galaxy typically lasts for a couple billion years, so one occasionally catches a large galaxy in the act of cannibalizing one of its dwarf galaxy satellites," Guhathakurta said. "The characteristic signature of such an event is a tidal stream: an enhancement in the density of stars, localized in space and moving as a coherent group through the parent galaxy."

Tidal streams are important because they represent a link between the victims and survivors of galactic cannibalism--an intermediate stage between the population of intact dwarf galaxies and the well-mixed stars dissolved in the halo.

The Andromeda galaxy is a unique test bed for studying the formation and evolution of a large galaxy, said Guhathakurta, who leads the Spectroscopic and Photometric Landscape of Andromeda's Stellar Halo (SPLASH) collaboration, a large survey of red giant stars in Andromeda. "Our external vantage point gives us a global perspective of the galaxy, and yet the galaxy is close enough for us to obtain detailed measurements of individual red giant stars within it," he said.

In a project led by collaborators Mikito Tanaka and Masashi Chiba of Tohoku University, Japan, the researchers used the Subaru 8-meter telescope and Suprime-Cam camera to map the density of red giant stars in large portions of the Andromeda galaxy, including the hitherto uncharted north side. This led to the discovery of two tidal streams to the northwest (streams E and F) at projected distances of 60 and 100 kiloparsecs (200,000 and 300,000 light years) from Andromeda's center. The study also confirmed a few previously known streams, including the little-studied diffuse stream to the southwest (stream SW), which lies at a projected distance of 60 to 100 kiloparsecs (200,000 to 300,000 light years) from Andromeda's center.

The SPLASH team has followed up with a spectroscopic survey of several hundred red giant stars in Streams E, F, and SW, using the Keck II 10-meter telescope and DEIMOS spectrograph at the W. M. Keck Observatory in Hawaii. The spectrograph spreads out the light from each star into a spectrum, which allows astronomers to measure the velocity of the star and distinguish Andromeda red giant stars from foreground stars in the Milky Way. The spectral data confirmed the presence of coherent groups of Andromeda red giant stars moving with a common velocity.

One of the next steps will be to measure the detailed chemical properties of red giant stars in these newly discovered tidal streams in Andromeda. Comparing the chemical properties of tidal streams, intact dwarf satellites, and the smooth halo will be of particular significance, Guhathakurta said.

Complex elements such as iron, magnesium, and calcium in the outer layers of a red giant star were produced within previous generations of massive stars that ended their lives as supernova explosions, spewing out newly forged elements into the interstellar medium. Thus, the fraction of complex elements found in stars indicates the degree to which the host galaxy's gas (the raw material from which new stars are formed) was enriched by supernova explosions from successive generations of massive stars.

"Massive galaxies like the Milky Way and Andromeda are very effective at recycling chemicals and therefore contain stars like our Sun that are relatively rich in complex elements--rich enough for rocky planets to have formed and for those planets to contain complex molecules such as proteins," Guhathakurta said.

Dwarf galaxies are less effective at recycling chemicals than massive galaxies. This is partly because the weaker gravity of a dwarf galaxy makes it harder for it to retain the chemically enriched gas that is blown out of massive stars during supernova explosions. As a result, stars in dwarf galaxies are more anemic (have a smaller fraction of complex elements) than those in the interior of massive galaxies. Moreover, the action of merging with a larger galaxy causes a dwarf galaxy to lose its gas, breaking the chemical cycle altogether.

"Dwarf galaxy cannibalism victims have had less time to recycle their chemicals than dwarf galaxy survivors, and this should be reflected as a difference between their chemical properties," Guhathakurta said. "Tidal streams should be somewhere between the victims and the survivors in terms of their chemical properties."

At the present time, detailed studies of the chemical properties of tidal streams, intact dwarf satellites, and smooth stellar halos are possible only in the Milky Way and Andromeda galaxies and their immediate surroundings. Existing telescopes and instruments are simply not powerful enough for astronomers to carry out such studies in more distant galaxies. This situation will improve greatly with the advent of the planned Thirty Meter Telescope later in this decade, Guhathakurta said.

Provided by University of California - Santa Cruz

Citation: New tidal streams found in Andromeda reveal history of galactic mergers (2010, January 7) retrieved 25 April 2024 from https://phys.org/news/2010-01-tidal-streams-andromeda-reveal-history.html