Milky Way May Fling Stars From Its Center

The Milky Way may catapult stars into its outer halo, astronomers report.
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In new research, astronomers have shown that clusters of supernovas can cause the birth of scattered, eccentrically orbiting suns in outer stellar halos.

The findings upend commonly held notions of how star systems have formed and evolved over billions of years.

Hyper-realistic, cosmologically self-consistent computer simulations from the Feedback in Realistic Environments 2 project enabled the scientists to model the disruptions in otherwise orderly galactic rotations.

"These highly accurate numerical simulations have shown us that it's likely the Milky Way has been launching stars in circumgalactic space in outflows triggered by supernova explosions," says senior author James Bullock, dean of the University of California, Irvine's School of Physical Sciences and a professor of physics and astronomy.

"It's fascinating, because when multiple big stars die, the resulting energy can expel gas from the galaxy, which in turn cools, causing new stars to be born."

Bullock says the diffuse distribution of stars in the stellar halo that extends far outside the classical disk of a galaxy is where the "archeological record" of the system exists. Astronomers have long assumed that galaxies are assembled over lengthy periods of time as smaller star groupings come in and are dismembered by the larger body, a process that ejects some stars into distant orbits. But the team is proposing "supernova feedback" as a different source for as many as 40% of these outer-halo stars.

Lead author Sijie Yu, a PhD candidate in physics, says the availability of a powerful new set of tools are partly why the findings are possible.

“The FIRE-2 simulations allow us to generate movies that make it seem as though you’re observing a real galaxy,” she notes. “They show us that as the galaxy center is rotating, a bubble driven by supernova feedback is developing with stars forming at its edge. It looks as though the stars are being kicked out from the center.”

Bullock says he did not expect to see such an arrangement because stars are such tight, incredibly dense balls and generally not subject to being moved relative to the background of space. “Instead, what we’re witnessing is gas being pushed around,” he says, “and that gas subsequently cools and makes stars on its way out.”

The researchers say that while they’ve drawn their conclusions from simulations of galaxies forming, growing, and evolving to the present day, there is actually a fair amount of observational evidence that stars are forming in outflows from galactic centers to their halos.

“In plots that compare data from the European Space Agency’s Gaia mission, which provides a 3D velocity chart of stars in the Milky Way, with other maps that show stellar density and metallicity, we can see structures similar to those produced by outflow stars in our simulations,” Yu says.

Bullock adds that mature, heavier, metal-rich stars like our sun rotate around the center of the galaxy at a predictable speed and trajectory. But the low-metallicity stars, subjected to fewer generations of fusion than our sun, rotate in the opposite direction.

He says that over the lifespan of a galaxy, the number of stars produced in supernova bubble outflows is small, around 2%. But during the parts of galaxies’ histories when starburst events are booming, as many as 20% of stars form this way.

“There are some current projects looking at galaxies that are considered to be very ‘starbursting’ right now,” Yu says. “Some of the stars in these observations also look suspiciously like they’re getting ejected from the center.”

The research appears in the *Monthly Notices of the Royal Astronomical Society*.

Additional researchers from UC Davis, UC San Diego, the University of Pennsylvania, the Flatiron Institute, the University of Texas at Austin, NASA's Jet Propulsion Laboratory, the California Institute of Technology, and Northwestern University contributed to the work. The National Science Foundation and the Heising-Simons Foundation supported the research.

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