Map of universe questioned: Dwarf galaxies don't fit standard model

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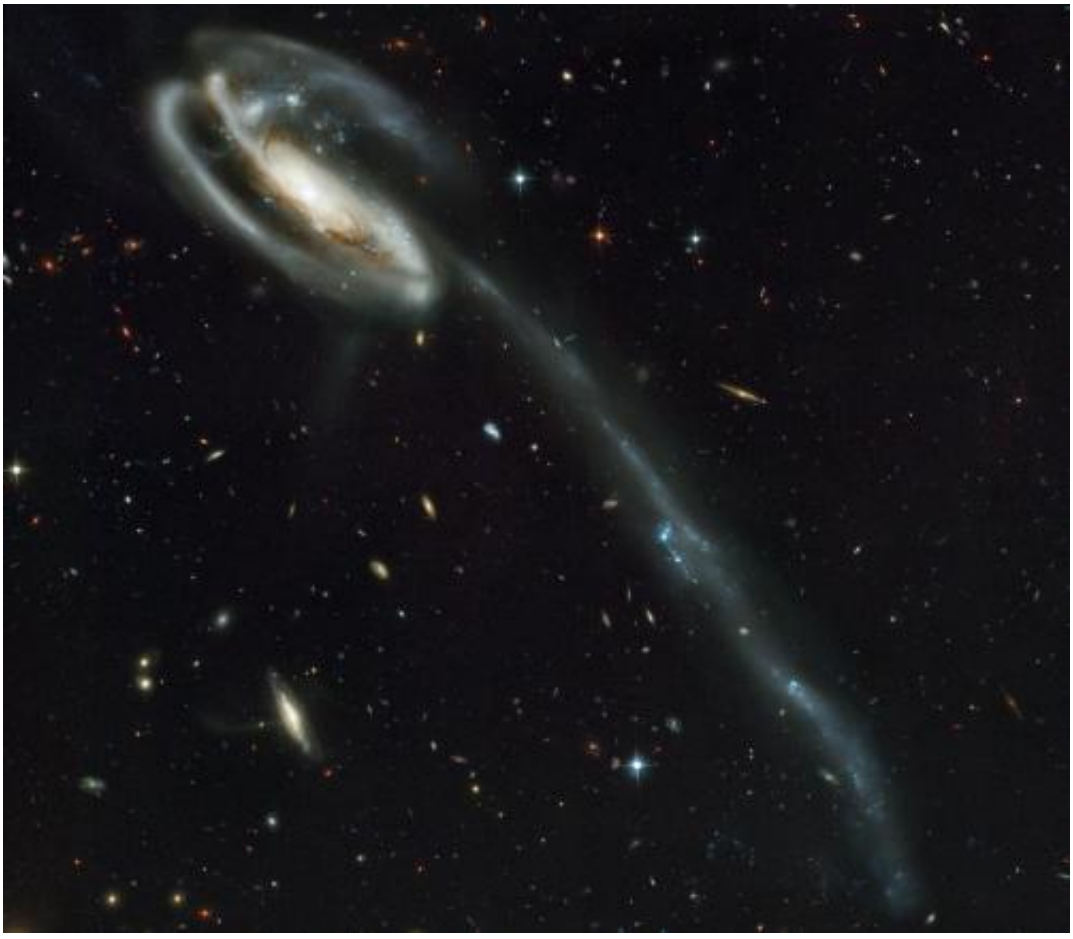

Material stripped from the galaxy during its collision with a smaller galaxy (seen in the upper left corner of the larger interaction partner) forms a long tidal tail. Young blue stars, star clusters and tidal dwarf galaxies are born in these tidal debris. These objects move in a common direction within a plane defined by the orientation and motion of their tidal tail. A similar galaxy interaction might have occurred in the Local Group in the past, which could explain the distribution of dwarf galaxies in co-rotating planes. Credit: NASA, Holland Ford (JHU), the

Satellite dwarf galaxies at the edges of the Milky Way and neighboring Andromeda defy the accepted model of galaxy formation, and recent attempts to pigeon-hole them into the model are flawed, an international team of scientists reports.

The mismatch raises questions about the accuracy of the standard model of cosmology, which is the widely accepted paradigm for the origin and evolution of the universe, the astrophysicists say.

A preprint of the research paper, accepted for publication by the *Monthly Notices of the Royal Astronomical Society*, is online at http://arxiv.org/abs/1406.1799.

The standard model, also called the "lambda cold dark matter model," says that satellite dwarf galaxies in the Milky Way and Andromeda are expected to behave a certain way: The galaxies would form in halos of dark matter, be widely distributed and would have to move in random directions, said Marcel Pawlowski, a postdoctoral researcher in the astronomy department at Case Western Reserve University and lead author of the new study.

"But what astronomers see is different," Pawlowski said. "We see the satellite galaxies are in a huge disk and moving in the same direction within this disk, like the planets in our solar system moving in a thin plane in one direction around the sun. That's unexpected and could be a real problem."

In the Milky Way, the dwarf galaxies and accompanying star clusters and streams of stars are in what's called the Magellanic plane, or what the

authors call the Vast Polar Structure; and in Andromeda, half of the satellites are in the Great Plane of Andromeda.

Pawlowski and 13 co-authors from six different countries examined three recent papers by different international teams that concluded the planar distributions of galaxies fit the standard model.

"When we compared simulations using their data to what is observed by astronomers, we found a very substantial mismatch," Pawlowski said.

With computers, the researchers simulated mock observations of thousands of Milky Ways using the same data as the three previous papers. They found just one of a few thousand simulations matched what astronomers actually observe around the Milky Way.

"But we also have Andromeda," Pawlowski said. "The chance to have two galaxies with such huge disks of satellite galaxies is less than one in 100,000."

When the researchers corrected for flaws they say they found in the three studies, they could not reproduce the findings made in the respective papers.

"The standard model contains various putative ingredients— such as dark matter and dark energy —which were introduced because the model wasn't consistent with observations," said Benoit Famaey, a senior research associate at the University of Strasbourg in France, and co-author of the study.

Famaey and the other authors are among a small but growing number of astrophysicists who find the standard model fails to replicate what's observed and therefore they seek alternatives.

Dark matter is thought to be an as-yet undetected matter that provides galaxies with enough mass to prevent the speed of their rotation from pulling them apart. If present, the unseen cloud of matter would be extremely unlikely to result in the planar structures seen.

The authors suggest an alternative and older explanation for the satellite dwarf galaxies: a collision between two galaxies. The collision may have ripped material from the galaxies and thrown it a great distance, much like tides on Earth. The resulting tidal dwarf galaxies are formed from the debris.

"Standard galaxies must contain dark matter, but tidal galaxies cannot contain dark matter," said Pavel Kroupa, a co-author of the study and a professor at the University of Bonn in Germany.

"There's a very serious conflict, and the repercussion is we do not seem to have the correct theory of gravity"

The group will continue to study tidal dwarf galaxies and whether another alternative to the standard model—modified gravity—fits what they observe.

The researchers say science may initially balk at the premise but has historically embraced challenges to accepted theories, and for good reason.

"When you have a clear contradiction like this, you ought to focus on it," said David Merritt, professor of astrophysics at Rochester Institute of Technology and co-author of the new study. "This is how progress in science is made."

Provided by Case Western Reserve University