PRESS RELEASE

Program Contact:
Peter Barnes
Senior Research Scientist
pbarnes@spacescience.org

IMMEDIATE RELEASE September 3, 2025

NEW VIEWS OF THE 3D ARCHITECTURE OF THE SOUTHERN MILKY WAY

https://doi.org/10.3847/1538-4365/adf32b
To be published in The Astrophysical Journal Supplement Series, 280, 31

September 3, 2025

Astronomers announced today the results of a new study into the 3D structure of the Milky Way, specifically for the cold gas where new stars form among our Galaxy's existing stars.

The Milky Way is a large spiral galaxy similar to many others that we can see in images from the Hubble or Webb space telescopes. Spiral galaxies are mostly circular and flat, where the stars and gas within them tend to orbit the galaxy's center in an orderly way, somewhat like the planets in our Solar System orbiting the Sun. The other main type of galaxy in the Universe, ellipticals, are rounder and more football-shaped, since their stars orbit their centers in somewhat more random directions.

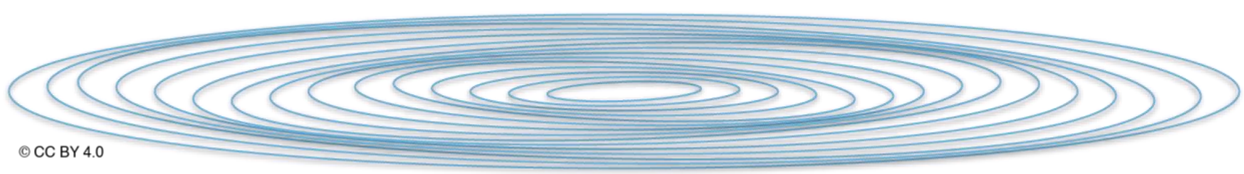
In spiral galaxies, gas tends to gather along the spiral arms, where gravity collects and compresses cold, dense gas, forming new stars. This ongoing star formation drives the overall evolution of the galaxy. Elliptical galaxies have much less gas and much less new star formation than spirals, so their evolution is slower.

Understanding the structure and evolution of the Milky Way is tricky from our position within it, since it's not always clear whether the features we are looking at are near the Sun or further away. For example, while nearer stars and clouds are easier to see, they also tend to get in the way of studying features on (say) the other side of the Galaxy. So, a complete picture of the whole Milky Way is difficult to assemble, and techniques which can place objects at their correct distance are therefore very valuable to our understanding of the Milky Way's actual structure and evolution.

The Three-millimeter Ultimate Mopra Milky Way Survey (ThrUMMS) is one such study of the cold gas cloud population in the southern Milky Way. While compiling data on the star formation activity of these clouds, the ThrUMMS team (led by PI Peter Barnes at the Space Science Institute in Boulder, CO) also discovered previously unnoticed features of their overall distribution in the Milky Way.

The team's first discovery was that the flat, spiral structure of the Milky Way is actually not so flat after all. By carefully measuring the distance to each of the cold gas clouds, they were also able to map how far above or below the midplane (the "Galactic Equator") they were. When this is done for all the clouds, they found that the average height (above or below) varies systematically with distance across the disk, so as to form a large-scale ripple pattern in the overall heights across the disk. This pattern seems to be quite widespread, and stretches most of the way to the Galaxy's center. (See first illustration below, or Fig C31 in the paper.)

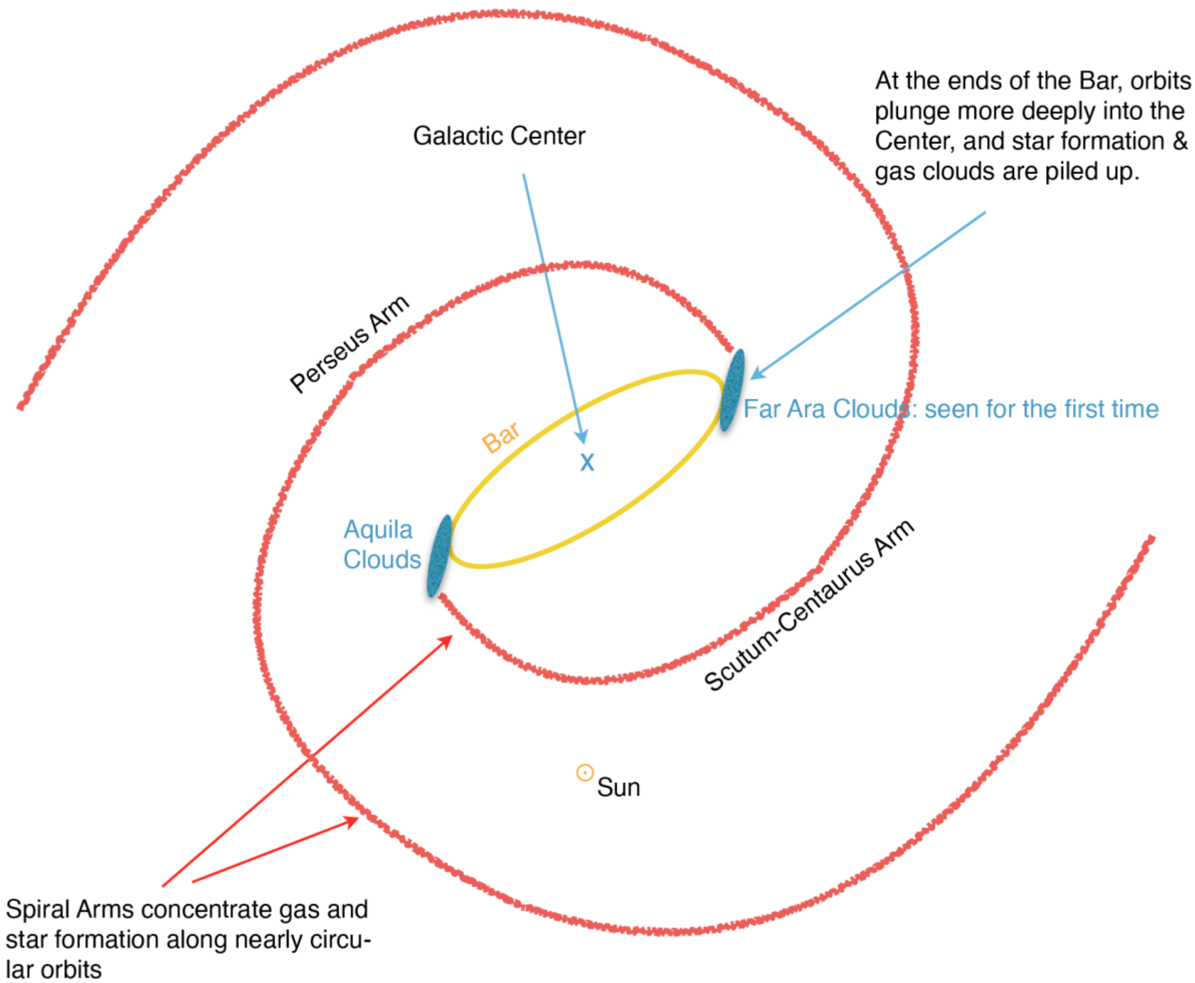
Ripples in the Midplane (side view)



What might cause such a ripple pattern to appear in the otherwise flat disk of the Milky Way? Computer models suggest that a close encounter (perhaps 200 million years ago) with one of the Milky Way's small satellite galaxies, the Sagittarius Dwarf, may have caused this ripple in our Galaxy's structure. The gravitational pull from the dwarf galaxy likely disrupted the normal orbits. If this is correct, the Milky Way can be understood to be "ringing like a bell" from the impact with the dwarf.

The other unexpected discovery was to identify, for the first time, a unique, large-scale feature on the other side of the Galaxy. The Milky Way turns out to be a "barred spiral" galaxy, unlike most normal spirals, where the graceful pattern of spiral arms goes all the way into the galaxy's center. About 10% of spirals have a "bar" in their centers, where the spiral structure going inwards is abruptly terminated by a straight line of stars and gas across the center. For the Milky Way, it was only recognized to have a bar about 20 years ago, and some of the features at the near end of the bar — in the direction of the constellation Aquila, about 18,000 light-years away from the Sun — have only been understood as such since then. (See second illustration below.)

The Milky Way as a Barred Spiral Galaxy (face-on view)



In contrast, the new features — in the direction of the constellation Ara, so "Far Ara Clouds" — probably lie at the far end of the bar (about 35,000 light-years away), and have only now been identified for the first time. They are unique because the bar's ends are where the more orderly, nearly circular orbits of stars and clouds transition into the "plunging" orbits of the bar material, and this change causes a mass pileup to occur, stimulating (for example) vigorous star formation activity. This means that the Far Ara Clouds will provide new opportunities to study the Milky Way's structure and evolution at large distances from the Sun.

The ThrUMMS team members for this study are:

Peter Barnes, Space Science Institute, Boulder CO 80301
Dylan Barnes, Florida Institute of Technology, Melbourne FL 32901
Audra Hernández, University of Wisconsin, Madison WI 53706
Sebastian Lopez, Ohio State University, Columbus OH 43210
Erik Muller, University of Sydney, NSW 2006, Australia

About SPACE SCIENCE INSTITUTE

Space Science Institute (SSI) is a nonprofit, public benefit research and education 501(c)(3) corporation founded in 1992 with a vision to expand humankind's understanding and appreciation of planet Earth, our Solar System, and the universe beyond. SSI's mission is to (a) enable scientists to make new discoveries, (b) increase science and technology literacy for people of all ages and backgrounds, and (c) inspire youth to pursue science-technology education and career opportunities. It is headquartered in Boulder, Colorado, with locations distributed across the U.S. and internationally.

www.spacescience.org

SSI scientists work on many prestigious space missions, including but not limited to the Mars Exploration Rovers, Rosetta, Cassini, Mars and Lunar Reconnaissance Orbiters, Mars Science Lander, Juno, ExoMars, OSIRIS-REx, and Mars 2020. Areas of research also include heliophysics, observational astronomy (with such facilities as Hubble Space Telescope, SOFIA), and exoplanets (Kepler). SSI's National Center for Interactive Learning (NCIL) fosters collaboration between scientists and educators to create nationally touring exhibits for museums and libraries, provide professional development and webinar training for science educators, and build popular digital games and apps with over a million hits.

ThrUMMS is based upon work funded by NSF through grant AST-2206584 to Space Science Institute. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
