Astronomers working out how galaxies' spiral arms form

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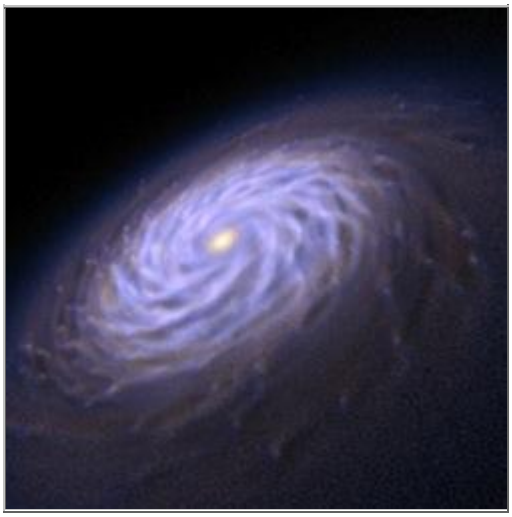
Courtesy of UW-Madison
and World Science staff

Not all galaxies are spiral-shaped. But those that are, exhibiting that majestic, pinwheel form that characterizes our galaxy and others, are perhaps the most emblematic of galaxies—the galactic image that has most captured the human imagination.



This image and the video animation below show a simulation of arm formation in spiral galaxies. The visualizations were created by Thiago Ize and Chris Johnson of the University of Utah's Scientific Computing and Imaging Institute.

Our solar system and Earth reside somewhere near one of the wispy, swept-back arms of the spiral Milky Way galaxy. And nearly 70 percent of the galaxies closest to us are spirals, suggesting they have taken the most ordinary of galactic forms in a universe with billions of galaxies.

But despite their common shape, how galaxies like ours get and maintain their characteristic arms has proved to be an enduring puzzle. How do the arms arise? Do they change or come and go?

The answers to these and other questions are coming into focus as researchers exploit powerful new computer simulations to follow the motions of as many as 100 million "stellar particles" or simulated stars as gravity and other astrophysical forces sculpt them into familiar galactic

shapes.

Writing April 1 in *The Astrophysical Journal*, a team of researchers report simulations that they say seem to resolve longstanding questions about the origin and life course of the arms.

“We show for the first time that stellar spiral arms are not transient features, as claimed for several decades,” said University of Wisconsin-Madison astrophysicist Elena D’Onghia, who led the research with Harvard-Smithsonian Center for Astrophysics colleagues Mark Vogelsberger and Lars Hernquist. “They are self-perpetuating, persistent and surprisingly long lived.”

Two theories on spiral arms have predominated. One holds that they come and go. A second, widely held idea is that the material in the arms – stars, gas and dust – is affected by differences in gravity and jams up, like cars at rush hour, sustaining the arms for long periods.

The new findings fall somewhere in between the two theories and suggest that the arms originate thanks to the influence of giant molecular clouds, star forming regions or stellar “nurseries” common in galaxies, the researchers said. Introduced into the simulation, the clouds, said D’Onghia, act as “perturbers” that are enough to not only trigger spiral arm formation but to sustain the arms indefinitely.

Click to play animation

“Past theory held the arms would go away with the perturbations removed, but we see that the arms self-perpetuate, even when the perturbations are removed,” she explained. “It proves that once the arms are generated through these clouds, they can exist on their own through [the influence of] gravity.”

The study modeled isolated galaxies. Some recent studies have explored the likelihood that spiral galaxies with a close neighbor — a nearby dwarf galaxy, for example — get their arms as gravity from the satellite galaxy pulls on the disk of its neighbor.

According to Vogelsberger and Hernquist, the new simulations can be used to reinterpret observations, looking at both the thick molecular clouds as well as gravitationally induced “holes” in galactic material as mechanisms driving the formation