Webb confirms a longstanding galaxy model

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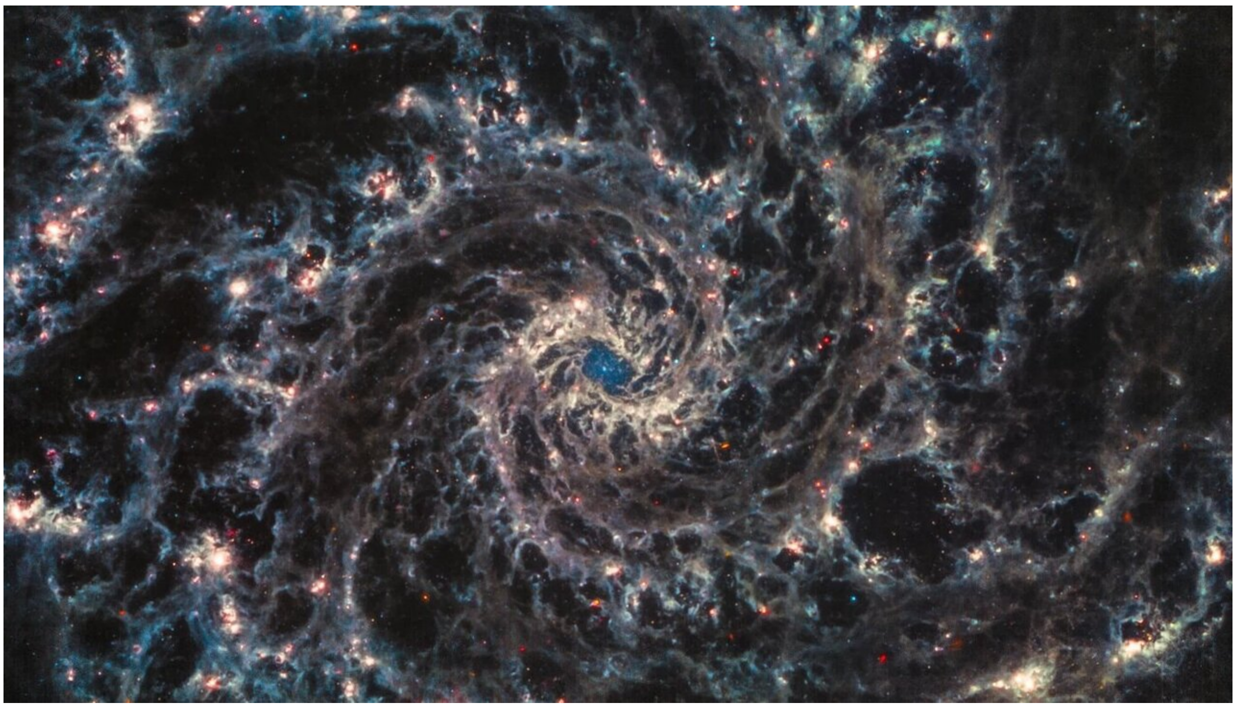

JWST image of the grand design spiral galaxy NGC 628. Credit: NASA / ESA / CSA / Judy Schmidt (CC BY 2.0)

Perhaps the greatest tool astronomers have is the ability to look backward in time. Since starlight takes time to reach us, astronomers can observe the history of the cosmos by capturing the light of distant galaxies.

This is why observatories such as the James Webb Space Telescope

(JWST) are so useful. With it, we can study in detail how galaxies formed and evolved. We are now at the point where our observations allow us to confirm long-standing galactic models, as a recent study shows.

This particular model concerns how galaxies become chemically enriched. In the early universe, there was mostly just hydrogen and helium, so the first stars were massive creatures with no planets. They died quickly and spewed heavier elements, from which more complex stars and planets could form.

Each generation adds more elements to the mix. But as a galaxy nurtures a menagerie of stars from blue supergiants to red dwarfs, which stars play the greatest role in chemical enrichment?

One model argues that it is the most massive stars. This makes sense because giant stars explode as supernovae when they die. They toss their enriched outer layers deep into space, allowing the material to mix within great molecular clouds from which new stars can form. But about 20 years ago, another model argued that smaller, more sunlike stars played a greater role.

Stars like the sun don't die in powerful explosions. Billions of years from now, the sun will swell into a red giant star. In a desperate attempt to keep burning, the core of a sun-like star heats up significantly to fuse helium, and its diffuse outer layers swell.

On the Hertzsprung-Russell diagram, they are known as asymptotic giant branch (AGB) stars. While each AGB star might toss less material into interstellar space, they are far more common than giant stars. So, the model argues, AGB stars play a greater role in the enrichment of galaxies.

The Cat’s Eye nebula is a remnant of an AGB star. Credit: ESA, NASA, HEIC and the Hubble Heritage Team, STScI/AURA

Both models have their strengths, but proving the AGB model over the giant star model would prove difficult. It's easy to observe supernovae in galaxies billions of light years away. Not so much with AGB stars. Thanks to the JWST, we can now test the AGB model.

Using JWST, the study, published in *Nature Astronomy*, looked at the spectra of three young galaxies. Since the Webb's NIRSpec camera can capture high-resolution infrared spectra, the team could see not just the presence of certain elements but their relative abundance.

They found a strong presence of carbon and oxygen bands, which is common for AGB remnants, but also the presence of more rare elements such as vanadium and zirconium. Taken altogether, this points to a type of AGB star known as thermally pulsing AGBs, or TP-AGBs.

Many red giant stars enter a pulsing phase at the end of their lives. The hot core swells the outer layers, things cool down a bit, and gravity compresses the star a bit, which heats the core, and the whole process starts over. This study indicates that TP-AGBs are particularly efficient at enriching galaxies, thus confirming the 20-year-old model.

More information: Shiying Lu et al, Strong spectral features from asymptotic giant branch stars in distant quiescent galaxies, *Nature Astronomy* (2024). DOI: 10.1038/s41550-024-02391-9

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