Astronomers find cosmic rays driving galaxy's winds

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Artist's illustration of cosmic ray driven winds (blue and green) superimposed on a visible-light image of the Triangulum galaxy M33 (red and white) observed with VLT Survey Telescope at ESO's Paranal Observatory in Chile. Credit: Institute for Research in Fundamental Sciences- IPM & European Southern

Astronomers using the National Science Foundation's Karl G. Jansky Very Large Array (VLA) have discovered an important new clue about how galaxies put the brakes on vigorous episodes of star formation. Their new study of the neighboring galaxy M33 indicates that fast-moving cosmic ray electrons can drive winds that blow away the gas needed to form new stars.

Such winds are responsible for slowing the rate of star formation as galaxies evolve over time. However, shock waves from supernova explosions and energetic, black hole-powered jets of material coming from galactic cores have been considered the primary drivers of those winds. Cosmic rays were thought to be minor contributors, particularly in galaxies like M33 that have regions of prolific star formation.

"We have seen galactic winds driven by cosmic rays in our own Milky Way and the Andromeda galaxy, which have much weaker rates of star formation, but not before in a galaxy such as M33," said Fatemah Tabatabaei, of the Institute for Research in Fundamental Sciences in Iran.

Tabatabaei and an international team of scientists made detailed, multi-wavelength VLA observations of M33, a spiral galaxy nearly 3 million light-years away and part of the Local Group of galaxies that includes the Milky Way. They also used data from previous observations with the VLA, the Effelsberg radio telescope in Germany, and millimeter-wave, visible-light, and infrared telescopes.

Stars much more massive than our sun speed through their life cycles, ultimately exploding as supernovae. The explosive shock waves can

accelerate particles to nearly the speed of light, creating cosmic rays. Enough of these cosmic rays can build pressure that drives winds carrying away the gas needed to continue forming stars.

"The VLA observations indicated that cosmic rays in M33 are escaping the regions where they are born, making them able to drive more extensive winds," said William Cotton, of the National Radio Astronomy Observatory.

Based on their observations, the astronomers concluded that the numerous supernova explosions and supernova remnants in M33's giant complexes of prolific star formation made such cosmic ray-driven winds more likely.

"This means that cosmic rays probably are a more general cause of galactic winds, particularly at earlier times in the universe's history, when star formation was happening at a much higher rate," Tabatabaei said. She added that "this mechanism thus becomes a more important factor in understanding the evolution of galaxies over time."

Tabatabaei, Cotton and their colleagues are reporting their findings in the October 25 issue of the *Monthly Notices of the Royal Astronomical Society*.

More information: S Tabatabaei et al, Cloud-scale radio surveys of star formation and feedback in Triangulum Galaxy M 33: VLA observations, *Monthly Notices of the Royal Astronomical Society* (2022). DOI: 10.1093/mnras/stac2514

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