Polarized shockwaves shake the universe's cosmic web

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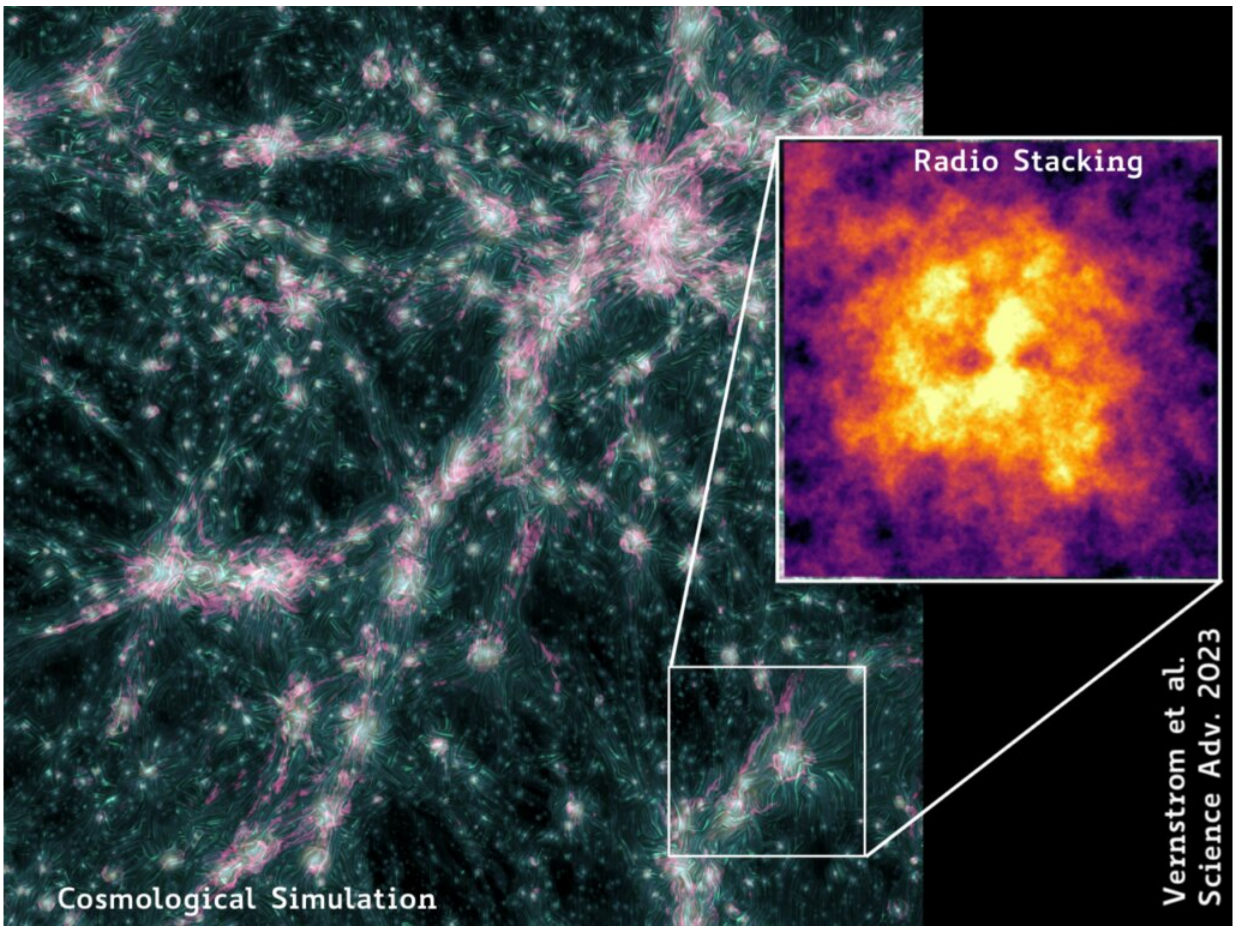


A composite image showing the magnetic fields of the cosmic web, featuring a pull out of how radio data was stacked. Credit: Vernstrom et al. 2023

ICRAR researchers have discovered tantalizing evidence of magnetic fields in the universe's largest cosmic structures.

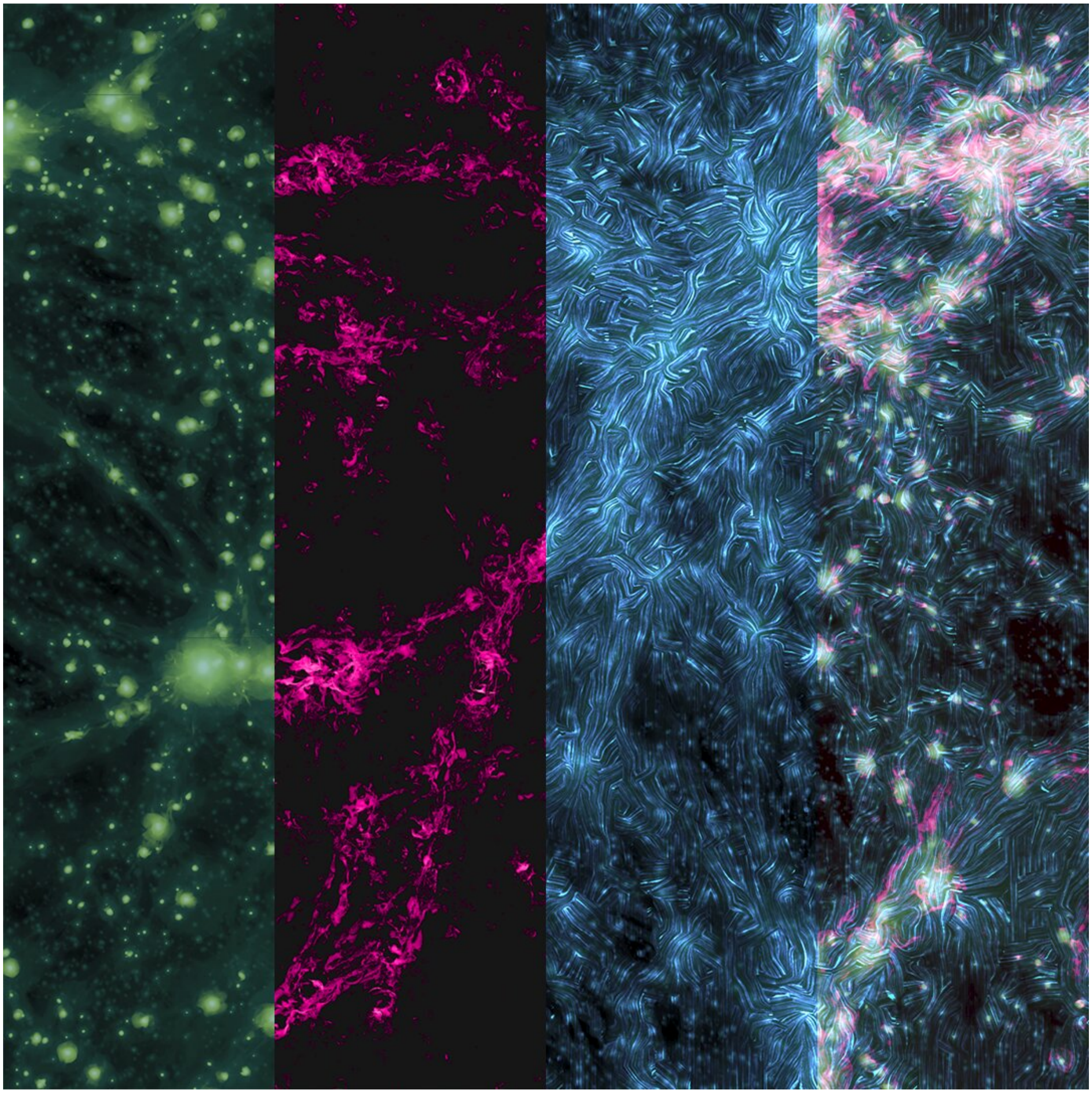
The cosmic web is how the universe looks at its largest scale—an interweaving web of filaments and clusters full of gases and galaxies which wind around cosmic voids millions of lightyears across.

This universe-spanning web was predicted by astrophysicists in the 1960s, with computer modeling giving us a glimpse of how this vast network truly looked in the 1980s.

Over the course of the past few decades, we've been able to map the Cosmic Web through observation, bringing with it the possibility of answering some of astronomy's biggest questions.

An area of particular interest is how magnetic fields behave on a cosmic scale, and what role they play in both galactic and cosmic structure formation.

New research published today in *Science Advances* and led by the International Center for Radio Astronomy Research (ICRAR) in partnership with CSIRO, Australia's national science agency, is helping us to further understand these cosmic magnetic fields.



A composite image of 3 different observations of the cosmic web (gas, radio and magnetic) accompanied by a composite image. Credit: Credit: F. Vazza, D. Wittor and J. West, Composition by K. Brown

Dr. Tessa Vernstrom from The University of Western Australia's (UWA) node of ICRAR, is the lead author of the research and describes magnetism as a fundamental force in nature.

"Magnetic fields pervade the universe—from planets and stars to the largest spaces in-between galaxies. However, many aspects of cosmic magnetism are not yet fully understood, especially at the scales seen in the cosmic web. When matter merges in the universe, it produces a shockwave which accelerates particles, amplifying these intergalactic magnetic fields," said Dr. Vernstrom.

Her research has recorded radio emissions coming from the cosmic web—the first observational evidence of strong shockwaves.

This phenomenon had previously only been observed in the universe's largest galaxy clusters and was predicted to be the "signature" of matter collisions throughout the cosmic web.

"These shockwaves give off radio emissions which should result in the cosmic web 'glowing' in the radio spectrum, but it had never really been conclusively detected due to how faint the signals are."

Dr. Vernstrom's team began searching for the cosmic web's "radio glow" in 2020 and initially found signals which could be attributed to these cosmic waves.

However, as these initial signals could have included emissions from galaxies and celestial objects other than the shockwaves, Vernstrom opted for a different signal type with less background "noise"—polarized radio light.

"As very few sources emit polarized radio light, our search was less prone to contamination and we have been able to provide much stronger evidence that we are seeing emissions from the shockwaves in the largest structures in the universe, which helps to confirm our models for the growth of this large-scale structure."

The research utilized data and all-sky radio maps from the Global Magneto-Ionic Medium Survey, the Planck Legacy Archive, the Owens Valley Long Wavelength Array, and the Murchison Widefield Array, stacking the data over the known clusters and filaments in the cosmic web.

The stacking method helps to strengthen the faint signal above the image noise, which was then compared to state-of-the-art cosmological simulations generated through the Enzo Project.

These simulations are the first of their kind to include predictions of the polarized radio light from the cosmic shockwaves observed as part of this research.

Our understanding of these magnetic fields could be used to expand and refine our theories on how the universe grows and has the potential to help us solve the mystery of the origins of cosmic magnetism.

More information: Tessa Vernstrom et al, Polarized accretion shocks from the cosmic web, *Science Advances* (2023). DOI: 10.1126/sciadv.ade7233

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