New system watches ionospheric weather conditions over the US southwest

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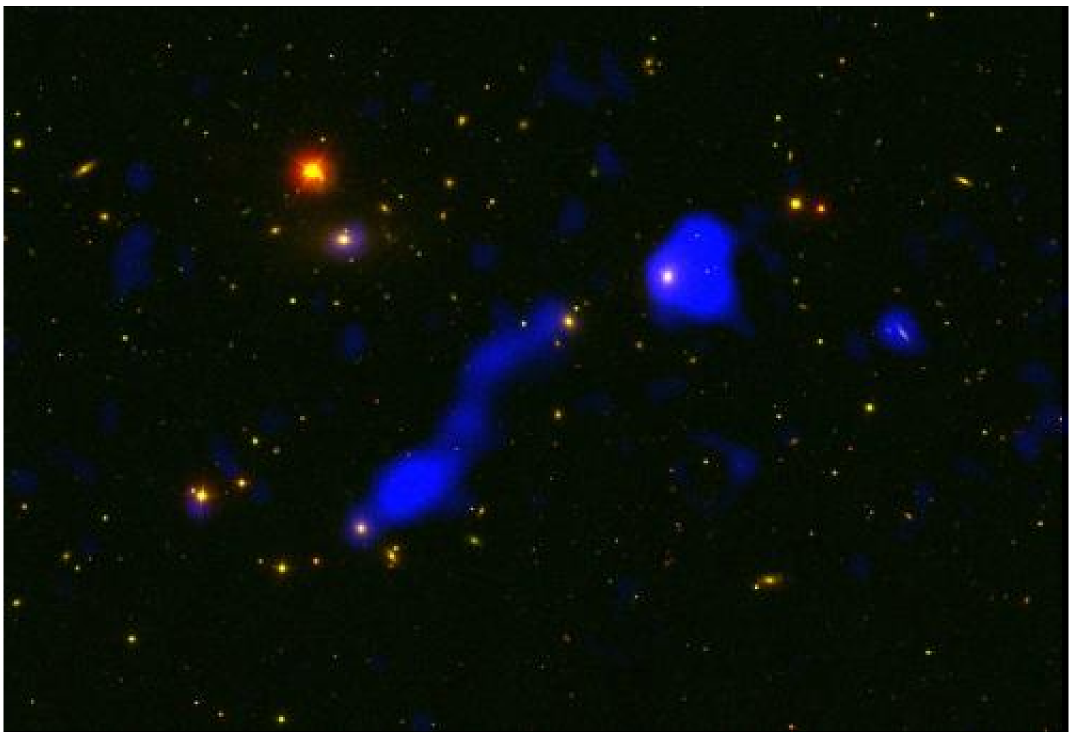

Radio (VLITE) and optical (SDSS) image showing the giant radio galaxy IC 711 and companions IC 708 and IC 712. All three systems are part of the distant galaxy cluster Abell 1314 and were serendipitously located in a field pointed at an unrelated low redshift galaxy. The radio data were fully processed through the VLITE pipeline and show the power of this new instrument. The field shown is the size of a full moon. Credit: Radio (blue) from VLA Low Band Ionospheric and Transient Experiment on the NRAO VLA. Optical (red and green) from the Sloan Digital Sky Survey. U.S. Naval Research Laboratory/Dr. Tracy Clarke

Imagine taking the world's most powerful radio telescope, used by scientists around the globe, and piping a nearly continuous data stream into your research laboratory. That is exactly what scientists at the Naval Research Laboratory (NRL) in Washington, D.C. have done in collaboration with the National Radio Astronomy Observatory's Karl G. Jansky Very Large Array (NRAO VLA). The newly-completed VLA Low Band Ionospheric and Transient Experiment (VLITE for short) has been built to piggyback on the $300 million dollar infrastructure of the VLA.

The primary scientific driver for VLITE is real-time monitoring of ionospheric weather conditions over the U.S. southwest. NRL ionospheric lead scientist Dr. Joseph Helmboldt says "This new system allows for continuous specification of ionospheric disturbances with remarkable precision. VLITE can detect and characterize density fluctuations as small as 30 parts per million within the total electron content along the line of sight to a cosmic source. This is akin to being at the bottom of Lake Superior and watching waves as small as 1-cm in height pass overhead. This will have a substantial impact on our understanding of ionospheric dynamics, especially the coupling between fine-scale irregularities within the lower ionosphere and larger disturbances higher up."

Ionospheric disturbances represent one of the most significant limitations to the performance of many radio-frequency applications like satellite-based communication and navigation (including the GPS in your phone) as well as ground-based, over-the-horizon systems (think ham radio or AM radio). While the fine-scale irregularities that VLITE is especially sensitive to aren't large enough to make your smart phone think you are at your neighbor's house when you're really at home, they are quite problematic for vital remote sensing surveillance systems like over-the-horizon radar. The additional insights provided by VLITE into the nature of these ionospheric ripples will help us to better understand how to cope with their effects on such systems.

"VLITE is also a powerful new tool in our arsenal for astrophysical research" says VLITE principle investigator Dr. Namir Kassim. He points out that "We know the Universe has many secrets including mysterious blips (so-called transients) that appear and vanish like fireflies in the night. Limited observing time at classical observatories hampers our ability to understand these intriguing objects. The power of VLITE is the nearly continual data stream over a large region of the sky. This opens up a new window on the transient Universe." At any given time, the region of the sky that VLITE peers at is so large that nearly 20 full moons would fit inside it.

Astrophysics lead scientist Dr. Tracy Clarke of NRL describes VLITE as "a symbiotic instrument that piggybacks on world-class science at the VLA. It operates as a stand-alone tool for ionospheric and astrophysical studies while at the same time VLITE provides the opportunity for enhanced science in the research program running on the VLA."

VLITE operations started with first light on July 17, 2014 but the real fun began two days before Thanksgiving, on November 25, 2014, when VLITE moved from a commissioning phase into full scientific operations. The system operates in real-time on 10 VLA antennas and provides 64 MHz of bandwidth centered on 352 MHz with a temporal resolution of 2s and a spectral resolution of 100 kHz.

This powerful new instrument operates in parallel with the VLA and is essentially 'driven' around the sky by the primary science observer. Data streams off the telescope through dedicated systems that bypass normal VLA operations. The data then take two roads, one through real-time processing on computers located at the VLA site, and the other through off-line processing at NRL's facility in Washington. Due to the large volume of nearly continuous incoming data, all data must be analyzed by an automated pipeline that was custom designed for VLITE. Pipeline designer Dr. Wendy Lane Peters of NRL describes this process as being like "sitting in the passenger seat of a Google car and not knowing where it is taking you. VLITE is along for the ride wherever the primary science program takes us. We have to anticipate what they might do so that our pipeline is smart enough to understand the incoming data."

Professor Bryan Gaensler, Director of the Dunlap Institute for Astronomy and Astrophysics at the University of Toronto, says that this is going to become the new way of doing astronomy. "It's a tragedy and a travesty that most of the information our telescopes gather from the sky is ignored and discarded. VLITE is part of a new generation of experiments that fully utilize the massive data torrents collected by the world's most powerful observatories."

Over the first two months of science operations, VLITE has recorded observations of sources ranging from the Sun, nearby stars and galaxies, to some of the most distant sources in the Universe. NRL astronomers and their colleagues have been poring over the pipeline images, improving their analysis pipeline and exploring the scientific potential of the instrument.

Provided by Naval Research Laboratory

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