VLBI: VERY LONG BASELINE INTERFEROMETRY AND THE STUDY OF THE UNIVERSE

RedIRIS and its advanced connectivity services, key in promoting cutting-edge research in the field of radio astronomy

Radio astronomy, a step further in understanding the Universe

Radio astronomy is a powerful tool for revealing the most hidden mysteries of the universe. Some celestial objects such as newly-formed stars and galaxies are only dimly visible with conventional telescopes because the clouds of dust and gas that surround them do not let light enter. Fortunately, since radio telescopes emit not only light, but also infrared and radio waves capable of crossing this barrier, the issue is solved. Thanks to them, discoveries surrounding protostars, protoplanetary cores and external galaxies have been made.

A collaborative, colossal radio telescope more powerful than any telescope on Earth

Traditionally, radio telescopes only worked on an individual scale. Very Long Baseline Interferometry (VLBI) is an astronomical technique in which multiple radio telescopes located very far from each other simultaneously observe the same region of the sky to obtain images that will be enhanced using the combination of individual data. VLBI, which incorporates the interference pattern, allows this network to behave as a single telescope with a diameter equal to the maximum separation between the participating antennas, which may be thousands of kilometres.

Important contributions of the VLBI network to non-astronomical fields

Using the technique of very long baseline interferometry, scientific advances have been made in other fields, such as the geodetic and geophysical areas: research on plate tectonics, the Earth's rotation and continental drift; the possibility of earthquake prediction, day length, changes in the tilt of the Earth's axis and tides, and the definition of a fundamental reference system for the Earth.

New technologies in interferometry: the e-VLBI

Thanks to the European project NEXPReS, the robustness of traditional VLBI has been enhanced by the speed and flexibility of the new electronic VLBI (e-VLBI), where data can also be correlated in real time. As added value, e-VLBI provides significant time savings and the ability to observe short-lived astronomical events such as supernova explosions or gamma-ray bursts.

Radio telescope in the Yebes Observatory (Guadalajara)

"Astronomy institutes in Europe and around the world coordinate their telescopes to obtain maps of celestial objects in as much detail as possible; this is the European VLBI Network (EVN). Thanks to GÉANT and national infrastructures like RedIRIS, this data can now be combined in real time. This is how the e-VEN came about, which is used to study phenomena such as supernovae or gamma-ray bursts from the moment they occur, or to track objects and material orbiting black holes, etc. The e-EVN requires great connectivity, expandable on demand, buffering systems, grid supercomputing, etc. All of this is achieved thanks to the collaboration of RedIRIS and similar infrastructures in other countries".

Dr. Francisco Colomer, Scientific-Technical Coordinator for Astronomy, Geophysics and Space Applications.
National Geographic Institute (IGN)

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The development of the e-VLBI requires certain specialised ICT services, such as a new specific software capable of processing up to 4 Gbps, and academic and scientific communications networks, like RedIRIS, which are essential for the transmission, reproduction and integrity of the data generated by the observatories taking part in e-VLBI activities.

Express interferometry network topology

The VLBI mechanism is deceptively simple, but behind it hides a complex array of scientific and technological resources: the information collected by the simultaneous observation of multiple radio telescopes is stored along with time signals from their atomic clocks, which are then sent to the correlator, a supercomputer that performs the correlation of data, thus generating the final celestial images. With a higher resolution than that achieved by the most powerful optical telescope on Earth, these are sent to a file which is accessible to scientists anywhere in the world.

The European VLBI Network (EVN)

The European VLBI Network (EVN) is a consortium originally founded in 1980 by five radio astronomy institutes in Germany, Italy, the Netherlands, Sweden and the United Kingdom. It currently brings together giant radio telescopes from 14 European institutes, including Spain, plus others in China, South Africa, Russia, Puerto Rico and other associated countries, such as Australia and the US.

EVN includes among its members the Joint Institute for VLBI in Europe (JIVE), with its headquarters in the Netherlands. It is responsible for hosting and operating the EVN supercomputer and supporting the EVN user community worldwide. EVN combines data collected by radio telescopes in real-time at rates of 1-4 Gbps each.

One of the Spanish organisations associated with EVN is the National Geographic Institute (IGN), a founding member of JIVE which also contributes to the coordination of the Network's supercomputer. The IGN has a 40-meter radio telescope in the Yebes Observatory (Guadalajara). Since the radio telescope has dark fibre, thanks to an agreement with RedIRIS and the Ministry of Economy and Competitiveness, the IGN regularly participates in interferometric observations at frequencies between 2 and 115 GHz.

GÉANT and national networks bring together members of the European VLBI

The physical transmission of this data requires cooperation among the pan-European academic and scientific GÉANT network and its national partners (NRENs), including RedIRIS, which is a member of the scientific and technical cooperation Forum EVN-NRENs. In the near future, thanks to real-time connections via fibre optics, any Spanish researcher can connect through RedIRIS and GÉANT to the most powerful interferometers in the world, like ALMA (Atacama Large Millimeter Array, Chile) or SKA (Square Kilometre Array, Australia-South Africa), both of which are under construction.

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EUROPEAN vlbi NETWORK Consortium for Very Long Baseline Interferometry in Europe