Connecting the dots for multi-messenger astrophysics

How do you see the invisible in our Universe? Various types of detectors can be used, and an EU-funded project is making it easier to piece together the bigger picture from the different signals they observe. In the process, it is helping to strengthen Europe's position at the leading edge of research into the nature of the Universe.

Once upon a time, all we could observe of space were the objects visible to our naked eyes. Today, extremely powerful telescopes have greatly extended our capabilities to explore galaxies far, far away – and many are designed to pick up signals or 'messengers' other than the kind of light our eyes have evolved to see.

Signals from the Universe reach Earth in forms as varied radio waves, X-rays and neutrinos.

It stands to reason that combining data from observations exploiting these different carriers could help to generate new knowledge faster. The EU-funded project ASTERICS set out to advance this approach, which is known as multi-messenger astrophysics.

The partners have devised methodologies and tools for dealing with the disparate data involved, and are preparing recommendations for the development of a future multi-messenger astrophysics platform, says project manager Rob van der Meer of ASTRON, the Netherlands Institute for Radio Astronomy.

Most importantly, however, ASTERICS has generated momentum for the required collaboration among the relevant research communities. When the project was launched, in May 2015, there was little established cooperation between the communities working with the different types of detectors, notes van der Meer.

'So, at the beginning of the project, the objective was to bring the developers and researchers in astronomy and astroparticle physics together,' a mission that van der Meer feels has been successfully accomplished. Now, with another six months to go, the emphasis has shifted to keeping this interaction going beyond the end of the project in April 2019.

Different telescopes...

'Multi-messenger astrophysics is an approach where you combine the information of two or more telescopes to get more information about the source you are looking at,' van der Meer explains. 'Different wavelengths and different particles provide different views of what's happening in the celestial object you are focusing on.'

Multi-messenger astrophysics has the potential to be even more fruitful than multi-wavelength astrophysics, because the instruments involved may well be designed for detection of signals other than electromagnetic radiation – light – from a distant object or event, van der Meer explains.

For example, they could be intended for the detection of neutrinos, a type of particle notably emitted during a supernova explosion. Or, for gamma rays, a special case in that they are also a form of electromagnetic radiation, but detected through the observation of particles and secondary light they produce when the particles interact in the atmosphere or water, he adds.

...common challenges

ASTERICS focuses on four large instruments that are currently under development: the Cherenkov Telescope Array, the Cubic Kilometre Neutrino Telescope, the Extremely Large Telescope and the Square Kilometre Array.

Respectively, these facilities are designed for gamma rays, neutrinos, visible light, and radio waves. Once they are operational, they will produce even larger amounts of data than their current precursor telescopes, van der Meer points out.

'What we want to do with this project is make the most of all these large telescopes,' he says. 'Of course, each community – optical, radio, astroparticle physics – is able to solve its own problems. But we also face common problems. By working together, we may be able to solve them more easily, and using each other's tools can help us to save time and money.'

Handling, pooling and processing the anticipated deluge of data is one such challenge, and ASTERICS is also keen to help ensure that data is easily found by users (including non-specialists), exchangeable between different systems and accurately described – to keep track of any processing that might have already been carried out, for example.

Activity in the project builds on work that began more than a decade earlier in the context of the Virtual Observatory and is helping to advance the ongoing development of this distributed, web-based research environment.

Many technologies supporting observations also have applications in other areas, says van der Meer. One such innovation advanced in ASTERICS involves ultra-precise timekeeping across the operation of the various telescopes, which seems to be of interest to stock market operations as well.

However, to the communities of researchers, engineers and citizens scientists linking up through ASTERICS, the allure of applications beyond their field is likely to pale in comparison with multi-messenger astronomy's potential to generate new knowledge. For instance, the highly celebrated detection of a gravitational wave on 17 August 2017 was complemented by observations using some 70 other telescopes and detectors of various types, with fresh insights emerging from this new level of collaboration.

Project details

- Project acronym: **ASTERICS**
- Participants: **Netherlands (Coordinator)**, France, Italy, UK, Spain, Germany
- Project N°: 653477
- Total costs: € 14 991 194
- EU contribution: € 14 991 194
- Duration: May 2015 to April 2019

See also

Project website: https://www.asterics2020.eu/
Project details:
https://cordis.europa.eu/project/rcn/196641/en

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