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Measuring the Earth and mapping our Galaxy

UTAS scientists have successfully completed tests on a revolutionary new instrument that will make it possible to measure the Earth and the effects of climate change with millimetre precision and map our Galaxy.

New technologies need to be developed to achieve this and a critical component is the instrument at the focus of the radio telescopes that receives light from distant quasars. A prototype receiver, provided by Callisto, that is much broader bandwidth than existing systems has been under testing at UTAS's Mount Pleasant Observatory near Hobart for the past few months. This testing has just culminated in observations with a similar telescope at Ishioka in Japan. Both telescopes observed a quasar called 3C279 in the constellation of Virgo. The light received by the telescopes left the quasar nearly 5 billion years ago.

"We were able to combine the signals from the telescopes and measure the difference in arrival time to an accuracy approaching one-trillionth of a second. It's really exciting because it tells us that the instrument is working," said Dr Lovell, an astronomer at the UTAS School of Physical Sciences.

Measuring positions on the Earth is difficult because everything is moving and there's no fixed reference point. "To measure where we are, we need to compare to things far away from the Earth that don't move. Those things are called quasars and are located at the edge of the Universe." Dr Lovell said.

The Callisto receiver during installation at Mt Pleasant

Quasars are so far away that the signal that comes from them takes billions of years to get to us even though it's travelling at 300,000 km a second. They are powered by black holes and appear as very small points of light when observed from Earth. That's why they form an ideal frame of reference.

Radio telescopes are really good at observing quasars. If you have two radio telescopes you can measure how long it takes for the quasar signal to reach one telescope compared to the other. This difference in time tells you how far apart the telescopes are. At the moment, these measurements can be made to centimetre precision.

"A frame of reference accurate on millimetre scales is needed to study important geophysical and climate processes, such as the effects of the melting of glaciers on sea level rise." said Dr Lovell, who is also chair of an international committee charged with developing next-generation observing strategies that will enable the millimetre-level measurements.

This is the first time that this new technology has been used to measure distances across the Pacific and also the first time a telescope in the southern hemisphere has been used. Global coverage is essential for this technique to be successful, so contributions from Australia to a worldwide network of observatories are critically important.

Australia's contribution to the network includes three radio telescopes across the continent, at Yarragadee (WA), Katherine (NT) and Hobart (TAS). The network is operated by UTAS as part of AuScope, which provides infrastructure for research in geological, geochemical, geophysical, and geospatial subjects. UTAS is the only university in the world to operate a continent-wide array of radio telescopes.

The Callisto receiver is particularly important for AuScope as the technology used is designed to be highly reliable and low maintenance, an important consideration when operating telescopes in remote locations.

"This achievement would not have been possible without international partnerships. We are extremely grateful for the generous contribution from colleagues at Japan's National Institute of Information and Communications Technology (NICT) and Geospatial Information Authority of Japan (GSI)" said Dr Lovell.

The new receivers, which will be installed at the three AuScope telescopes early next year, will also allow astronomers to map our galaxy. Professor Simon Ellingsen at the UTAS School of Physical Sciences is leading a team that will take advantage of these new developments to look through the gas and dust between the stars in our galaxy to map the spiral arms.

"It's very difficult to work out the shape and structure of our galaxy because the Earth is inside it. In effect it's hard to see the woods for the trees and we actually know more about how other galaxies look than our own at the moment." said Prof Ellingsen. "There are parts of the galaxy that are only visible from the southern hemisphere and we need an array of telescopes that are thousands of kilometres apart in order to measure distances to the young stars that live in the spiral arms."

The receiver upgrade has been made possible as a result of Australian Research Council Linkage Infrastructure, Equipment and Facilities (LIEF) funding (project number LE150100105). The project is a partnership between UTAS, Harvard-Smithsonian Centre for Astrophysics (USA), Geoscience Australia, CSIRO Astronomy and Space Science, Auckland University of Technology (NZ), Max Planck Institute for Radio Astronomy (Germany) and Callisto (France).

The new receiver is manufactured by Callisto (Toulouse, France) who provides sensitive instrumentation for radio telescopes. At the heart of this new receiver is an innovative wideband antenna feed, specifically designed for VLBI and radio astronomy applications by the California Institute of Technology. For more information see www.callisto-space.com

Regular updates on the AuScope VLBI project are published at www.facebook.com/AuScopeVLBI.

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