PAWSEY supercomputing centre

PROJECT LEADER
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SYSTEMS USED
Using Galaxy as a key part of the telescope

AREA OF SCIENCE
Radioastronomy

APPLICATIONS USED
ASKAPsoft

THROWING LIGHT ON DARK MATTER

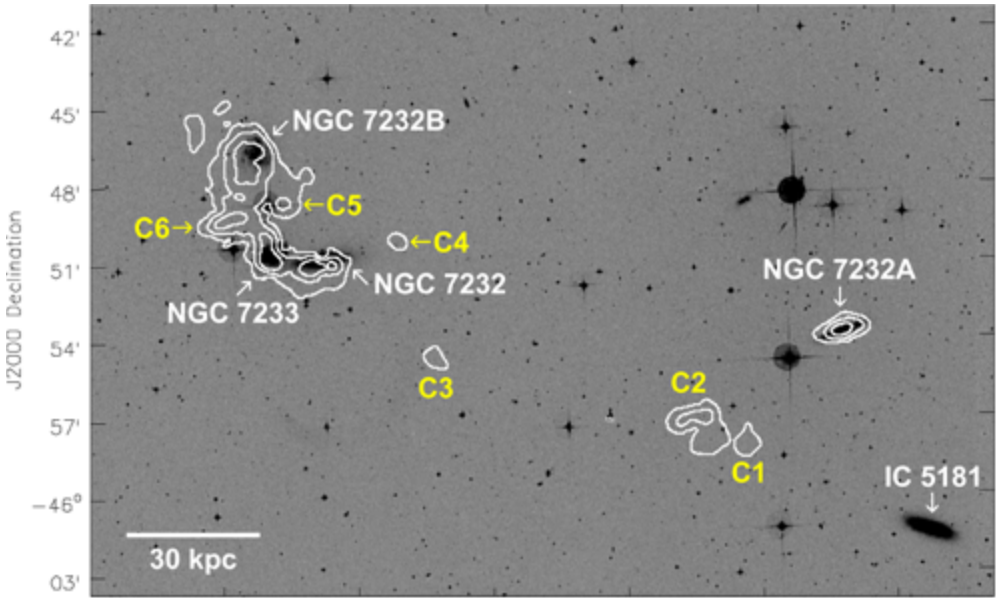
36	7	9 billion	78 million
Antennas	Newly detected galaxies	Solar masses	Light-years away

Australia is experiencing a renaissance of space exploration, with major new science and industry projects. Huge space projects have huge data processing requirements and Pawsey Supercomputing Centre is working with astronomers to meet their computing needs as they explore the cosmos.

The Australian Square Kilometre Array Pathfinder (ASKAP) is one of these projects and will soon be a cornerstone of Australian astronomy. The array features 36 antennas mapping the night sky 30 square degrees at a time.

ASKAP became fully operational this year, but even before then astronomers performed early science with a sub-set of the 36-antenna array. One of these scientists is Dr Karen Lee-Waddell who works as a data processing and imaging scientist on the Widefield ASKAP L-band All-Sky Blind Survey (WALLABY), which has just detected seven new galaxies. WALLABY is one of the ten Survey Science Projects established to take advantage of ASKAP's unique observing capabilities. With the help of Pawsey, Dr Lee-Waddell is processing terabytes of data to explore the Universe.

Partner Institution: CSIRO



ASKAP hydrogen emission associated with the NGC 7232/3 triplet. Hydrogen contours – at (1, 3, 6) × 10^{20} atoms/cm^2 – are superimposed on a DSS2 blue archival image. Pertinent optical galaxies are labelled in white. A physical scale bar assuming a group distance of 24 Mpc (78 million light-years) is shown in the bottom left of the image. Lee-Waddell, K., et al. "WALLABY early science-II. The NGC 7232 galaxy group." Monthly Notices of the Royal Astronomical Society (2019).

THE CHALLENGE

Dr Lee-Waddell uses ASKAP to measure the hydrogen spectral line of a galaxy to determine its distance and mass. Galaxies spin faster than their mass would suggest and by comparing the mass and spin of galaxies, WALLABY can calculate the amount of dark matter present. Dark matter is one of the greatest mysteries in science and measuring it allows astronomers to understand how it affects the universe.

"We don't fully understand dark matter, that's why we call it 'dark'. We assume galaxies are in these balloons of dark matter because of the extra mass, but we don't know the shape of that concentration. We don't really know how it affects things. We do know it has a gravitational pull, forming galaxies and stars," says Dr Lee-Waddell.

ASKAP's ability to map large sections of the sky is vital to this research, allowing astronomers to catalogue hundreds of thousands of new galaxies. The array is huge – with over six million parts and enough optical fibre to wrap itself around the moon one and a half times. With its unique engineering design and novel phased array feed receiver technology, ASKAP will generate more than 200 terabytes of data per day.

"The projected data rate of the full array is nine terabytes per hour. Currently, we're ingesting about half that. That's equivalent to streaming about 4000 Netflix movies at once."

THE SOLUTION

The massive amount of data produced by ASKAP requires supercomputing power to process and store. Pawsey's Galaxy supercomputer performs batch processing for ASKAP, turning raw data into usable science for astronomers like Dr Lee-Waddell. We are aiming to get as close as possible to processing the data in "real time", producing images as quickly as the raw data arrives.

"Right now, we're streaming four terabytes an hour, and we generally do that for 12 hours at a time. That's just raw data – the signal from the sky. We have to do a lot of computations and processing to get useable data out of that. That's where Pawsey comes in. We take these several terabytes of data and make insightful images of galaxies."

Storage limitations mean data is refined down to 5% of its initial size. What remains is the truly scientifically important data that astronomers can use. For WALLABY, these galaxies can be measured for their mass and other properties. However, the other data may contain momentous discoveries – like the first fast radio burst found in Parkes radio dish archival data. The recently announced $70 million upgrade to Pawsey's supercomputing infrastructure will help astronomers process and store more data, helping fuel new discoveries.

THE OUTCOME

The early science recorded by Dr Lee-Waddell on 12 of the 36 ASKAP antennas has already led to the detection of seven new galaxies, which is just scratching the surface of understanding dark matter and the Universe around us. With ASKAP mapping more sky than ever before, many more galaxies are expected to be found, providing new insight into the physical processes occurring in these systems.

"With the full array, we will survey 75% of the entire sky and look at the hydrogen gas content of galaxies. The WALLABY science project predicts the detection of well over half a million new galaxies. We're trying to understand the Universe. Understanding different parts of the Universe helps us understand the fundamentals of everything around us." says Dr Lee-Waddell.

Learning more about these galaxies and what lies within them will expand our knowledge of physics and astronomy. That knowledge can be used to improve technologies for industry here on Earth, like scanners and communications networks.

Fundamental astronomy research like the WALLABY Survey Science Project is the foundation of new discovery. From early space missions creating satellite technology, to fast reliable Wi-Fi invented by CSIRO. The benefits of this research are often as unknowable as they are revolutionary to society.

More than this though, Australia is entering a new space renaissance. The Australian Space Agency was recently founded, and small businesses are looking up, developing satellite technology and new space industries.

Meanwhile, WALLABY's work to measure dark matter will contribute to our knowledge of gravity, even as Australia harnesses this force to develop new industries and scientific discovery in space.

Both rely on the cutting-edge supercomputing power of Pawsey, as well as world-class scientists and engineers like Dr Lee-Waddell, to uncover the mysteries of the Universe.

CSIRO acknowledges the Wajarri Yamaji as the traditional owners of the Murchison Radio-Astronomy Observatory site.