PAWSEY
supercomputing centre

PARTNER INSTITUTION
THE UNIVERSITY OF WESTERN AUSTRALIA

LISTENING TO THE RIPPLES OF THE UNIVERSE

PROJECT LEADER
PROF LINQING WEN
linqing.wen@uwa.edu.au

SYSTEM
MAGNUS AND ATHENA

TIME ALLOCATED
ATHENA 1,000,000 CORE HOURS
MAGNUS 3,500,000 CORE HOURS

AREA OF SCIENCE
GRAVITATIONAL-WAVE ASTRONOMY

APPLICATIONS USED
GRAVITATIONAL-WAVE PIPELINE

Gravitational waves are helping us delve deeper than ever before into the fabric of our universe. Since the first gravitational wave was detected in 2015, a brave new field of astronomy has grown in response. The research's impact is vast, plumbing the depths of black holes, checking the accuracy of Einstein's general theory of relativity, and helping us understand how our universe fundamentally works.

Professor Linqing Wen and her team at the OzGrav ARC Centre of Excellence for Gravitational Wave Discovery at the University of Western Australia are improving our chances of detecting these waves.

The team are focused on optimising detection method for the Laser Interferometer Gravitational-Wave Observatory (LIGO) in the United States, as well as its European counterpart, Virgo. Professor Wen's team also contributed to the international effort which allowed LIGO to detect the first gravitational wave in 2015. LIGO scientists were awarded the 2017 Nobel Prize in physics for this discovery.

2018

SUPERCOMPUTING FOR GRAVITATIONAL WAVE DISCOVERY IN LIGO'S THIRD SCIENCE RUN

THE CHALLENGE

While our experience with gravity on Earth makes it the most familiar fundamental force, it's also the weakest. Radio, optical and many other types of telescopes can easily scope out light and sound many galaxies over, but detecting gravitational waves is far more difficult.

Gravitational waves are so subtle that even our most advanced technology can only detect waves from the largest cosmic gravitational events.

The first detected gravitational wave involved the merging of two black holes, each roughly 30 times more massive than our own sun, allowing LIGO detectors to read a change in its detectors about 10,000 times smaller than a proton for just over 0.2 seconds.

The detection methods at the core of the gravitational wave searches must be accurate and responsive to react to these subtle changes in small time windows. This is where Professor Wen's work comes into play.

"These flashes from gravitational waves are very short and the electromagnetic light from them might only last for around two seconds. It's important for us to detect that blip quickly, then tell our optical and radio telescopes to point towards its origins so we can catch possibly extremely short-duration light from the gravitational wave event. Our software does this automatically and can send the trigger in under 30 seconds," said Professor Wen.

To perfect the detection method, Professor Wen's team needed to test it against large-scale simulated data as well as detector data from previous LIGO science runs.

THE SOLUTION

LIGO's third science run is due to start at the beginning of 2019 with new, advanced sensors capable of detecting fainter gravitational waves.

In preparation for this run, Professor Wen's team are in midst of fine-tuning the search pipelines so can run more smoothly and automatically requires an incredible amount of computing power. To accomplish these, Professor Wen's team used Pawsey Supercomputing Centre's Advanced Technology Cluster, Athena, as well as the Magnus supercomputer.

While Magnus is one of the most advanced supercomputers in the southern hemisphere, Athena was designed to provide researchers access to cutting edge technologies to propel their science. Professor Wen's team were able to take advantage of the state-of-the-art nodes available in Athena containing either many-core Xeon Phi processors or four NVIDIA "Pascal" GPUs.

"It would take us millions of CPU hours to test the program. We're trying to build a robust, low-latency program and that requires a lot of testing using simulations and data from previous science runs."

OUTCOME

Professor Wen's team are now preparing the newly improved detection method for incorporation into the upgraded LIGO systems. The team are in the final stages, checking over the program's data and sorting for errors. Soon, the work will become an important part of the search for more gravitational waves throughout the universe; how and why they form.

"At the moment we have a full team checking the data around the clock to ensure we're not reading any false positives. That the program isn't accidentally reading gravitational waves when they're not there. We have regular meetings where we all get together to work as a team as the research requires expertise in many areas." said Professor Wen.

The demand for faster and better detection and localization of gravitational wave signals requires ever more advanced supercomputing facilities like Pawsey. As the processing power grows, so too does our ability to measure and define the very fabric of the universe we live in.

"We've been working with Pawsey for a while now and we hope to continue that relationship in the future. We have proprietary access to LIGO detector data and our work is very dependent on processing power. We're at the point now where we can collect so much data but what we can do with it is dependent on how powerful our computers are."