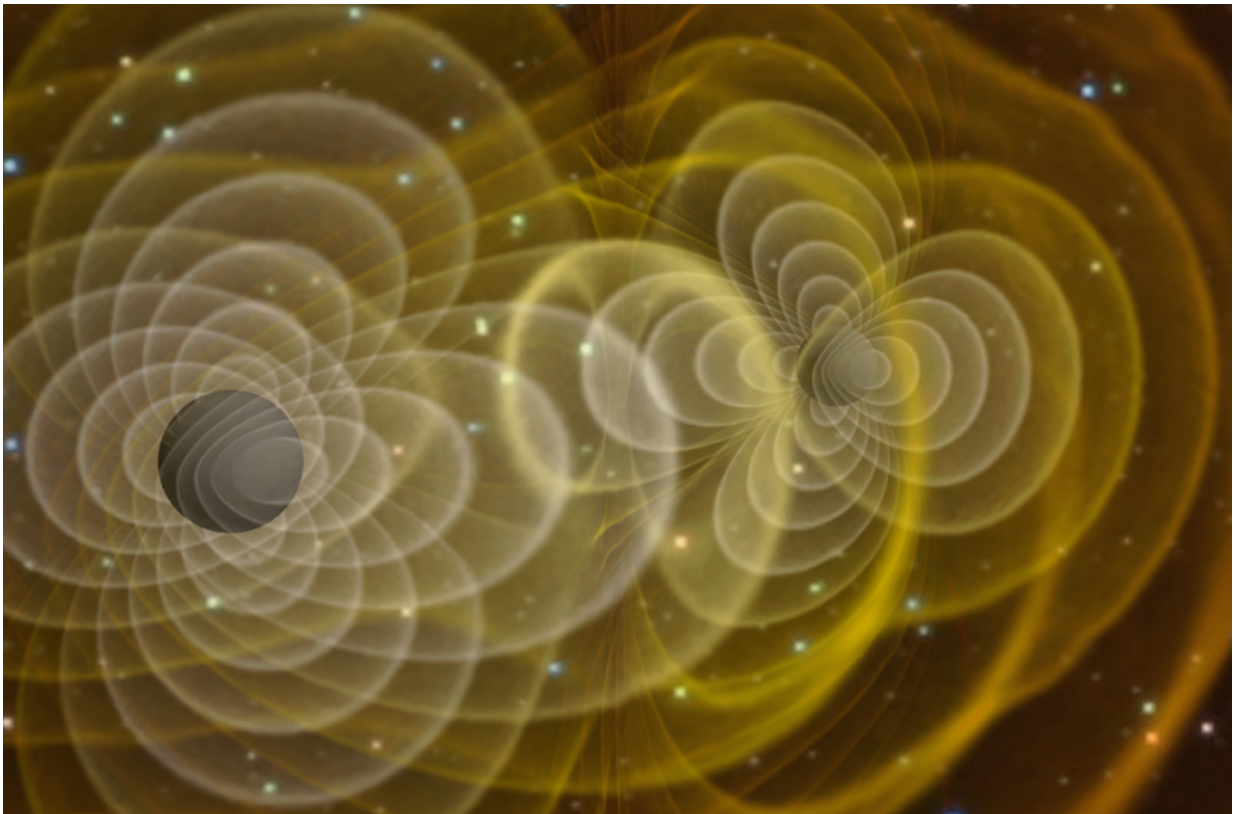


# New laser breakthrough to help understanding of gravitational waves

May 30 2022

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A visualization of a supercomputer simulation of merging black holes sending out gravitational waves. Credit: NASA/C. Henze

Gravitational wave scientists from The University of Western Australia have led the development of a new laser mode sensor with unprecedented precision that will be used to probe the interiors of

neutron stars and test fundamental limits of general relativity.

Research Associate from UWA's Centre of Excellence for Gravitational Wave Discovery (OzGrav-UWA) Dr. Aaron Jones said UWA coordinated a global collaboration of gravitational wave, [metasurface](#) and photonics experts to pioneer a new method to measure structures of light called "eigenmodes."

"Gravitational wave detectors like LIGO, Virgo and KAGRA store enormous amount of [optical power](#) and several pairs of mirrors are used to increase the amount of laser light stored along the massive arms of the detector," Dr. Jones said.

"However, each of these pairs has small [distortions](#) that scatters light away from the perfect shape of the laser beam, which can cause excess noise in the detector, limiting sensitivity and taking the detector offline.

"We wanted to test an idea that would let us zoom in on the [laser beam](#) and look for the small 'wiggles' in power that can limit the detectors' sensitivity."

Dr. Jones said a similar problem is encountered in the telecoms industry where scientists are investigating ways to use multiple eigenmodes to transport more data down optical fibers.

"Telecoms scientists have developed a way to measure the eigenmodes using a simple apparatus, but it's not sensitive enough for our purposes," he said. "We had the idea to use a metasurface—an ultra-thin surface with a special pattern encoded in sub-wavelength size—and reached out to collaborators who could help us make one."

The proof-of-concept setup the team developed was over one thousand times more sensitive than the original apparatus developed by telecoms

scientists and the researchers will now look to translate this work into gravitational wave detectors.

OzGrav-UWA Chief Investigator Associate Professor Chunnong Zhao said the development is another step forward in detecting and analyzing the information carried by [gravitational waves](#), allowing us to observe the universe in new ways.

"Solving the mode sensing problem in future gravitational wave detectors is essential if we are to understand the insides of [neutron stars](#) and further our observation of the universe in a way never before possible," Associate Professor Zhao said.

The study has been accepted for publication in *Physical Review A*.

**More information:** Metasurface Enhanced Spatial Mode Decomposition, arXiv:2109.04663v2 [physics.optics]  
[arxiv.org/abs/2109.04663](https://arxiv.org/abs/2109.04663)

Aaron W. Jones et al, Metasurface-enhanced spatial mode decomposition, *Physical Review A* (2022). DOI: 10.1103/PhysRevA.105.053523 , [journals.aps.org/pr/abstract/.../PhysRevA.105.053523](https://journals.aps.org/pr/abstract/10.1103/PhysRevA.105.053523)

Provided by University of Western Australia

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