The UWA Gravitational Wave Astronomy Group

PhD/Masters/Honors/Vacation Projects

https://research-repository.uwa.edu.au/en/persons/linqing-wen

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Eligibility Criteria:

The projects are suitable for students from astronomy and astrophysics, physics, math, computer science or engineering (signal processing). Some programming skills in C, Python, or Matlab might be required.

Research Scholarship: available for qualified PhD and Vacation students.

Overview:

Gravitational waves (GWs) are ripples of space-time predicted by Einstein more than 100 years ago. In September 2015, we have detected the first GW signal from the merger of two black holes. The 2017 Nobel Prize for Physics was awarded to three pioneers in the field for their decisive contributions to the discoveries. In 2017, we have detected for the first time GWs from the merger of two neutron stars and, most excitingly, we also detected the electromagnetic radiation associated with the binary merger. These opened up an exciting era of gravitational wave astronomy.

The Gravitational Wave Astronomy group at the UWA is at the frontier of gravitational wave detection. We are one of the five groups in the world that are authorized to generate Open Public Alerts (OPAs) for gravitational wave detection (https://emfollow.docs.ligo.org/userguide/ for SPIIR pipeline). We are a member of the 2017 ARC Center of Excellence for Gravitational Wave Discovery (OzGrav, https://www.ozgrav.org), a long-time member of the LIGO-Virgo Collaboration (LVC) (https://www.ligo.org) that is leading the GW discoveries, a member of the UWA research cluster “Gravitational Wave Technology and Education” (https://www.uwa.edu.au/research/gravitational-wave-technology-and-education), research cluster “Machine Learning Applications for Physical Sciences” (https://www.uwa.edu.au/research/machine-learning-applications-for-physical-sciences), and a member of the Parkes Pulsar Timing Array (https://www.atnf.csiro.au/research/pulsar/ppta/). Besides LVC, our collaboration institutions also include Caltech, ICRAR-UWA, ICRAR-Curtin, and top Chinese universities (USTC, Tsinghua U and BNU)

Project:

(vacation project can be a small part of a project listed.)

- **Rapid Online Detection of Gravitational Waves from Binary Black Holes and Neutron Stars**
  (Projects within the LIGO-Virgo Scientific Collaboration)

  This project includes running and monitoring online real-time gravitational wave search using the SPIIR pipeline developed at the UWA to detect gravitational wave events during the ongoing LIGO's science runs.

  It could include a rapid follow up of each detected event on its significance, astrophysical properties (e.g., mass and spin), applying supercomputing technique to speed up the search, and using injections and simulations to study the sensitivity of the searches.

- **Pre-merger Detection of Gravitational Waves from Merging Binary Neutron Stars and Neutron Star-Black Hole Binaries and Electromagnetic Follow-ups**
  (Projects within the LIGO-Virgo Scientific Collaboration, collaborate with ICRAR-Curtin, MWA and ASKAP)

  This project aims at detecting some bright gravitational wave signals before the final merger of two neutron stars or a neutron star and a black hole, early warnings to other telescopes for rapid follow up observations of electromagnetic flashes during the merger.

- **Machine Learning for GW Discoveries**
  (Projects within the LIGO-Virgo Scientific Collaboration, collaborate with ICRAR-UWA and UWA Computer Science)

  Apply various machine learning techniques for detection, classification and localization of gravitational wave events.

- **Deep Search for Gravitational Wave Signals in Coincidence with Fast Radio Bursts and Gamma Ray Bursts**
  (Project within the LIGO-Virgo Scientific Collaboration, collaborate with ASKAP/MWA/CRAFT)

  Systematic deep searches for sub-threshold GW signals; targeted search for potential gravitational wave counterpart of fast radio bursts (FRBs), gamma-ray bursts (GRBs) and potentially other astrophysical transient

events.

- **Binary Black Hole Merger Modeling and Using GW Data to Probe our Universe**
  (Collaborate with Caltech and USTC)

  Study the GW event population, e.g., its mass, spin, directional distributions and probe the formation history of binary compact objects; using gravitational wave data to probe parity symmetry of gravity, and geometry of our Universe. Analytical and numerical studies of binary black hole merger models with potential electromagnetic counterparts.

- **Algorithm Design, Mathematical Optimization, and Graphics Processing Units (GPUs) Acceleration**
  (Collaborate with UWA Computer Science and Tsinghua U in China)

  Accelerate the search pipeline using smart algorithms including GPU-acceleration, optimization of filter design, data whitening, and pipeline automation.