

Astrophysical Sciences & Technology  
Ph.D. Dissertation Defense

**Yuanhao Zhang**

**Searching for Gravitational Waves from Scorpius X-1  
with a Cross-correlation Method:  
from Mock Data to Advanced LIGO**

Advisor: John T. Whelan

Tuesday July 11<sup>th</sup>, 2017 11:00 am  
Location: Carlson Auditorium 76 – 1125

**Abstract:**

Gravitational waves (GWs) are propagating ripples of space-time predicted by general relativity (GR). 100 years after Albert Einstein published his theory of GR, the Laser Interferometer Gravitational-Wave Observatory (LIGO) found the first direct detection of GW in the first advanced LIGO observing run. The GW signal known as GW150914, was the first of a series of binary black hole mergers observed by LIGO. These detections marked the beginning of gravitational-wave astronomy. The continuous wave (CW) signal emitted by fast spinning neutron stars is another interesting source for a detector like LIGO. The low mass X-ray binary Scorpius X-1 (Sco X-1) is considered to be one of the most promising CW sources. With improving sensitivity of advanced detectors and improving methods, we are getting closer to being able to detect an astrophysically feasible GW signal from Sco X-1 in the coming few years.

Searching for CWs from neutron stars of unknown phase evolution is computationally intensive. For a target with large uncertainty in its parameters such as Sco X-1, the fully coherent search is computationally impractical, while faster algorithms have limited sensitivity. The cross-correlation method uses not only simultaneous but also non-simultaneous data in a maximum time offset from same and different detector. These data are combined coherently based on the signal model. We can adjust the maximum coherence time to trade off computing cost and sensitivity. The cross-correlation method is flexible and so far the most sensitive. This search gave the best results in a Sco X-1 mock data challenge and recent LIGO observation. I will introduce the method, the test in mock data and the first astrophysical observation run in advanced LIGO data.