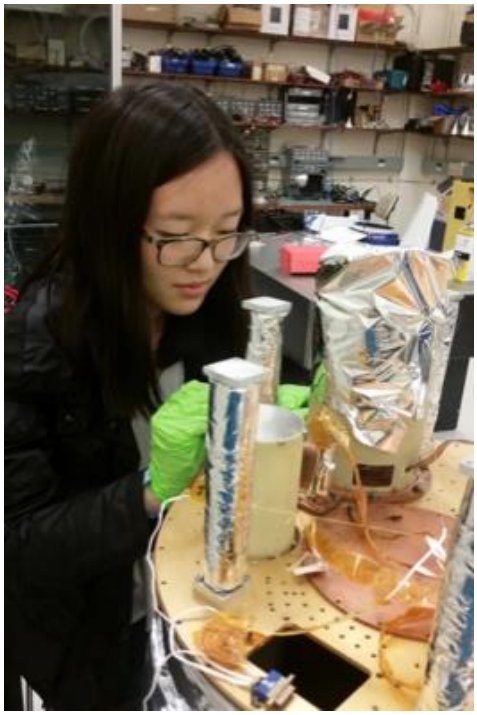

Investigating a New Type of Detector for Far-Infrared Spectroscopy
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Astronomers have determined that the rate of star birth peaked in the early universe, just about 6 billion years after the Big Bang. What drove star formation in the early universe? To answer this question remains one of the goals of modern astrophysics.

Through PURM, I had the opportunity to work in the lab of Dr. James Aguirre in the Department of Physics and Astronomy. My project was to assist a graduate student in the testing of a new type of photon-counting detector that would lead to a high-resolution spectrometer optimized for far-infrared wavelengths. Our interest in this wavelength range relates to the potential to understand the star formation mechanisms at work in the early universe. Many of the galaxies present during this time period are shrouded in dust, which makes them difficult to observe at optical wavelengths. However, spectral lines exist in the far-infrared range and serve as tracers of star formation.

The detectors we investigated are called Kinetic Inductance Detectors (KIDs) because they rely on the superconducting phenomenon of kinetic inductance arising in resonant circuits. As such, they require extremely low temperatures of <1 K to operate and it was necessary to test them using a lab cryostat. My main responsibility was to repair thermometry wiring to set up a signal path through the cryostat. In addition, I set up thermometer sensors and heaters to monitor and control the process of cooling the cryostat down from room temperature to as low as 250 mK. Through this, I developed a working knowledge of cryostat design and application, as well as digital electronics.

Besides testing the detectors, I also worked on investigating a potential application for a KID-based spectrometer: finding exoplanets. Since astronomers discovered the first exoplanets around 20 years ago, various methods to detect exoplanets using modern technology have emerged. One in particular that has yielded great success is the radial-velocity method. This method relies on the measurement of the small velocities of a star due to gravitational tugs of an orbiting planet, which is derived from Doppler shifts in a high-resolution spectrum. I used simulated stellar spectra to determine whether a KID-based spectrometer would offer a sensitivity advantage compared to traditional spectrometers in the detection of exoplanets using radial velocity measurements. In doing so, I acquired data analysis and computational skills in Python.

I am excited to continue working with Dr. James Aguirre in the upcoming semester and further pursue astrophysics research.