PHOEBE Research Summary (Fall 2019- Current):
(Research advisor: Dr. De Lee)

In my research, I experimented with using PHOEBE, PHysics Of Eclipsing BinariEs (Prsa et al., 2016), modeling software to fit photometric and radial velocity data of eclipsing binaries. PHOEBE is an open-source Python package that can be used to reproduce and fit light curves, radial velocity curves, and spectral line curves. I presented these capabilities during the Spring Semester of 2020 at NKU's Celebration of Student Research and Creativity. My purpose in using software like PHOEBE was to model eclipsing binary systems by combining spectra from the Apache Point Observatory Galactic Evolution Experiment (APOGEE) survey (Majewski et al., 2017) with photometry and then using PHOEBE to fit the parameters of this system.

At that time, I was working towards the ability to use real data to find unknown binary parameters of a system, an approach often referred to as the inverse problem (Conroy et al., 2020). There were plenty of ways to solve the inverse problem. However, taking in a large amount of data and accurately calculating the unknown binary parameters proved to be computationally expensive. One way of resolving this issue was by using statistical methods to reduce the number of necessary calculations. Specifically, I utilized the Markov-Chain Monte Carlo (MCMC) method. The MCMC method, a Bayesian statistical method, is often used when dealing with a large data set of different values; given a prior distribution and a likely distribution, it allowed me to derive accurate posterior distributions with far less computational work. The process involved using several random points, or walkers, and then analyzing these points to find the best approximation for a posterior distribution. The approximation was generally close to the actual value and didn't require as much work to find the parameter as it would have otherwise (Pasha).

The prior distribution was constructed to be relatively narrow around the initial distribution, leaving little room for deviation. Consequently, the values were closely aligned, and the likelihood distribution was also closely centered around known values, exhibiting Gaussian characteristics, while the prior distribution was uniform. In contrast, I encountered two particular issues with the posterior distribution. The first issue was that the walkers, or random points used in the model, would stray further from the data than I intended. For example, if I established the standard deviation at 0.001, it might expand to 3.5 in the posterior distribution after applying the model. The second issue was an inconsistency in the posterior distribution for two of the parameters, even though they fell within the allowed range for the other two. Attempts to alleviate these problems by adding more walkers only seemed to exacerbate them. To continue to address these challenges, I plan to employ the new fitting algorithms available in PHOEBE 2.3 (Conroy).