Decoding X-ray variability in MAXI J1820+070 with NICER data
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**Project summary:**

For the project, I use advanced X-ray spectral-timing techniques to study a black hole X-ray binary called MAXI J1820+070. This system was observed by the NICER telescope during its outburst in 2018. The application of spectral timing to X-ray binaries can provide key information on accretion processes near compact object. The focus of the project is on the study of phase lags between different energy bands and how these depend on properties of the quasi-periodic oscillations (QPOs) seen in this source.
Most of the project consists of writing my own spectral-timing code and developing new techniques to study the development of phase lags in MAXI J1820+070 and their connection with QPOs. It is thought that QPOs arise due to geometric changes in the configuration of matter near the black hole. These geometric changes in turn were expected to lead to a difference in phase lags as the QPO develops. During the project, it became clear that the phase lags at the QPO frequency depend on the hardness ratio between the soft and the hard band of data segments of tens of seconds. This hardness-phase lag relation at the QPO frequency was unknown before and will constrain models of the origin of QPOs in the future.
The project not only involves the analysis of NICER data, but also creating realistic simulated data. Applying the newly invented methods to the simulated data improves our understanding of both the methods and of the real data. Most of the programming is done in Python and the X-ray spectral fitting tool Xspec.

**Planning:**

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| September: | Introduction to X-ray timing techniques |
| October: | First data analysis and trying new methods |
| November: | Simulation of data to verify methods |
| December: | Develop method to find QPO phase, apply QPO phase-resolved timing techniques |
| January: | Improve simulations, introduce Impulse Response Functions |
| February – March: | Check dependence of phase lags on flux and hardness ratio |
| April: | Spectroscopy using Xspec on data to see find possible spectral changes with flux and hardness ratio |
| May – early June: | Complete analysis and collect final results |
| Mid June – July: | Write up into thesis and prepare final presentation |