Prof. Patrick Hall, Modeling and analysis of quasar spectra

When a supermassive black hole in a distant galaxy is surrounded by a disk of matter, the matter heats up to temperatures of tens of thousands of degrees. The resulting object is called a quasar and is luminous enough to be seen across the universe. Ultraviolet photons emitted from the inner disk ionize gas farther from the quasar, and the gas can produce broad emission and absorption lines. The detailed properties of this emission and absorption are expected to correlate with fundamental properties of the system such as black hole mass and spin and the mass inflow and outflow rates as a function of radius in the disk. Knowledge of these properties would improve our understanding of the cosmic evolution of quasars and galaxies.

My research group has access to a large database of spectroscopy and photometry of Sloan Digital Sky Survey quasars with which to study the variability of their disks and outflows. Current science topics include understanding very short-term variability in some broad absorption line (BAL) troughs, finding and studying extremely high velocity outflows (0.1c to 0.2c), understanding redshifted troughs which are likely rotating disk winds, understanding the acceleration and deceleration of BAL outflows, and understanding continuum variability hard to explain with standard accretion disks.

Our group is now engaged in modelling the disks and outflows to compare the predictions of those models to uniformly analyzed observations. Analyzing the detailed properties of quasar spectra requires separating the intrinsic emission and the overlying absorption. This project will advance the above science topics by applying machine learning techniques to recover intrinsic signals in quasar spectra in the presence of noise and known systematic deviations. Familiarity with such techniques is in great demand due to their increasingly wide applicability in science and industry.

The student will work with Prof. Hall to apply computational methods to model quasar spectra as weighted sums of template spectra and to use those model spectra for scientific analysis. This work includes deriving the template spectra from a set of tens of thousands of existing quasar spectra. The student will modify existing MATLAB code, write new code, compile and analyze scientific results on a chosen topic based on those codes, and contribute significantly to writing up the results for publication in a peer-reviewed journal.