Wolfgang Kerzendorf – Colloquium Seminar – September 25, 2025
MSU

Title: Calibrating Stellar Explosions as Probes of the Evolving Universe

Supernovae are the luminous and violent end points of stellar evolution. Supernovae provide the distance measurements that revealed the accelerating Universe, and also forge iron-group and r-process elements, which shape the chemical makeup of galaxies and planets. Because of their central role in physics, supernovae have been the focus of decades of observational campaigns and theoretical modeling. Despite these remarkable efforts, we have only a broad understanding of their progenitors and explosion mechanisms. The detailed physics – crucial for precision cosmology and for tracing chemical evolution – likely can only be revealed by the synergy of theory and observation.

Over the past six years, my group has built a framework that bridges observation and theory. The framework consists of plasma and radiative-transfer simulations, machine-learning emulators, and Bayesian inference. We can then reconstruct stellar explosions from their spectra in a statistically rigorous way.
In my talk, I will show how this new methodology uncovers the details of stellar explosions. First, I scrutinize the progenitor and explosion mechanisms of thermonuclear supernovae. Second, I show how we calibrate hydrogen-rich supernovae to be new first-principles-based cosmic distance indicators. Third, I discuss how binarity affects the deaths of the most massive stars in the Universe. Together, these advances demonstrate the power of combining physical models with statistical inference specifically in the upcoming era of rapidly increasing observational data.

Finally, I will give an overview of how the unprecedented discovery streams from the Rubin Observatory's LSST and NASA's Roman Space Telescope will allow us to make precision maps connecting stellar evolution to stellar explosions, and calibrate both nucleosynthetic yields and luminosities required for cosmic cartography. These new observational campaigns coupled with our framework will uncover how stars live, die, and shape the Universe.