

Huey-Wen Lin – Colloquium Seminar – September 3, 2026
MSU – PRTC

Title:

The Secret Life of Protons: Mapping Quarks and Gluons with Supercomputers

Abstract:

Protons and neutrons make up nearly everything we see around us from the atoms in our bodies to those in the planets and stars in the sky. But what are they actually made of, and how do their tiny building blocks work together to create the world we experience?

Deep inside every proton and neutron are quarks and gluons, governed by the theory of quantum chromodynamics (QCD). Unlike more familiar particles like electrons, protons and photons, quarks and gluons are never found alone. Their constant strong interactions, exchanging gluons, bind them permanently within hadrons like the proton and neutron.

To explore this phenomenon, we want to compute the consequences of QCD theory, but its interactions are too strong for physicists' traditional tools. One answer is supercomputers. Using a powerful computational technique called lattice QCD, we can simulate the behavior of quarks and gluons from the first principles of QCD, and use these calculations to explore the inner landscape of protons and neutrons.

In this talk, we take a journey from the world of atoms down to the femtoscale, the realm of quarks and gluons, and see how supercomputers allow us to explore this hidden world. I will highlight a few recent discoveries from lattice QCD, including how quarks and gluons share the proton's momentum and how we can learn about the proton's structure in ways that are difficult to access in experiments. Along the way, we will see how ideas from quantum mechanics and

computer science come together to help us peek inside the heart of matter.