Announcing the Final Examination of Dipendra Khatri for the degree of Doctor of Philosophy in Physics

Date: June 18, 2025
Time: 11:00 a.m.
Room: PSB 445
Dissertation title: Sub-cycle nonlinear optics in solids.
Abstract:

The rapid advancement of digital electronics and telecommunication systems necessitates processing information at increasingly higher speeds. However, modern semiconductor technology faces fundamental physical limitations in transistor miniaturization and clock frequency due to quantum mechanical constraints. To overcome these barriers, ultrafast optoelectronics, leveraging light-matter interactions, offers a promising alternative. Light, as the fastest carrier of information, enables signal processing at frequencies far beyond conventional semiconductor technology.

Advancements in laser technology have enabled stable and reliable ultrashort light pulse sources, lasting only a few femtoseconds at optical wavelengths. When utilized for signal processing, they could enable clock frequencies over 1000 times higher than current semiconductor technologies.

This dissertation focuses on developing few-cycle laser sources in the mid-infrared (MIDIR) and near-infrared (NIR) spectral ranges using a Yb:KGW driving laser and designing and demonstrating a TIPTOE-based waveform characterization technique. The first part involves developing a sub-three-cycle MIDIR source using multiplate glass compression of a two-stage OPA (Light Conversion -ORPHEUS) output, with its waveform measured via a CMOS-based TIPTOE technique. This source and method are used to study sub-cycle nonlinearity in low- and high-bandgap semiconductors (Si and ZnO).

The second part develops a few-cycle NIR source using a two-stage hybrid nonlinear compression approach: a gas-filled multi-pass cell and a hollow-core fiber, generating sub-10-fs pulses. For waveform characterization, the TIPTOE technique is extended using an AlGaN photodiode, providing real-time laser field oscillation measurements. This system is further applied to study vibrational nonlinearity in fused silica. iv

This work advances ultrafast pulse generation and measurement techniques, enabling the study of light-matter interactions in sub-femtosecond time scale and paving the way for next-generation ultrafast optoelectronic technologies.

Outline of Studies:

Major: Physics

Educational Career:
M.Sc. in Physics and Material Science University of Memphis, TN 2020

Committee in Charge:
Dr. Michael Chini (Chair)
Dr. Zenghu Chang
Dr. Li Fang
Dr. Peter Delfyett (External Committee Member)

Approved for distribution by Dr. Michael Chini, Committee Chair, on June 08, 2025.

The public is welcome to attend.