Announcing the Final Examination of Z. Alphonse Marra for the degree of Doctor of Philosophy in Physics

Date: June 27, 2024
Time: 1:00 PM
Room: Physical Sciences Building (PSB) 160
Zoom link: https://ucf.zoom.us/j/98583520686
Dissertation title: An Ultrafast, Mid-wave Infrared Source for Driving High-order Harmonics Beyond the Water Window

Abstract:
This dissertation defense details the development of the world's first cryogenically cooled Fe:ZnSe-based chirped pulse amplifier, a mid-wave infrared source for strong-field physics experimentation. The long upper-state lifetime provided by cryogenically cooling the Fe:ZnSe gain medium allows free-running, diode-pumped Er:YAG lasers to be used as pump lasers. The amplifier is seeded by a novel two-stage optical parametric amplifier pumped at 1 μm, which is potentially carrier-envelope phase-stable.

The system is capable of producing 247-fs pulses at 333 Hz and 4.6 mJ with a center wavelength of 4.07 μm, although exact characteristics vary for different repetition rates and arrangements. The spectral bandwidth avoids strong atmospheric CO_2 absorption centered around 4.3 μm, allowing operation in ambient air with good beam quality. The laser is simple, stable, reliable, and boasts a high repetition rate and average power compared to other systems. By focusing the 18-GW beam in air, harmonics up to the ninth order were observed indicating its potential for use in strong-field experimentation. Few-cycle pulses were generated by passing the beam, at a repetition rate of 400 Hz, through a large-diameter gas-filled hollow-core fiber followed by dispersion compensating bulk CaF_2. A krypton-filled fiber at 370 kPa yielded 1.14-mJ, 42-fs pulses centered at 4.07-μm, while an oxygen-filled fiber at 310 kPa delivered 0.78-mJ, 39-fs pulses spanning 3 to 5.5 μm.

This work is a step toward a high repetition rate mid-wave infrared driver of isolated attosecond, keV-level, X-ray pulses. Fe:ZnSe is a unique gain medium with potential to become a disruptive technology across a variety of fields, especially in strong-field science, in which many physical phenomena are enhanced at longer wavelengths.

Outline of Studies:
Major: Physics

Educational Career:
BA, Physics, University of Wisconsin-Madison, Madison, WI, 2019

Committee in Charge:
Dr. Zenghu Chang (Chair)
Dr. Michael Chini
Dr. Peter Delfyett
Dr. Jonathan W. Evans (External Committee Member)

Approved for distribution by Dr. Zenghu Chang, Committee Chair, on June 5, 2024

The public is welcome to attend.