Colton Fruhling

+1 402 238 8628
colton.fruhling@huskers.unl.edu
LinkedIn: Colton Fruhling
Extreme Light Laboratory

Research Interest

During my graduate training, I worked on extreme nonlinear interactions between light and matter with an emphasis on nonlinear Thomson scattering. My research has involved a mix of ideas and techniques from many research fields, for example, correlation 'ghost' imaging of relativistic electron beams with Thomson scattering, or imparting orbital angular momentum to x-rays generated from relativistic light-matter interactions for space communication. Going forward in my career, I am interested in all aspects of nonlinear optical phenomena, not only at those extreme intensities. I have always made it a point to attend any university seminar or international conference session where nonlinear optical topics are discussed.

Education

University of Nebraska Lincoln — Expected: May 2021
PhD, Physics and Astronomy — Lincoln, NE
Dissertation title: Fundamental Studies of Nonlinear Thomson Scattering
Advisor: Dr. Donald Umstadter - Director of the Extreme Light Laboratory

University of Nebraska-Lincoln — May 2019
MS, Physics and Astronomy — Lincoln, NE

Colorado State University — May 2014
BS, Physics and Astronomy — Fort Collins, CO
Graduated with Honors
Thesis title: Aparatus for the study of magnetic material in the presence of out-of-plane field with optical access
Advisor: Dr. Kristen Buchanan

Doctoral Projects

Listed below are some of the major projects I worked on during my doctoral research.

Highly Nonlinear Thomson Scattering

- Developed novel technique to overlap terawatt micron sized laser fields with femtosecond temporal resolution using sub-micron imaging and spectral interferometry
- Measured x-rays produced by multiphoton scattering from single electron in relativistic laser field
- Wrote first nonlinear Thomson code including coherency effects to study possibility of information transfer between electrons and photons during interaction

Optical Injection for Laser Wakefield Accelerator

- Achieved micron-femtosecond spatiotemporal overlap inside an underdense plasma
- Demonstrated the first evidence for optically injected electron beams via ponderomotive scattering

Nonlinear Thomson Scattering from Elliptically Polarized Light

- Studied with experiment the effect of laser polarization on polarizatio of emitted harmonics in nonlinear Thomson Scattering

- Designed an experimental setup utilizing single photon counting for high precision measurements

Petawatt Laser System Management

- Worked closely with a highly skilled team to keep complex laser system in peak performance. Flexibility of daily goals and perseverance are required for troubleshooting the many subsystems
- Alignment of Kerr lens mode-locking oscillator and multipass amplifiers, Alignment and modeling of Offner strecther, and intimate knowledge of ultrafast optical systems and chirp pulse amplification laser systems
- Collaborative designing and fabrication of piezoelectric driven automatic alignment system to improve laser system stability

RESEARCH

Research Assistant 2014-Present
Univeristy of Nebraska-Lincoln: Extreme Light Laboratory: Doctoral research on the nonlinear interaction of light and matter

Research Assistant 2013 - 2014
Colorado State University: Designed apparatus for applying magnetic field to material with optical access and modeled spin waves with Matlab

Research Intern 2012
US Strategic Command: Part of a diverse research team providing recommendations on best practices for collaborating with sensitive material

COLLABORATIONS

Working with a large laser system as a research assistant allowed for many opportunities to collaborate with scientists across the US.

Polarization-Resolved Measurements of Nonlinear Thomson Scattering 2020
Brigham Young University: Justin Peatross and Michael Ware

- Measured intensity scalings for polarization resolved Thomson scattering showing that matching between spot size and pulse duration is critical for most efficient interaction
- Coordinated multiple experiments simultaneously to successful publications

Radio frequency electromagnetic pulses from ultrashort pulse electron beam interactions 2020
Air Force Research Laboratory: Jennifer Elle

- Created and constructed experimental setup for successful laser wakefield electron beam generation in one week's time
- Operated and optimized laser wakefield driven electron beams

Relativistic intensity diagnostics for strong-field QED experiments 2019
Stanford University: David Reiss and Philip Bucksbaum

- Proposed suggestions for measurements of relativistic electrons generated by relativistic ponderomotive scattering and assisted in experimental setup

Laser wakefield betatron enhancment with tailored density profile 2019
University of Nebraska-Lincoln: Matthias Fuchs

- Aligned and characterized entire terawatt laser system for experimental use

HONORS AND AWARDS

GAANN Fellowship 2015-2017
Awarded to graduate students with excelent records pursuing highest degree in areas of national need

Best poster presentation 2017
High power Laser workshop: *Stanford Linear Accelerator Center*

Teaching Experience

Tutoring 2019 - 2020
Physics 212: Introductory Electricity and Magnetism

Recitation Teaching Assistant 2015 - 2016
Physics 212: Introductory Electricity and Magnetism

Lab Teaching Assistant Fall 2014
Physics 211: Classical Mechanics

Scientific Outreach

Physicist proposes way to record shutter speeds of molecule-glimpsing 'cameras' 2020
University of Nebraska-Lincoln news

Sunday with the Scientists 2017
Shared high powered laser physics with community of Lincoln

Saturday Science 2015
Led elementary aged students in hands on experiments

Computer Skills

Programming: Matlab, Python (NumPy, SciPy, Matplotlib), Fortran
Software: Monte Carlo (CAIN), Particle-in-cell (EPOCH), Finite Element (OpenFOAM), Ray Tracing (BEAM4)
Document Creation: Microsoft Office Suite, LaTex, Illustrator

Conference Posters and Presentations

Fruhling, C. (2020). Measuring Attosecond Electron Pulses with Coherent Nonlinear Thomson Scattering. *Bulletin of the American Physical Society*. 2020

Fruhling C., Golovin G., Banerjee S. & Umstader D.(2019), Probing wake structure of nonlinear wakes via optical phase-space excitation, *Anomalous Absorption Conference* 2019

Fruhling C., Golovin G. . . . &Umstadter D.(2018), Experimental demonstration of optical injection of electrons into a laser wakefield, 6^{th} *High-Power Laser Workshop* 2018

Fruhling C., Yan W. . . . & Umstadter D.(2017),Highly Nonlinear Thomson Scattering X-ray Source and Its Applications, 5^{th} *High-Power Laser Workshop* 2017

Fruhling, C., Yan W., . . . & Umstadter D.(2016), Highly Nonlinear Inverse Compton Scattering, *International Committee of Ultra-High Intensity Lasers* 2016

Publications

Fruhling, C., Schulzke C., Romero M., Wang J., Ware M., Peatross J., & Umstadter D. (2021), Polarization-Resolved Nonlinear Thomson Scattering of Elliptically Polarized Light, *Physical review X* 2021
In Review

Fruhling, C., Golovin, G., & Umstadter, D. (2020). Attosecond electron bunch measurement with coherent nonlinear Thomson scattering. *Physical Review Accelerators and Beams*, 23(7), 072802. 2020

Golovin, G., Horný, V., Yan, W., **Fruhling, C.**, Haden, D., Wang, J., ... & Umstadter, D. (2020). Generation of ultrafast electron bunch trains via trapping into multiple periods of plasma wakefields. *Physics of Plasmas*, 27(3), 033105. 2020

Haden, D., Golovin, G., Yan, W., **Fruhling, C.**, Zhang, P., Zhao, B., ... & Umstadter, D. (2020). High energy X-ray Compton spectroscopy via iterative reconstruction. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 951, 163032. 2020

Golovin, G., Yan, W., Luo, J., **Fruhling, C.**, Haden, D., Zhao, B., ... & Umstadter, D. (2018). Electron Trapping from Interactions between Laser-Driven Relativistic Plasma Waves. *Physical review letters*, 121(10), 104801. 2018

Zhao, B., Banerjee, S., Yan, W., Zhang, P., Zhang, J., Golovin, G., **Fruhling C.**,... & Umstadter, D. (2018). Control over high peak-power laser light and laser-driven X-rays. *Optics Communications*, 412, 141-145. 2018

Yan, W., **Fruhling, C.**, Golovin, G., Haden, D., Luo, J., Zhang, P., ... & Umstadter, D. (2017). High-order multiphoton Thomson scattering. *Nature Photonics*, 11(8), 514-520. 2017

Zhao B., Yan B., Zhang P., Banerjee S., Golovin G., **Fruhling C.**, ... & Umstadter D. (2016), A System to Control the Energy of a High-power Laser System with Application to X-ray Generation at Ultra-high Intensity, *Front. Opt.* (pp. JW4A-97) 2016

REFERENCES

Dr. Donald Umstadter
University of Nebraska-Lincoln
donald.umstadter@unl.edu
1 402-472-8115

Dr. Sudeep Banerjee
Arizona State University
sudeep.banerjee@asu.edu
1 480-815-6323

Dr. Justin Peatross
Bringham Young Univesity
peat@byu.edu
1 801-422-5043