The NSF Statutory Mission

Photo Credit: Maria Barnes, NSF

Plasma Physics

- Plasma Physics is a study of matter and physical systems whose intrinsic properties are governed by collective interactions of large ensembles of free charged particles. 99.9% of the visible Universe is thought to consist of plasmas. The underlying physics of the collective behavior in plasmas has applications to space physics and astrophysics, materials science, applied mathematics, fusion science, accelerator science, and many branches of engineering.

- The Plasma Physics program supports research that can be categorized by several broad, sometimes overlapping, sub-areas of the discipline including: magnetized plasmas in the laboratory, space, and astrophysical environments; high energy density plasmas; low temperature plasmas; dusty, ultra-cold, and otherwise strongly coupled plasmas; non-neutral plasmas; and intense field-matter interaction in plasmas.

[The Innovation Platform, Issue 22]

PHYSICS

National Science Foundation: Understanding the visible Universe through plasma physics

The U.S. National Science Foundation is supporting a broad portfolio of research across the field of plasma science and engineering

THE U.S. National Science Foundation (NSF) describes the discipline of plasma physics as a study of matter and physical systems whose intrinsic properties are governed by collective interactions of large ensembles of free charged particles.[1] 99.9% of the visible Universe is thought to consist of plasmas. The underlying physics of the collective behaviour in plasmas has applications to space physics and astrophysics, materials science, applied mathematics, fusion science, accelerator science, and many branches of engineering.

This description of the discipline has served as the defining guidepost of the Plasma Physics program within the NSF Division of Physics for the past decade. The broader field of Plasma Science and Engineering (PSE) was most recently reviewed in 2021 by the National Academies of Sciences, Engineering, and Medicine (NASEM) in the Decadal Assessment of Plasma Science,[2] 'Plasma Science: Enabling Technology, Sustainability, Security, and Exploration'. PSE encompasses many of the nominally distinct disciplines where the knowledge of the physics of plasmas is critical to understanding the Universe as we know it, and to developing new technologies that rely on plasma's unique properties. In the US, many of these are supported by dedicated programs within NSF and other federal science agencies.

The study of collective interactions in complex, many-body, nonequilibrium systems is not unique to plasmas. In fact, one could argue that a plasma where electromagnetic forces dominate the collective interactions is one of the simplest examples of such a system. A recent NSF-funded workshop,[3] Working Across Scales in Complex Systems, explored parallels between plasma physics and biological physics in

The P3 (Plasma Physics Platform)-installation at ELI Beamlines where the exper

Recent NSF-funded projects that have used, or are aiming to use, NIF or JLF:

Jun Ren (Delaware State U.), "Excellence in Research: Seeding Stimulated Raman Backscattering with Intense and Ultra-Intense Laser Pulses"

Christopher Orban (OSU) et al., "Collaborative Research: Enhancing Laser Based Ion Sources with High Data Rate Techniques"

Thomas White (U. Nevada, Reno), "CAREER: Non-Adiabatic Effects in Dense Plasmas"

Petros Tzeferacos (U. Rochester), "TDYNO: Fluctuation Dynamo, Heat Transport, and Ion Acceleration in Magnetized Turbulence"

Maria Gatu Johnson (MIT), "Unique Application of High Energy Density Plasmas for Nuclear Astrophysics Experiments"

Plasma Physics

Matthew R. Edwards
Assistant Professor of Mechanical Engineering

Stanford University

CAREER: Plasma Optics for Compact Ultra-High-Power Lasers

High-power lasers that provide ultrashort pulses of intense light are a critical technology for fundamental science and a range of industrial, medical, and national security applications. The key constraint on laser power and performance is damage to glass and metal optics: to prevent high-power lasers from destroying themselves, their optics must be large. The size and expense of large optics make higher laser powers impractical and limit possible applications of existing systems. This project replaces optics inside high-power lasers with plasma components, allowing the control of a thousand times higher light intensity and leveraging machine learning to provide a unique, physics-based solution to a bottleneck in laser development. It also creates educational and research opportunities to train students in plasma physics and high-power laser engineering. The compact plasma-based high-power lasers developed here will both advance scientific fields like particle physics, plasma physics, quantum optics, and astrophysics and enable the use of high-intensity light for applications like nuclear fusion energy, radiotherapy for cancer treatment, x-ray imaging for sensitive material detection, and the construction of advanced accelerators and light sources for semiconductor manufacturing...

THE GÉRARD MOUROU
CENTER FOR ULTRAFAST
OPTICAL SCIENCE
UNIVERSITY OF MICHIGAN

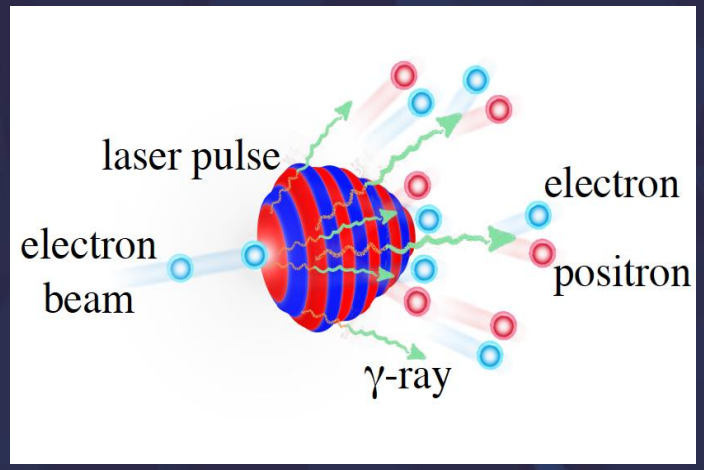
Zettawatt-Equivalent Ultrashort Pulse Laser System

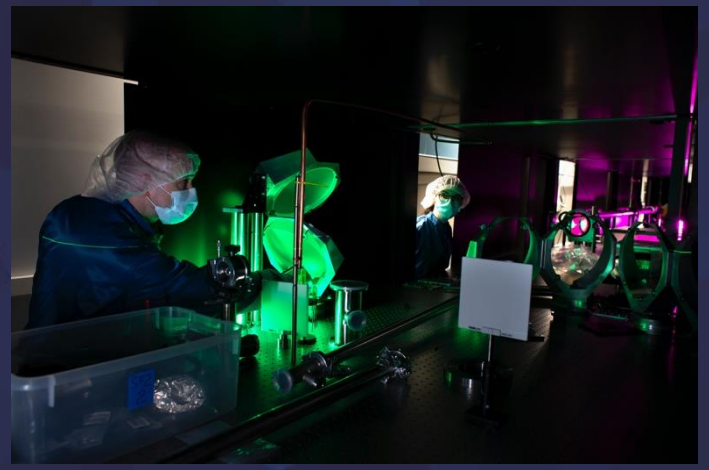
ZEUS

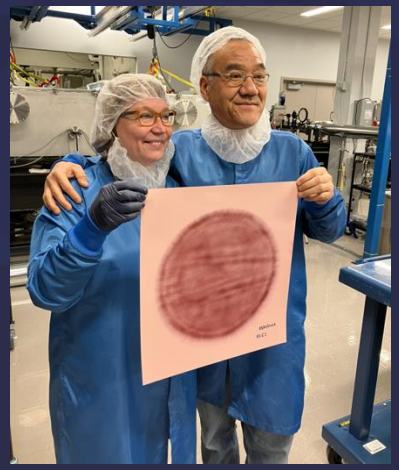
3 Petawatt power laser facility
Experiments on:

- Testing extreme field physics
- Unique particle & photon sources
- Applications of sources across STEM

Operates as an NSF user facility
2 PW pulses demonstrated!







https://zeus.engin.umich.edu/

Mid-scale Research – Awards # 1935950 and 2126181

ZEUS

Home | About | Research | Users | Education | News and Events

NSF ZEUS User Facility

U.S. National Science Foundation Zettawatt-Equivalent Ultrashort pulse laser System (ZEUS) User Facility

About

The NSF ZEUS User Facility has the highest-power laser system in the US and among the highest-power lasers worldwide for the next decade. ZEUS operates as an NSF sponsored user facility, offering external users experimental access using a merit-based peer reviewed proposal system to advance science frontiers and enable discovery.

Learn more >
Take a 360 Tour of ZEUS >

Research

The NSF ZEUS User Facility allows exploration of fundamental yet unanswered questions regarding non-linear quantum electrodynamics in relativistic plasmas, including quantum radiation reaction and electron-positron pair production mechanisms.

Learn more >

FY 27 Proposal Cycle

Proposals for the ZEUS FY 27 cycle ar
February 16, 2026 by 5 PM EST

The call for proposals for the FY27
access to ZEUS laser facility is ope
Proposals must be submitted thro
the MyZEUSPortal. If you have que
please contact the ZEUS team at z
users@eecs.umich.edu.

Proposal Guidelines >
Info for Users >

FY 27 Proposal Deadline

The call for proposals for the FY27 cycle access to ZEUS laser facility is open. Information about **proposal preparation** and the **expected laser parameters and target area capabilities** are detailed on the **ZEUS website**. Proposals must be submitted through the **MyZEUSPortal**.

Proposals for the FY27 cycle are due by February 16, 2026 at 5 PM EST.

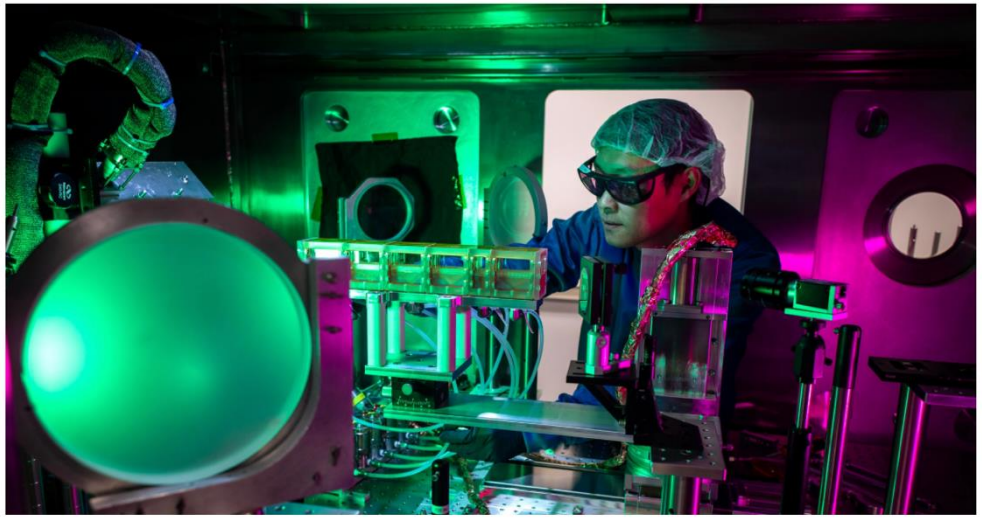
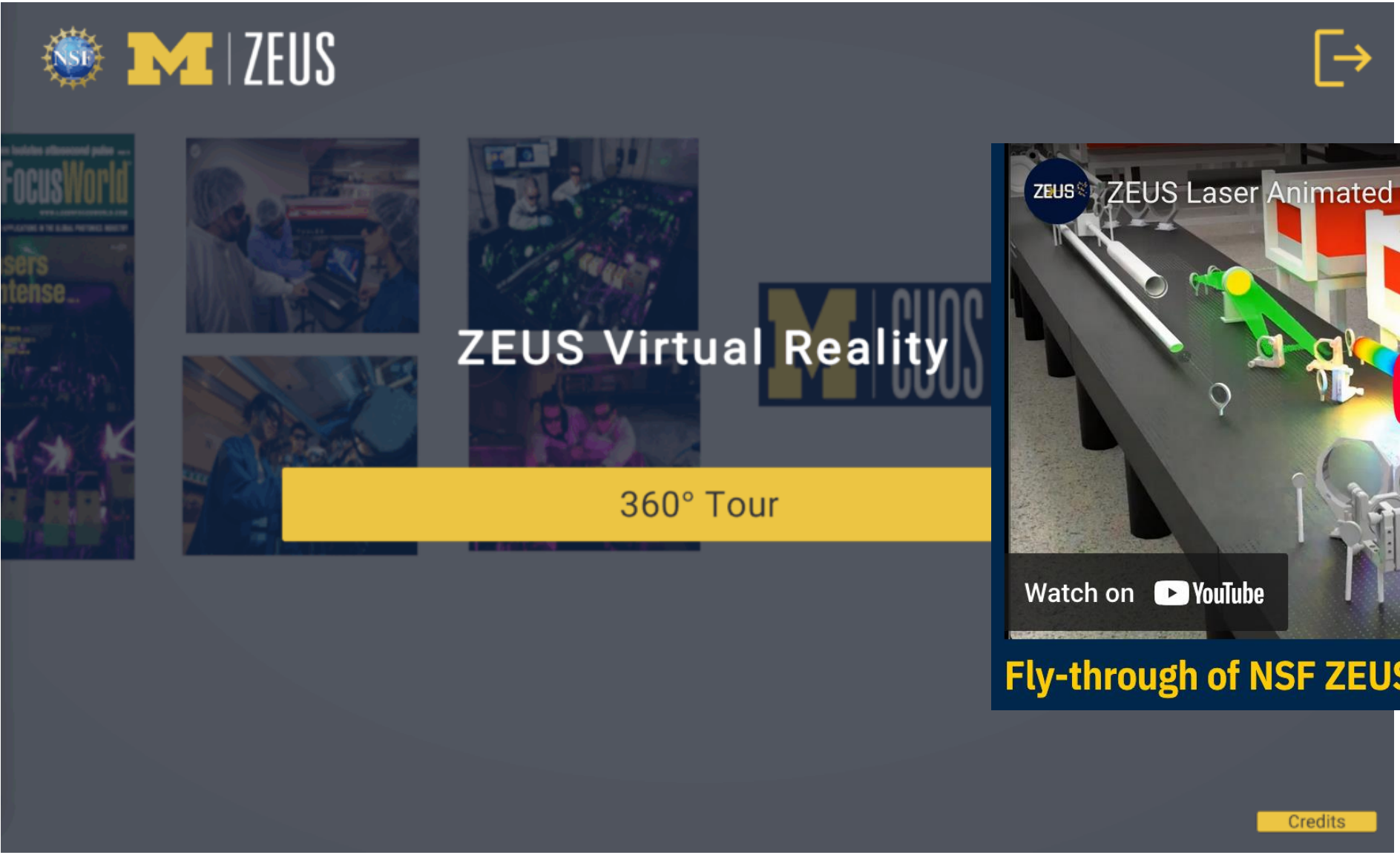


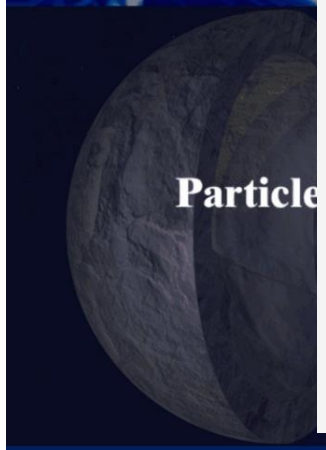
Photo: Marcin Szczepanski/Michigan Engineering

https://zeus.engin.umich.edu/



Fly-through of NSF ZEUS laser facility

https://zeus.engin.umich.edu/



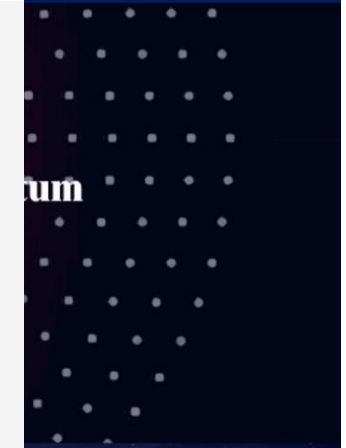
Community Update

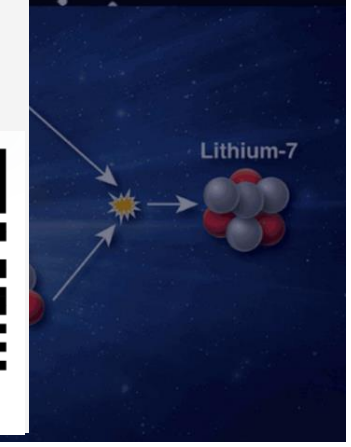
February 24, 2026 11:00 AM – 12:30 PM EST

Join the team for a live briefing and Q&A covering the latest technical and collaborative milestones, including: laser facility updates, experimental systems, project timelines, and community highlights.

Whether you are a potential user, a collaborator, or a student, this is your chance to get the latest information and ask questions directly to the NSF OPAL team.

Register here! → https://rochester.zoom.us/meeting/register/TV288XQmQXa5tA3veYxj9A#/registration



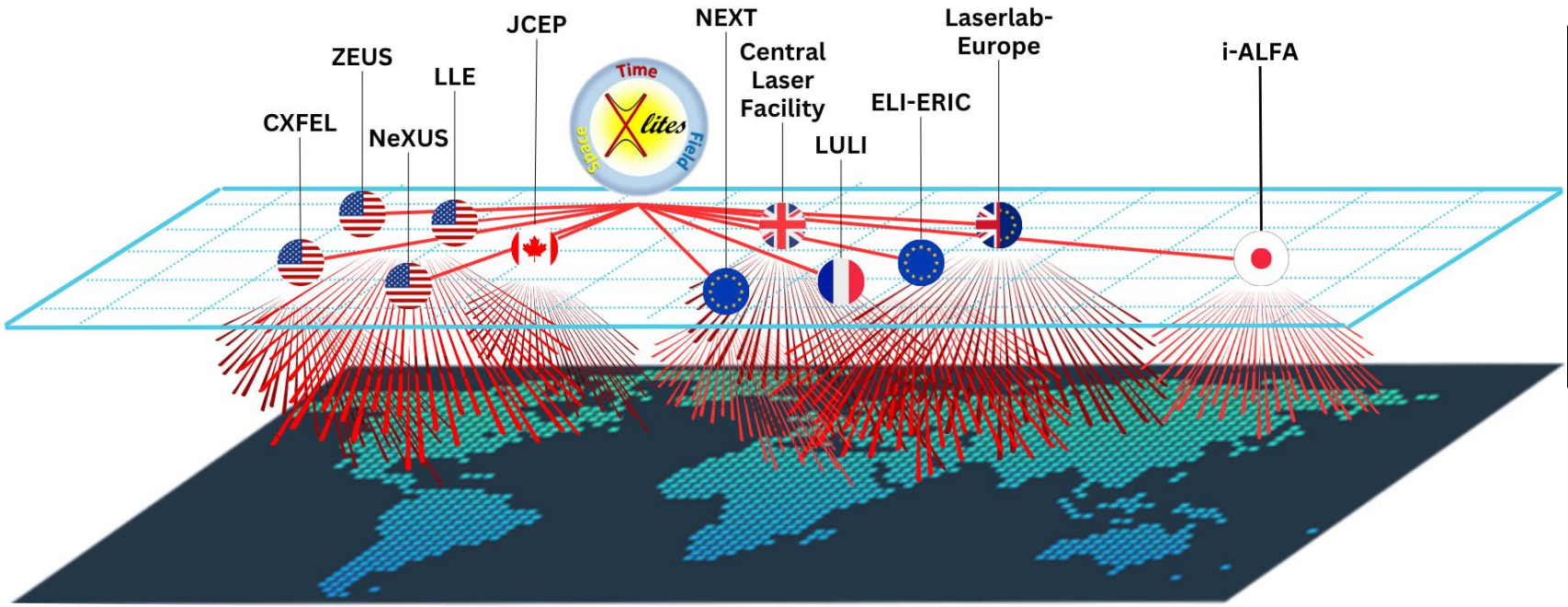


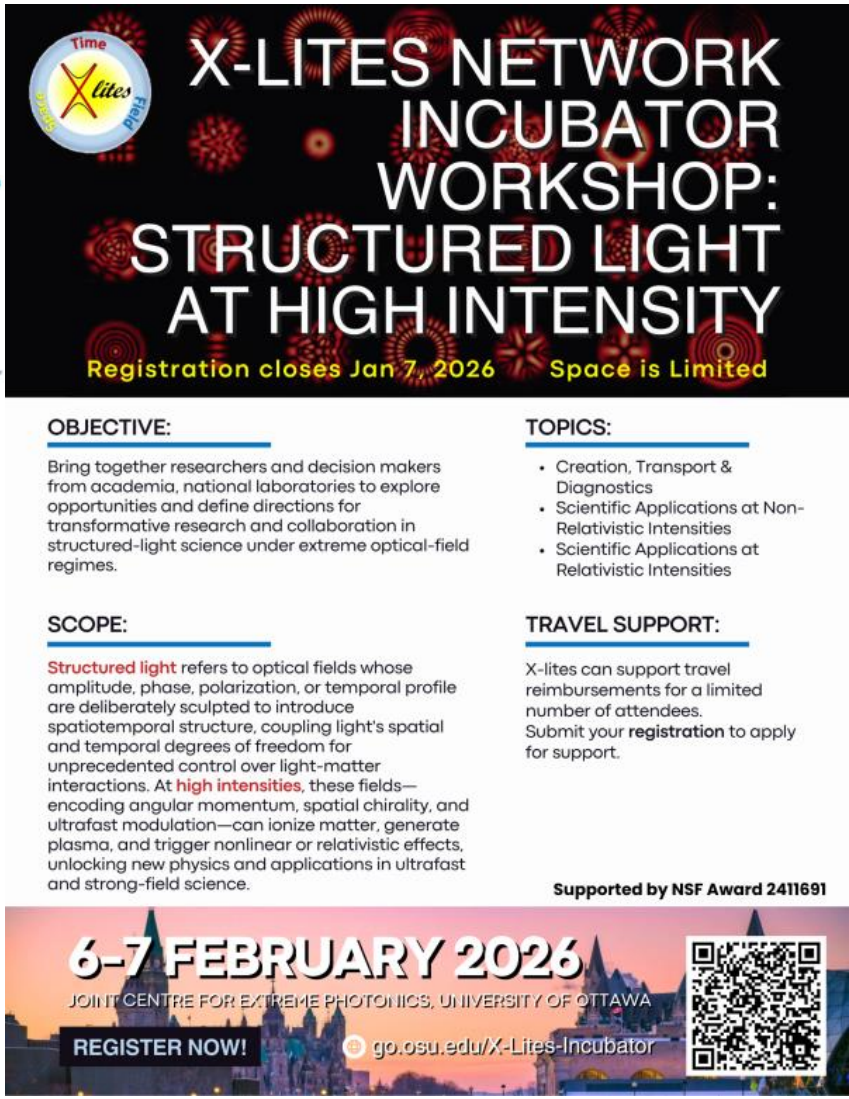
https://nsf-opal.rochester.edu/

NSF OPAL: Next Generation Experimental User Facility

Groundbreaking Science | Workforce Development | Transformational Technology

International Partnerships





X-lites - the Extreme Light in Intensity, Time, and Space network (https://opticalscience.osu.edu/x-lites) promotes collaboration around the world to make use of new extreme light facilities. X-lites is bringing together facility users and facility operators to support high-impact science and engineering using extreme light.

Workshop Goals:

- Address the current state of scientific understanding regarding the design and fabrication of optical materials and components for next generation high-power laser technologies
- Identify scientific gaps hindering progress, and
- Offer solutions for bridging the associated technological gaps.

NEXT-GENERATION OPTICAL MATERIALS AND COMPONENTS FOR HIGH-POWER LASERS WORKSHOP

Multi-PetaWatt (MPW) Diagnostic Community Workshop
May 21-22, 2026 at U. Michigan - Ann Arbor

- **Workshop Goals:**
  - Understand and identify diagnostic technologies and detector science that will be used to address scientific frontiers for multi-petawatt facilities
  - Identify technical gaps in bridging present diagnostic solutions to the MPW scale and leverage technology solutions from complementary fields
  - Develop and connect diagnostic scientists across the MPW community
  - Working group areas to survey the state-of-the-art in
    - Hard X-rays
    - Particle beam diagnostics
    - Ultrafast high-power optical diagnostics

- **Registration and white paper submission: Due March 31, 2026**

https://nsf-opal.rochester.edu/mpw-diagnostic-community-workshop/

Co-chairs – Contact for more information!

Steve Ivancic, steve.ivancic@rochester.edu
Louise Willingale, wlouise@umich.edu
Mike Downer, downer@physics.utexas.edu

MPW DIAGNOSTIC COMMUNITY WORKSHOP
MAY 2026

Register today!

UNDERGRADUATE SUMMER SCHOOL

June 1 - 5, 2026

The Center for Matter at Atomic Pressure (CMAP) at the University of Rochester is hosting a week-long, residential summer program for undergraduate students who are eager to learn more about the physics of extreme states of matter!

CMAP consists of world-leading physicists, astrophysicists, and planetary scientists with expertise that spans theoretical and numerical modeling, and experiments. Over the course of a week, undergraduates will have access to modern computational and educational tools that they can leverage across a wide range of disciplines

Open to undergrads at U.S. colleges and universities, each student will be introduced to the science of extreme pressure in an immersive, collaborative environment. This program aims to engage undergraduate students in the field of high-energy-density physics and promote a learning environment where they are exposed to new research tools and techniques.

NSF PHYSICS FRONTIERS CENTER

What is CMAP?

Funded by the National Science Foundation (NSF) and hosted at the University of Rochester, the Center for Matter at Atomic Pressures (CMAP) is dedicated to exploring matter under the uncharted, extreme conditions at which most of the known mass in the universe resides.

SCAN ME

Apply Online by March 8

https://cmap.rochester.edu/