Nuclear Engineering and Radiological Sciences
Winter 2019 Colloquium

X-ray Sources from Laser-Plasma Acceleration:
Development and Applications for High Energy Density Sciences

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Friday, February 8th
4pm-5pm
White Auditorium, G906 Cooley
Refreshments served at 3:45

Bright sources of x-rays, such as synchrotrons and x-ray free electron lasers (XFEL) are transformational tools for many fields of science. They are used for biology, material science, medicine, or industry. Such sources rely on conventional particle accelerators, where electrons are accelerated to gigaelectronvolts (GeV) energies. The accelerating particles are also wiggled in magnetic structures to emit x-ray radiation that is commonly used for molecular crystallography, fluorescence studies, chemical analysis, medical imaging, and many other applications. One of the drawbacks of synchrotrons and XFELs is their size and cost, because electric field gradients are limited to about a few 10s of MeV/M in conventional accelerators.

This seminar will review particle acceleration in laser-driven plasmas as an alternative to generate x-rays. A plasma is an ionized medium that can sustain electrical fields many orders of magnitude higher than that in conventional radiofrequency accelerator structures. When short, intense laser pulses are focused into a gas, it produces electron plasma waves in which electrons can be trapped and accelerated to GeV energies. This process, laser-wakefield acceleration (LWFA), is analogous to a surfer being propelled by an ocean wave. Betatron x-ray radiation, driven by electrons from laser-wakefield acceleration, has unique properties that are analogous to synchrotron radiation, with a 1000-fold shorter pulse. This source is produced when relativistic electrons oscillate during the LWFA process.

An important use of x-rays from laser plasma accelerators we will discuss is in High Energy Density (HED) science. This field uses large laser and x-ray free electron laser facilities to create in the laboratory extreme conditions of temperatures and pressures that are usually found in the interiors of stars and planets. To diagnose such extreme states of matter, the development of efficient, versatile and fast (sub-picosecond scale) x-ray probes has become essential. In these experiments, x-ray photons can pass through dense material, and absorption of the x-rays can be directly measured, via spectroscopy or imaging, to inform scientists about the temperature and density of the targets being studied.

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344, supported by the LLNL LDRD program under tracking code 13-LW-076, 16-ERD-024, 16-ERD-041, supported by the DOE Office of Fusion Energy Sciences under SCW 1476 and SCW 1569, and by the DOE Office of Science Early Career Research Program under SCW 1575.

Félicie Albert is currently a staff scientist at the Lawrence Livermore National Laboratory in the National Ignition Facility and Photon Science directorate and the Joint High Energy Density Sciences (JHEDS) organization. She was hired at LLNL in 2008 as a postdoctoral researcher in the photon science and applications (PS&A) program to work on nuclear resonance fluorescence experiments, and became a permanent member of the technical staff in 2010. She earned her PhD in physics in 2007 from the Ecole Polytechnique in France, her MS in Optics from the University of Central Florida in 2004, and her BS in engineering from the Ecole Nationale Supérieure de Physique de Marseille, France, in 2003. Her areas of expertise include the generation and applications of novel sources of electrons, x-rays and gamma-rays through laser-plasma interaction, laser-wakefield acceleration, and Compton scattering. She has conducted many experiments using high-intensity lasers.

Félicie was awarded a 2016 U.S. Department of Energy Early Career Research Program Award to develop new x-ray sources for high energy density science experiments, and has been leading several Laboratory Directed Research and Development (LDRD) Projects at LLNL. She is the recipient of the 2017 American Physical Society (APS), Division of Plasma Physics Katherine E. Weimer Award for outstanding contributions to plasma science research, of the 2017 Edouard Fabre Prize for contributions to the physics of laser-produced plasmas, of a LLNL Director's Early and Mid-Carreer Recognition award in 2015, and was selected by the APS as an outstanding referee in 2015. She serves on many technical review panels, conference committees, editorial boards, and is regularly involved in outreach activities for large or specialized audiences. She has over 70 refereed publications and has given over 35 invited talks at international conferences.

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