

Laser-Plasma Science and Applications with Intense Laser Pulses

Recent advances in laser–plasma science and emerging applications enabled by intense laser pulses will be discussed in this colloquium. Intense laser–matter interactions provide a unique platform for generating extreme plasma conditions, enabling fundamental studies of plasma physics as well as the development of advanced particle and radiation sources. Recent progress has significantly expanded the applications of laser–plasma interactions in accelerator science, high-energy radiation generation, electromagnetic technologies, and future energy research. The presentation will first introduce laser wakefield acceleration driven by multi-petawatt femtosecond laser pulses, together with the generation of high-brightness betatron gamma-ray sources. The underlying laser–plasma acceleration mechanisms and their potential applications in ultrafast imaging, high-energy-density plasma diagnostics, and compact radiation sources will be discussed. It will then present recent studies on laser-induced electromagnetic pulse (EMP) generation and plasma filamentation. Finally, research plans for laser-fusion plasma science will be presented. Building upon extensive experience in ultra-intense laser–plasma science, the proposed research program will focus on laser-driven plasma compression, the generation of high-temperature and high-density plasmas, advanced plasma diagnostics, and integrated computational modeling. These efforts aim to establish the scientific and technological foundation for next-generation laser fusion. Overall, laser–plasma science is expected to become a key enabling technology that drives transformative advances across accelerator science, advanced radiation sources, fusion energy, and many other interdisciplinary fields.