

New Perspectives in Free-Electron Laser Light Sources

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Free-electron lasers (FELs) have become one of the most powerful sources of coherent radiation, providing ultrashort and extremely intense pulses from the infrared to the hard X-ray spectral region. Their development has opened new opportunities in physics, chemistry, biology, materials science, and studies of matter under extreme conditions.

This seminar will introduce the fundamental principles underlying FEL operation, from the interaction between a relativistic electron beam and the radiation field in an undulator to the collective amplification process that leads to high-gain coherent emission. The main FEL configurations and their characteristic properties will be discussed, providing the background needed to understand the capabilities and limitations of present-day sources.

An overview of the international landscape of FEL facilities will then be presented, highlighting the different approaches adopted by major operating and planned facilities worldwide. Particular attention will be devoted to some of the main directions currently driving FEL research and development. These include the generation of increasingly short, down to attosecond, radiation pulses; the improvement of temporal and spectral coherence through external seeding, self-seeding, and oscillator-based schemes, and the extension of coherent FEL operation toward new wavelength and pulse-structure regimes.

The seminar will also discuss advances in electron-beam generation and acceleration, including novel acceleration techniques and concepts aimed at reducing the size, complexity, and cost of FEL facilities. These developments may ultimately enable more compact sources while preserving, or potentially extending, the performance of present large-scale installations