I-02

The applications of a short-wavelength FEL

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The third-generation synchrotron light sources today offer exciting new scientific capabilities due to the high brightness of their hard x-ray beams. Yet further dramatic increases in source brightness are becoming technically feasible with the advent of free-electron lasers (FELs) operating in the hard x-ray region. The peak brightness of machines under consideration exceeds that of today's third-generation sources by more than ten orders of magnitude. In addition, an FEL would produce an x-ray beam with very high transverse coherence and sub-picosecond pulse length. These characteristics should open up completely new areas of x-ray science, such as nonlinear x-ray optics and femtosecond time-domain spectroscopy. Some areas of current research, such as imaging and interferometry, could be extended to much shorter wavelengths and faster measurements. The intense beam could also be used to modify materials on a nanometer scale. Formidable technical problems in the areas of optics, sample preparation, and data collection will need to be solved before an FEL beam could be effectively utilized. Research in these areas is now beginning to be pursued in the U.S., Germany, and Japan.