The Extreme Light Infrastructure, ELI: from Relativistic to Ultra-Relativistic Optics

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We will describe the European Light Infrastructure, called ELI for Extreme Light Infrastructure, dedicated to the fundamental study of laser-matter interaction in a new and unsurpassed regime of laser intensity: the ultra-relativistic regime ($I_L > 10^{23}$ W/cm^2). In this regime the laser field is strong enough to accelerate the proton to relativistic velocity leading to superior particle beams. These investigations will rely on an exawatt-class laser ~100-1000 times more powerful than either the Laser Megajoule in France or the National Ignition Facility (NIF) in the US. In contrast to these projects, ELI will attain its extreme power from the shortness of its pulses (femtosecond and attosecond). The infrastructure will serve to investigate a new generation of compact accelerators delivering energetic particle and radiation beams of femtosecond (10^{-15} s) to attosecond (10^{-18} s) duration. Relativistic compression offers the potential of intensities exceeding $I_L > 10^{25}$ W/cm^2, which will challenge the vacuum critical field as well as provide a new avenue to ultrafast attosecond to zeptosecond (10^{-21} s) studies of laser-matter interaction. ELI will afford wide benefits to society ranging from improvement of oncology treatment, medical imaging, fast electronics and our understanding of aging nuclear reactor materials to development of new methods of nuclear waste processing.

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