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Preface to Special Topic: Extreme High-Field Physics Driven by Lasers

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With the continuous development of high power laser technologies, lasers with peak power at 10 petawatt (PW) or above are becoming available soon in a few laboratories worldwide. Such lasers may be focused to an intensity above 10^{23} W/cm^2, at which heavy elements such as uranium can be stripped of electrons, entirely leaving behind pure atomic nuclei, and electrons can be accelerated to more than 10 GeV. We are entering an unprecedented regime of laser-matter interactions, where collective effects, relativistic effects, and quantum electrodynamic (QED) effects all play significant roles. Extremely rich nonlinear physics in this regime could be tested experimentally, such as radiation reaction, gamma-ray and pair production via different processes, laser driven nuclear physics, laser-vacuum polarization, etc. It is expected that the new understanding of physics for these extreme high field conditions will lead to a wide range of applications.

Even though very few experimental efforts have been made so far, significant theory and simulation studies have been carried out in this field. Here we are pleased to publish seven papers dedicated to this specific topic in *Matter and Radiation at Extremes*. In Ref. 1, An *et al.* report a new gamma-ray source under construction to generate highly-polarized, high-brightness, and monoenergetic gamma rays within a wide energy range from 1 to 100 MeV based on the 2.5 GeV high-energy electron accelerator BEPCII at IHEP in Beijing. Wu *et al.* present numerical simulations on laser interaction with heavy metals for laser intensities varying from 10^{20} to 10^{24} W/cm^2 in Ref. 2. In nonlinear Thomson scattering, high energy photons can be produced with unique properties, which is described by Chen *et al.*[3] In the work of Zhu *et al.*,[4] it is shown that a plasma channel is advantageous to produce collimated gamma-rays and electron-position pair jets with multi-PW lasers. In Ref. 5, Koga *et al.* consider the possibility of probing vacuum polarization with micro-bubble implosions, where unprecedented high fields can be induced by ultra-high intensity lasers interacting with pre-formed targets. In the work of Bolaños *et al.*,[6] a new type of solid target is found for the benefit of efficient electron acceleration and subsequent applications. Bright neutron sources can be produced from multi-PW laser-driven ion acceleration, which provide a new way for nuclear physics, as discussed by Chen *et al.*[7]

Generally, research on this topic is highly cross-disciplinary, covering particularly laser plasma physics, nuclear physics, accelerator physics, quantum electron dynamics, and astrophysics. Exploration in this area is just at the beginning, and many interesting discoveries and applications are expected in the coming years when such high power lasers become available for experiments.

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