HIGH ENERGY DENSITY SCEINCE WITH HIGH POWER LASER AND XFEL IN JAPAN

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High power laser technologies are now opening a variety of attractive fields in high energy density (HED) sciences and technologies that deal with high-density plasma or plasma devices [1], e.g. material science in extreme states, particle acceleration, laboratory astrophysics, medical applications, nuclear science including laser fusion and vacuum quantum optics. Now we are focusing on three kinds of fields in the HED sciences, i.e. high pressured condensed matter, laser wake-field acceleration and vacuum quantum optics, and exploring them with high power lasers including X-ray Free Electron Laser (XFEL).

One of the most interesting topics is creation of high pressures of GPa to TPa in solid matter with high power lasers. To explore such states of matter, we are now caring out a project using an XFEL or SACLA under RIKEN and optical high power lasers in Japan. This is called the **HERMES** project: High Energy density Revolution of Matter in Extreme States project. The HERMES project consists of 3 steps to explore the HED science. As the 1st step, we have constructed a 40TW/25fs laser and a 20J/530nm long pulse laser system synchronized with the SACLA. Extreme states of matter in the pressure range of 100GPa are created by the optical laser light and the XFEL beam will clear the dynamics of the compression, deformation and phase transition of the extreme states of matter. In the 2nd step, we are constructing 2 beams of 500TW/25fs lasers and developing a 400J long pulse laser. The extreme states with pressures of TPa will be investigated with the 2nd step system. Incasing the optical laser power up to 10PW as the 3rd step, we would expect expanding the field of HED science such as quantum vacuum optics.

Exotic states would be also created in vacuum with the combination of high power lasers and a plasma devices, which was vacuum quantum optics. One of the topics in vacuum quantum optics is observation of light scattering from the vacuum due to the quantum fluctuations in a strong electromagnetic field and other the measurements of x-ray scattering in a strong gravitational field or acceleration field. These states are now being investigated with a theoretical approach and will be explored at the 2nd to 3rd step of the **HERMES**.

In order to realize laser-plasma acceleration, plasma photonic devices for the effective control of plasma waves and light propagation are necessary. The pointing stability of the electron beam emitted is now less than 0.3mrad by using the plasma photonic device. We are also developing a plasma photonic device for the phase control and multi-stage acceleration of electrons. A new project has started to realize the laser-plasma accelerator system in the range of GeV for laboratory-scale X-ray light sources and XFEL, which is called the **LAPLACIAN** project: Laser Acceleration Platform as a Coordinated Innovative Anchor project. The **LAPLACIAN** project is being promoted under collaboration of Osaka University, RIKEN, JAEA, KEK and other Universities in Japan

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