Magnetic dynamics and confinement properties in non-equilibrium extreme radiation plasma

D. Kawahito and Y. Kishimoto

Graduate School of Energy Science, Kyoto university, Uji, Kyoto, Japan, 611-0011
kawahito.daiki.56m@st.kyoto-u.ac.jp

The interaction between high power laser in the range of $10^{20\text{-}23}$W/cm^2 and high-Z structured material can lead to a high energy density plasma consisting of high energy relativistic electrons, multiply charged high-Z ions, strong X-rays and γ-rays resulting from various types of electronic transition of exotic atomic states, bremsstrahlung, radiation damping. In such state, the secondary interaction between the plasma and the radiation exhibits the non-stationary and non-thermodynamic energy transport through the specific interesting processes such as multi-photo ionization, photo-nuclear reaction, and electron-positron pair creation [1], which we refer it as "*non-equilibrium extreme radiation plasma (NERP)*". It provides a new platform in studying non-linear quantum electrodynamics and extreme state in universe, and also in exploring new application such as heavy ion acceleration [2] and strong γ-ray source, etc.

However, the material structure tends to be broken up before such reaction takes place as the increase of the irradiated laser intensity. Thus, it is necessary to keep the high energy density state during a certain time scale for emphasizing the interaction between the plasma dynamics and radiation processes.

Here, we propose a magnetic confinement system composed of a lattice-like assembly of high-Z sub-μm rods and external magnetic field [3] as seen in Fig.1. In the laser interaction with the system, the each rod is ionized to high charge state and then expands to radial direction leading to the compression of the magnetic field. It is settled to the magnetic vortex surrounding the rod through the current induction along the cylindrical direction. It is found that the magnetic amplitude increases up to 10 times the external magnetic field, and the beta value, which is ratio of thermal pressure to magnetic pressure, reaches to $\beta \simeq 1$ in our simulation results as seen in Fig.2. Such condition depends on the arrangement of rod and also direction of the external magnetic field. We will present the detail of the magnetic dynamics and the confinement process coupled with atomic and radiation processes.

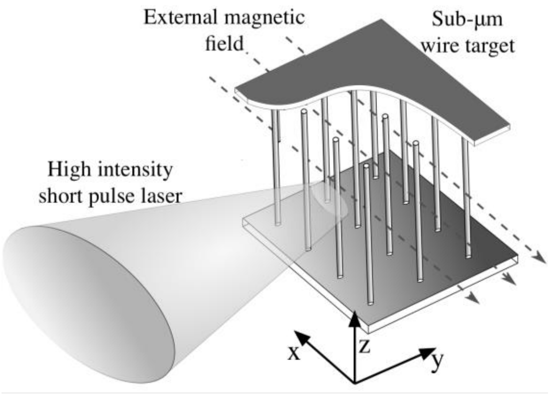

Fig.1 Magnetic confinement system by utilizing the structured material.

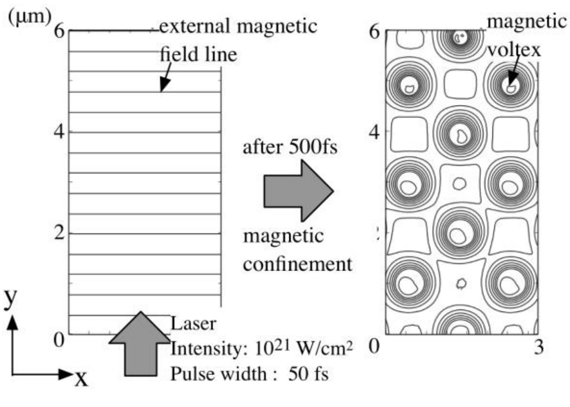

Fig.2 Generation of magnetic vortex around the rod in 2D PIC simulation result.

References

[1] G. A. Mourou, T. Tajima and S. V. Bulanov., Rev. Mod. Phys. 78 (2006) 309
[2] D. Kawahito, Y. Kishimoto, *et al*., J. Phys.: Conf. Ser. 717, 012066 (2015)
[3] S. Fujioka et al., Sci. Rep. 3, 1170 (2013).