論文題目要旨

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論文題目: Study of Gas Target Instability Effects on Laser Wakefield Acceleration

(レーザー航跡場加速におけるガス標的不安定性の影響に関する研究)

論文要旨:Laser wakefield acceleration (LWFA) is capable of accelerating electrons to high energy in a short distance due to the strong electric field inside plasma wave. This characteristic makes it feasible to develop compact free electron laser (FEL). Preparing high quality and reproducible electron beams for the undulator of FEL via LWFA remains a challenge. Quasi-monoenergetic electron beam can be produced by the shock injection method since the electron injection is well localized. However, the electron beam quality is sensitive to shock front properties.

This work focuses on the development of plasma targets to deliver high quality electron beam suitable for extreme ultraviolet FEL. The experimental and numerical studies show that shock fluctuation has a strong relation to the stability of the upstream gas flow provided by the supersonic nozzle. By employing a stilling chamber and meshes into the gas flow, the effect of turbulence and vortex structures in the gas flow are significantly suppressed in both simulations and experimental measurement. The corresponding fluctuation of shock front can be reduced from 20 μ m to 1.5 μ m. Reproducible electron beams with charge of 20pC, peak energy of 370 MeV and energy spread less than 2% are achieved on the LAPLACIAN platform in RIKEN SPring-8 Center, Japan. The pointing fluctuation of the electron beams are 0.5 mrad. Such electron beams meet the requirements of future extreme ultraviolet FEL experiments.