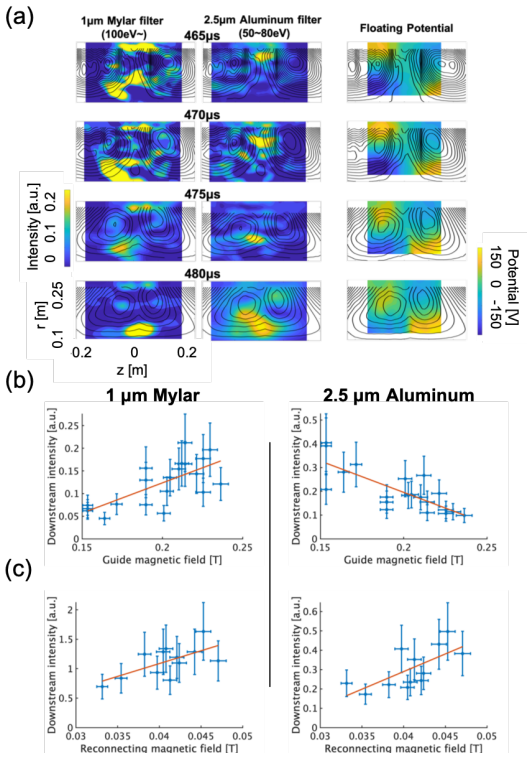
7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Multi-view Imaging of Energetic Electron during High-Guide Field Magnetic Reconnection in Tokamak Merging Experiment

Shinjiro Takeda[1], Yukehi Okunishi[1], Yunhan Cai[1], Hiroshi Tanabe[1], Yasushi Ono[1]
[1] The University of Tokyo
e-mail (speaker): stakeda@ts.t.u-tokyo.ac.jp
As an AAPPS-DPP standard, we do not need to add your postal address.

Reconnection electric is found to accelerate electrons to the downstream for the first time during high guide magnetic fields, forming a quadrupole electrostatic potential profile for the following ion acceleration and heating. In this important process, the production of energetic electrons has been detected in both PIC simulations [1] and laboratory plasmas [2,3]. The spatial profile of the energetic electrons is often measured by observing the bremsstrahlung emitted from the electrons. In this study, we measured the high-guide-field reconnection of two merging tokamaks using a stereo-view soft X-ray cameras [4], which enables us to simultaneously measure two-dimensional images of the Bremsstrahlung through two different filters. A compact vacuum vessels with a built-in microchannel plate and filtered pinholes are installed in the TS-6 spherical tokamak merging device. The two filters are a 1-μm Mylar film for high-energy electrons and a 2.5-μm aluminum film for low-energy electrons. Two-dimensional soft X-ray emission profiles were reconstructed from the measured line-integrated stereo images.

The soft X-ray emission contours were measured as shown in Fig. (a). The left column shows the high-energy electron image measured through a Mylar filter, and the middle column shows the low-energy electron image through an aluminum filter. The time evolution of the electrostatic potential shown in the right column agrees qualitatively with the scenario of accelerated energetic electrons forming a quadrupole potential. It can be seen that the emission peaks are localized around the X-point at t = 470 μs in the high-energy electron image and at 468 μs in the low-energy electron image. The downstream emission peak at t = 475 μs was observed in both the high-energy and low-energy images. When the experiment was performed with different intensities of the reconnecting and guide magnetic fields, the magnetic field dependence of the emission intensity at the X point was confirmed as shown in Fig. (b): the intensity of the high energy emission peak increases with the guide magnetic field amplitude, while the intensity of the low energy emission peak decreases. This fact suggests that the electron acceleration near the X point increases with the length of the magnetic field lines in the X point region where no poloidal magnetic field exists. On the other hand, the downstream emission peaks increased with reconnecting field strength for both high and low energy electrons (Fig. (c)). This emission is considered to come from the electrons accelerated to the downstream region by an electric field parallel to the magnetic field. It may also include high-energy electrons due to Fermi acceleration [5]. In order to clarify the mechanism for the electron acceleration, we have increased the number of X-ray images through different filters from two to six and are obtaining two-dimensional Bremsstrahlung spectral information, and are currently conducting experiments with the system extended to four viewpoints.



Time evolution of soft X-ray emission in two energy bands and floating potential (a) and magnetic field dependence of emission intensity in two energy bands at the X-point (top) and in the downstream region (bottom) (b).

References
[1] P. Pritchett, et al.: *J. Geophys. Res.*, Vol.109, A01220 (2004)
[2] T. Yamada, et al.: *Nucl. Fusion,* Vol.56, 106019 (2016)
[3] M. Inomoto, et al.: *Nucl. Fusion*, Vol.59, 086040 (2019)
[4] J. Xiang, et al.: *Rev. Sci. Instrum.,* Vol.92, 083504 (2021)
[5] J. T. Dahlin: *Phys. Plasmas*, Vol. 27, 100601 (2020)