論 文 の 内 容 の 要 旨

論文題目　Development of Multi-Filter Soft X-ray Imaging Diagnostic for High-Energy Electron Study of Magnetic Reconnection(磁気リコネクションの高エネルギー電子の検証のためのマルチフィルターの軟Ｘ線イメージング計測の開発)

氏　名　向　俊光

Magnetic reconnection has been widely observed both in space plasma, such as solar flares, coronal mass ejection and interaction of solar wind with Earth's magnetosphere, and in laboratory plasmas. Compared with space plasma, laboratory plasmas can be controlled, and probes are able to be inserted into plasma directly. To better understand magnetic reconnection, plasma merging experiments have been carried out on TS-6 device (Tokyo University Spherical Torus Device No. 6).

During the evolution of the magnetic reconnection, the magnetic topology is rearranged, resulting in breaking and reconnecting of magnetic field lines. At the same time, magnetic energy is converted to thermal or kinetic energy by heating or accelerating charged particles. The ion heating characteristic during magnetic reconnection has been sufficiently investigated on TS-4, MAST, and TS-6, while electron heating and acceleration mechanism is still not well understood.

A multi-filter high-resolution tangential-view soft X-ray (SXR) tomographic imaging diagnostic has been developed on TS-6 spherical tokamak (ST) merging device for investigating high-energy electrons. To measure SXR with different energy ranges, multiple micro-channel plates (MCPs) are respectively installed in vacuum chambers, which are equipped with different filters. Especially designed lenses and fiber bundles serve as optical system to transfer images from phosphor plates of MCPs to a high-speed imaging system. This design also

enables us to simultaneously measure two images appearing on phosphor plates of MCPs by just one high speed imaging system.

Tomographic method based on the Phillips-Tikhonov regularization has also developed to reconstruct line-integrated images into local emissivity of SXR, which reflects the spatial distribution of high-energy electrons. The principle and algorithm of this method is introduced in detail, and the effectiveness and accuracy are also verified.

Relying on this SXR diagnostic, SXR emitted from the TS-6 plasma merging experiments was successfully detected for the first time. The energy range of SXR was distinguished to be higher than 100 eV but lower than 400 eV, based on the multi-filter arrangement of this SXR diagnostic. According to the reconstructed results of local SXR emissivity, electron acceleration in the X-point and downstream regions have been both successfully measured. Downstream acceleration can be enhanced with the increase of poloidal magnetic field (PF), while X-point acceleration can be enhanced with the increase of toroidal magnetic field (TF). On the other hand, the increasing of TF can also make the X-ray burst occur earlier.