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Collisional Merging of a Field-Reversed Configuration in the FAT-CM Device

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The collisional merging experiments of field-reversed configurations (FRCs) at super Alfvénic velocity have been successfully initiated in the FAT-CM device at Nihon University. Drastic increase of the excluded-flux leading to the improved confinement performance of FRC has been observed. This process has an important role to realize FRC based high-beta reactor core to capture high-energy beam ions and it has been clearly observed by magnetic diagnostics of excluded flux and internal probe array. The experimental results are compared with 2D MHD simulation results computed for the typical condition of the FAT-CM experiments. In order to investigate the collisional merging process of a FRC at super Alfvénic velocity, the FAT device has recently been upgraded to FAT-CM, consisting of two field-reversed theta-pinch (FRTP) formation sections and the central confinement section. Collisional merging of the two separately translated FRCs causes a conversion of the kinetic energy to mostly thermal ion energy, which contrasts with the spheromak merging dominated by magnetic energy, resulting in an increase of the ion pressure that drastically expands the FRC volume. The confinement chamber of FAT-CM device is made of stainless steel (inner bore is 0.78m) serving as a flux conserver in the timescale of the translation and merging process. Quasi-static confinement coils (inner diameter of 1.03m) are placed along the confinement region. Initial FRCs are formed by the FRTP method in two formation sections. The initial FRCs are accelerated by the gradient of the external guide magnetic field and then injected into the confinement chamber. The translated FRCs collide in the middle of the confinement chamber at the relative velocity in the range of 300 - 400 km/s. By the collisional merging, radial expansion of the plasma is clearly observed and the plasma size, in the quasi-equilibrium phase, increase more than twofold compared with the single translation case. The averaged electron density of the merged FRC is ~2.5 × 10^20 /m^3, which is ten times higher than the previous experiments performed in C-2U device at TAE. The shape of the simulated FRC agrees with experimental results. This also indicates a successful merging of the FRCs, and resulting in the radial expansion and excluded-flux increase due to the collisional merging, as observed in experiments.

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