

Formation studies of field-reversed configurations on the HFRC-F device

Yue Peng¹, Bo Rao^{1*}, Yong Yang¹, Ming Zhang¹, Zhijiang Wang¹ and Yuan Pan¹

¹ International Joint Research Laboratory of Magnetic Confinement Fusion and Plasma Physics, State Key Laboratory of Advanced Electromagnetic Engineering and Technology, School of Electrical and Electronic Engineering, Huazhong University of Science and Technology, Wuhan, 430074, China

*E-mail: borao@hust.edu.cn

Abstract

Collisional-merging is a way to form high-performance field-reversed configuration (FRC) plasma after decades of research. In order to improve the properties of the merged plasma, one feasible way is to optimize the formation process and enhance the parameters of the initial plasma before translation.

An experimental device named HFRC-F has been constructed in Huazhong University of Science and Technology, which is used to investigate the field reversed theta-pinch (FRTP) formation process of FRCs. The formation region of HFRC-F device has a large size with a radius of 0.3 m and length of 2.6 m. The coil system consists of 12 theta-pinch coils and 4 quasi-steady state coils, which can generate a max bias field of -0.16 T, a max pre-ionization field of 0.15 T with a frequency of 150 kHz and a max main field of 0.5 T in quartz tube, and can achieve various changes such as alterable magnetic field configuration between cusp and mirror. As for now, magnetic diagnostics and CO₂ interferometry are installed to measure the density, magnetic flux and calculate other parameters of the plasma.

Initial HFRC-F experiments obtain typical parameters with plasma density of $4 \times 10^{20} \text{ m}^{-3}$ and lifetime of 75 μs with $B_{\text{bias}} = -0.015 \text{ T}$, $B_{\text{PI}} = 0.015 \text{ T}$ and $B_{\text{main}} = 0.035 \text{ T}$. The results also show that, 1) the larger the bias magnetic field, the longer the lifetime of FRC. 2) the larger the main magnetic field, the higher the density of formed plasma. 3) the PI magnetic field should not be too large relative to the bias field, otherwise ionization will occur near the zero crossing of the total magnetic field, leading to a small initial frozen flux.

In addition, a magnetohydrodynamics (MHD) simulation software called USim is used to study the effect of the initial density of plasma, the amplitude of the bias and main magnetic field, the configuration of the bias field, the rise time of the main field on the plasma parameters. It is hoped that these works can improve the parameters of the formed plasma.