Density regime of low-aspect-ratio RFP plasmas in RELAX

M. Sugihara, K. Oki, R. Ikezoe, T. Onchi, A. Sanpei, H. Himura, S. Masamune,
T. Akiyama[a], A. Ejiri[b], Y. Sakamoto[c], K. Nagasaki[d], V. Zhuravlev[e]

Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto 606-8585, Japan
[a] *National Institute for Fusion Science, 322-6 Oroshi-cho, Toki 509-5292, Japan*
[b] *The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa 277-8561, Japan*
[c] *Japan Atomic Energy Agency, 801-1, Mukoyama, Naka 311-0193, Japan*
[d] *Kyoto University, Gokasho Uji 611-0011, Japan*
[e] *Kurchatov Institute, Kurchatov-Sq Moscow 123182*, Russia

e-mail address of submitting author: sugiha07@nuclear.es.kit.ac.jp

The reversed field pinch (RFP) is one of the toroidal confinement systems for high-beta plasmas. Recent progress of the RFP research has demonstrated some attractive features the advantages of the RFP concepts; tokamak-comparable confinement has been achieved in MST at total beta value of as high as 26% with electron and ion temperatures in keV range in a weak external toroidal field, and new self-organized state of Single Helical Axis (SHAx) state has been found in RFX as a possible improved confinement state where magnetic surfaces recover as a result of transition to helical RFP equilibrium. The low-aspect-ratio (A) RFP configuration has further attractive features such as high fraction of neoclassical pressure-driven (bootstrap) current. Moreover, the safety factor (q) profile shows that the rational surfaces of m=1/high n modes are less closely spaced in the core region in low-A configuration, desirable to avoiding the magnetic chaos due to the growth of resistive tearing instabilities.

RELAX is a low-A RFP machine to explore the above new regime of RFP configuration. The major (minor) radius R (a) is 0.51m (0.25m) with A of 2. The RELAX plasmas have demonstrated the advantages in low-A RFP such as easy access to quasi-single helicity (QSH) state where magnetic fluctuations are dominated by a dominant single mode and small numbers of secondary modes. Appearance of a simple helical structure has also been reported in high-speed visible light images. Furthermore, attainment of a helical RFP equilibrium has also been demonstrated. In the present study, the line-averaged electron density has been measured over a wide range of RFP discharge parameters in RELAX: the plasma current I_p from 40 to 80 kA, the fill pressure of hydrogen from 0.1 to 2.0 mTorr, and the pinch parameter Θ ($=B_p(a)/\langle B_t\rangle$) from ~2.0 to 3.5, with field reversal ratio F ($=B_t(a)/\langle B_t\rangle$) from slightly positive (~0.1) to deep reversal of ~-1.0. A 104-GHz heterodyne interferometer was mainly used throughout the present experiment, while a new 60-GHz homodyne interferometer has also been developed for the lower density measurement. The new 60-GHz interferometer is characterized by the use of cross-detector system in which two components, orthogonal to each other, of the transmitted wave are detected to improve the accuracy of the phase shift estimate. The measured density varied from ~$3\times 10^{18}m^{-3}$ to ~$20\times10^{18}m^{-3}$, depending upon the discharge parameters. Dependence on the electron density of the above-mentioned characteristic behaviors of low-A RFP plasmas will be discussed.