§76. Collaborative Research on Electron Cyclotron Heating in High-density Plasmas Using the 28GHz High Power Gyrotron System

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First 28 GHz ECCD effect was confirmed in Ohmically sustained plasma with feedback regulation of Center Solenoid (CS) coil current. Maximum toroidal field has been B_0 = 0.25 T at a major radius of R = 0.64 m using a Toroidal Field Coil (TFC) power supply with its maximum current of 50 kA in the QUEST. 2nd harmonic Electron Cyclotron Resonance (ECR) layer was located inside plasma at R = 0.32 m. Figure1 shows time evolution of TFC current, B_v, CS coil current and I_p with and without the superposed 28 GHz injection. Sine the Ohmic discharges have been conducted with rather low field, the I_p was started-up to the 30 kA level at the low field, and later the field was ramped up to the maximum. Although the plasma current has been controlled with the feedback, it began to increase by the 28 GHz injection against retarding electric field by ramp-up of the CS coil current. Recharging phenomena in the CS coil power supply were clearly observed. The I_p was fully driven only by the 2nd harmonic off-axis 28 GHz injection.

Fully non-inductive current drive experiments have been conducted with the 28 GHz ECH/ECCD system in the QUEST to demonstrate high-density/current plasma start-up and sustainment with 2nd harmonic ECH/ECCD. Figure 2 shows time evolution of I_p, B_v and the plasma shaping parameters of aspect ratio A, elongation κ and triangularity δ in the inner limiter-configuration. The I_p was ramped up at high ramp-up rate of ~ 0.5 MA/s. The 54 kA I_p was finally obtained by ramping up B_v, and was sustained for 0.9 sec. The plasma shaping was almost kept at stable configuration for 1.3 sec. The magnetic axis radius R_{ax} and A were 0.67 m and 1.4, respectively. In B_v ramp-up experiments, the I_p of 66 kA was non-inductively attained with the 28 GHz injection.

High-density plasmas beyond cutoff density for main 8.2 GHz injection were tried to attain by the 28 GHz injection for EBWCD experiments. 2nd harmonic and fundamental ECR layers were located at R = 0.32 m and 0.54 m for the 28 GHz and 8.2 GHz injections at B_0 = 0.25 T, respectively. Spontaneous density jump across the cutoff density was observed in the superposed injections. Figure 3 shows time evolution of I_p, line-averaged density, Hα intensity, R_{ax}, minor radius a, β_p* (sum of average poloidal beta β_p and half plasma internal inductance l_i) with and without the density jump. Flux signals of inward and outward positions are also shown in the density jump case. The gas fueling was applied at t = 2.9 sec to increase the density. The operating parameters including the gas fueling were identical in both discharges. Hα intensity was kept constant, and R_{ax} and a were slightly decreased in the density jump case. I_p was once decreased, but was recovered finally. β_p* was first decreased by the decrement of a, and secondarily by the increment of I_p. The plasma was self-organized to be more stable shaping, and then the I_p was recovered in the high-density plasma. The flux signals showed inward shift of plasma current distribution, suggesting from the decrement of R_{ax}

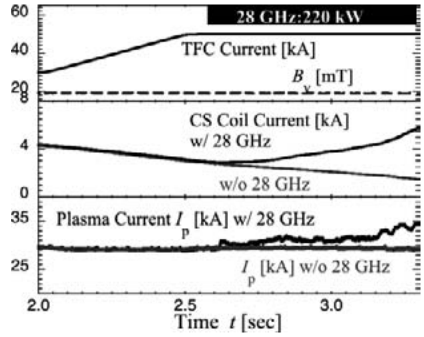

Fig.1: Time evolution of TFC current, B_v, the CS coil current and I_p w/ and w/o superposed 28GHz injections.

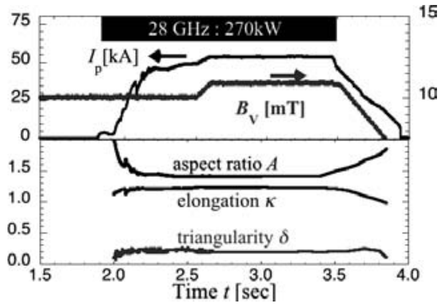

Fig.2: Time evolution of I_p, B_v , aspect ratio A, elongation κ and triangularity δ in the inner limiter-configuration.

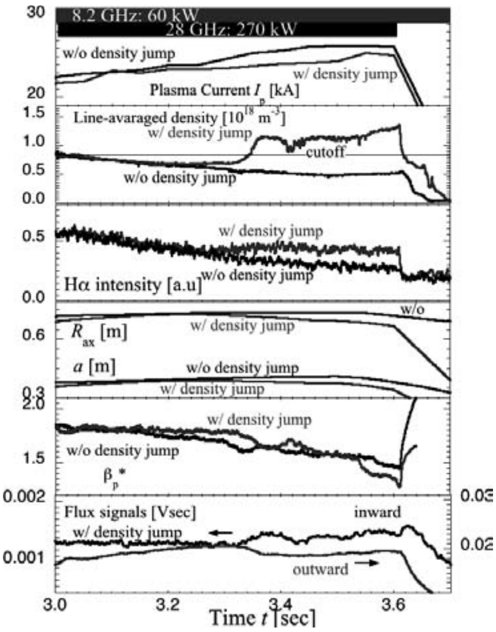

Fig.3: Time evolution of I_p, line-averaged density, Hα intensity, R_{ax}, a and β_p w/ and w/o the density jump. Flux signals of inward and outward positions are also shown in the density jump case.*