§63. Non-inductive Current Drive and Particle Recycling Study in Steady State Divertor Configuration in QUEST

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<u>Recent Achievement of the non-inductive current drive and sustainement of steady plasma</u> 1)-8)

28 GHz Electron Cyclotron Current Drive (ECCD) effect was clearly observed in ohmically heated plasmas with feedback regulation of Center Solenoid (CS) coil current in inboard off-axis heating scenario. Recharging phenomena in the CS coil power supply were observed by superposed 28 GHz injection. In non-inductive current drive experiments only by the 28 GHz injection, 54 kA plasma current was sustained for 0.9 sec. High non-inductive plasma current of 66 kA was also attained by the 28 GHz ECH/ECCD in the Spherical Tokamak (ST) configuration. Density jump across cutoff density of 8.2 GHz was observed in the superposed 28 GHz and the 8.2 GHz injections. The 50 kA plasmas were sustained by the 8.2 GHz superposed injection into the 28 GHz target plasma if the vertical field was enough high. The high density/current experiments have been conducted, concerning Electron Bernstein Wave Heating and Current Drive (EBWHCD) with the 8.2 GHz injection.

Successful production of high βp plasma ($\varepsilon\beta p$ □ 1) and its long pulse sustainment by fully non-inductive (NI) current drive with the help of a modest power (< 100 kW) Electron Cyclotron Waves is demonstrated. We found that (i) high βp plasma is naturally self organized to form a stable natural Inboard Poloidal field Null (IPN) equilibrium, (ii) a critical βp, which defines the transition boundary from Inboard Limiter (IL) to IPN equilibria and (iii) a new feature of plasma self organization to enhance its negative triangular shape to sustain high βp. This result shows a relatively simple method to produce and sustain high βp plasma close to the equilibrium limit in a stable configuration exploiting its self organization property.

Hydrogen wall pumping is studied in steady state tokamak operation (SSTO) of QUEST. Duration of SSTO is up to 10 minutes. Wall pumping is dominant during most SSTO, the wall pumping rate is 1-6×10^{18} H/s and after plasma termination wall started to release H_2, release rates were in range of 10^{20} H/s. H_2 retention in the fully metal tokamak during SSTO is found to be around 70-80% of injected particles. PdCu membrane probes are used to measure plasma driven permeation of atomic hydrogen (H) at different positions. Incident H flux was numerically calculated using TMAP7 diffusion code. Assumption that H flux is proportional to H_α was used to fit permeated curve. Wall release/retention rate was calculated for SSTO. He release rate is used as an indicator of the wall behaviour.

A new analysis method to realize steady state tokamak operation SSTO has been examined in QUEST with all metal wall baked at 100°C. Using particle flux perturbations driven by particle source H_2 and plasma-wall interaction PWI the system functions of processes of retention and release into/from the wall are determined both in time and frequency domains. The system function for the particle circulation has been determined by perturbation technique and independent measurement of partial pressure and permeation flux. The temporal evolution of system function, especially very low frequency component, must be controlled in order to sustain the steady-state discharge.

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