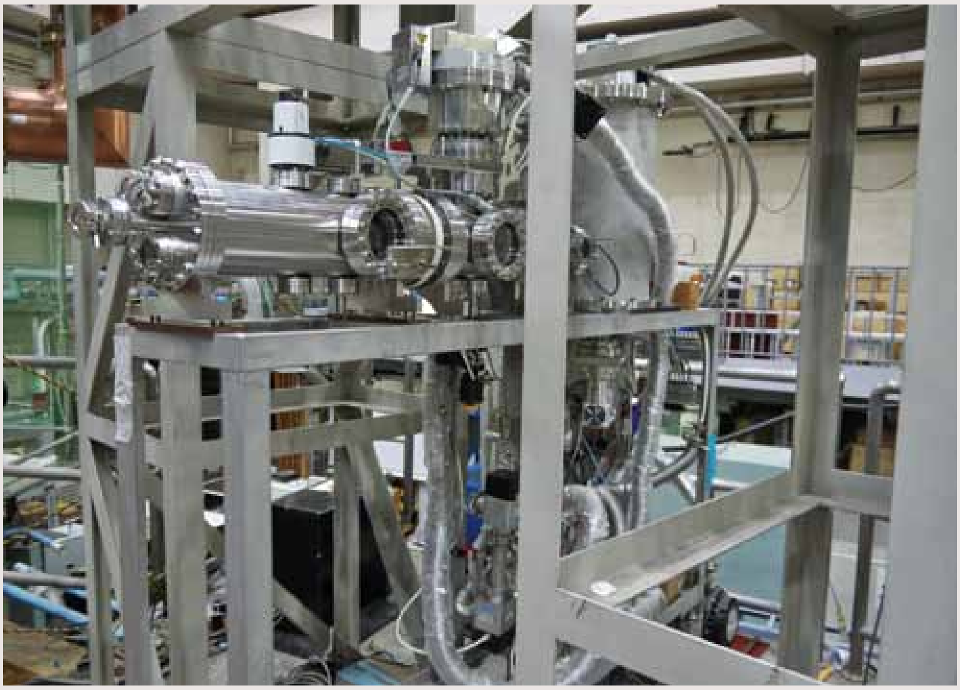
8. Bilateral Collaboration Research Program

Kyoto University



A small/slow pellet injector for Heliotron J

Highlight

A small/slow pellet injector is ready for Heliotron J expeiment

The ice-pellet injection system has been developed [1] for the new particle supply method following the supersonic molecular beam injection (SMBI) under the bidirectional collaboration program in Heliotron J. This method is considered to be effective specially to supply particles into the plasma core region.

Study of density control using pellet injection: The conditions of the pellet injector are; injection speed is less than 300 m/s and the diameter is less than 1 mm for the plasma parameters of Heliotron J. The injection test was successfully done in FY 2015, then, the injection experiment to NBI and ECH+NBI plasmas is planned in this campaign. Figure 1 shows the time evolution of plasma parameters: (a) line-averaged plasma density, (b) Hα line emission near the pellet injection port, (c) plasma stored energy and (d) ECH and NBI heating timing. The density increase after pellet injection is very rapid and exceeds 5×10^{19} m^{-3} for NBI plasmas. Plasma stored energy decreases just after the injection, then, increases up to 3.4 kJ from 1 kJ. The penetration length of pellet is investigated using Hα detector alleys for ECH+NBI plasmas. The increase of the Hα line is recognized from the edge sight-line (pellet injector side) to central line. However, in some shots, the pellet penetrates through the entire plasmas, then; the optimization of the injection conditions is needed. The target plasma density and magnetic field configuration dependence are next subjects for the pellet injection experiment.

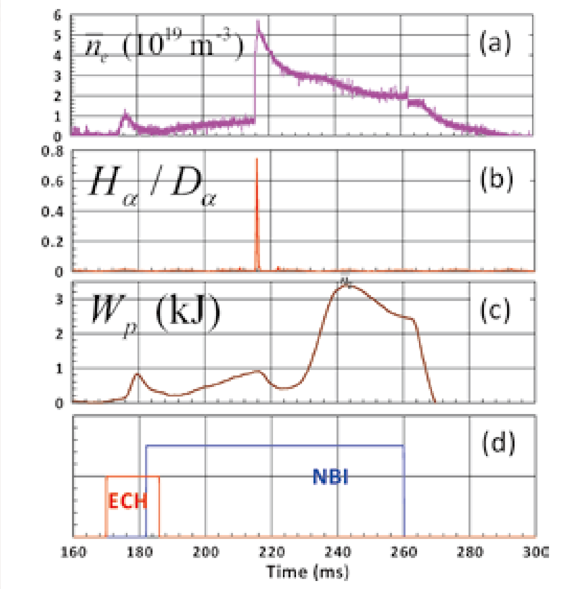


Fig. 1. Time evolution of plasma parameters in the case of the pellet injection into NBI+ECH target plasma. (a) line-averaged electron density, (b) Hα line intensity, (c) plasma stored energy, and (d) timing of heating devices.

Research Topics from Bilateral Collaboration Program in Heliotron J

The common objectives of the researches in Heliotron J under this Bilateral Collaboration Program are to investigate experimentally/theoretically the transport and stability of fusion plasma in advanced helical-field, and to improve the plasma performance through advanced helical-field control. Picked up in FY2016 are the following seven key-topics; (1) understanding plasma heat/particle transport phenomena with self-formation of plasma structure and its control by the magnetic field control, (2) development of high-density plasma production scenario and investigation of high-beta plasma confinement, (3) instability control, (4) plasma current control and its application for plasma performance improvement, (5) sophistication of the diagnostic systems for local measurement, (6) clarification of ECH/EBW heating scheme, (7) study of the boundary plasma physics.

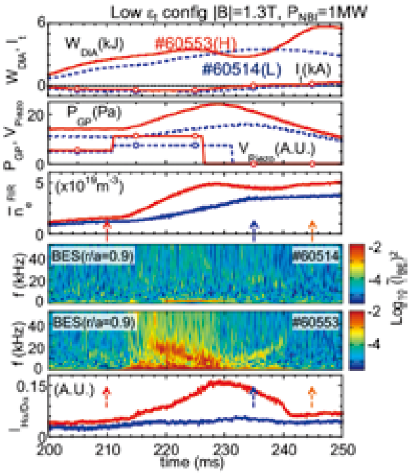


Fig. 2. Comparison of the plasma parameters obtained in H-mode transition (#60553) and no-transition (#60514) plasmas by HIGP. Time evolution of stored energy, toroidal current (It), applied voltage of Piezoelectric-type valve (VPiezo), neutral gas pressure close to the valve (PGP), line-averaged electron density by FIR (neFIR), power spectrum of density fluctuation by BES (IBE), Hα/Dα intensity.

H-mode transition in NBI plasma induced high-intensity gas puffing (HIGP) [2]**:** The H-mode transition in the NBI plasmas has been found using HIGP method in the low-toroidicity magnetic configuration. The relation of H-mode transition to density fluctuation is investigated under the conditions of NBI injection power: 1MW and B: 1.3 T. Figure 2 shows the time evolution of plasma parameters with and without HIGP (#60553 and #60514). The plasma stored energy decreases after HIGP pulse, then, it recovers and increases. During HIGP the bursting fluctuation of which frequency is from 5 kHz to 30 kHz, is observed from the beam emission spectroscopy (BES) measurement. The toroidal mode of this fluctuation is 2 determined from the magnetic measurement. The bursting is from 0.3 kHz to 3 kHz and its toroidal mode is supposed to be 0. , and is probed to propagate radially outwards using the BES. This fluctuation is considered to induce the particle pumping-out since the fluctuation diffuses outwards.

The isotope effect on long range correlation (LRC) and the nonlinear coupling with turbulence [3]**:** Using three sets of electrostatic probes, the turbulence is studied from simultaneously measured floating potential (V_f). The V_f fluctuation of low frequency, < 4 kHz, with LRC in the toroidal direction is observed and is found to couple with the broadband fluctuation nonlinearly. The experiment of the isotope effect is performed changing the ratio of hydrogen to deuterium, shot by shot. Figure 3 (upper) shows the hydrogen-ratio dependence on the amplitude and coherence for about 1 kHz fluctuation. The fluctuation amplitude and coherence is almost proportional to the deuterium ratio. Figure 3 (lower) shows the comparison of nonlinear-coupling strength of the deuterium case to the hydrogen case. The nonlinear coupling in the low frequency region is stronger for the deuterium. This result suggests isotope effect for LRC.

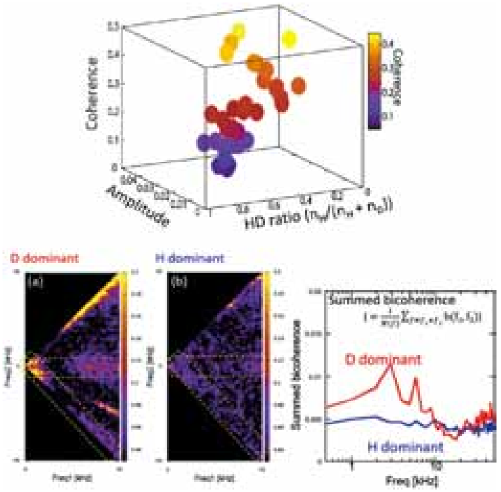


Fig. 3. Isotope effects of the LRC amplitude and the correlation in toroidal direction in the upper figure. Enhanced activity of the LRC is observed in D plasmas. Results of bicoherence analysis for (a) D dominant and (b) H dominant discharges. (c) Spectra of summed bicoherence in the H and D dominant discharges.

[1] G. Motojima, *et al.*, “Injection barrel with a tapered structure for a low speed and small size cryogenic hydrogen pellet in medium-sized plasma fusion devices”, RSI **87**, (2016) 103503.

[2] S. Kobayashi, *et al.*, “Study of H-mode transition triggered by high-intensity gas puffing in NBI plasmas of Heliotron J”, 26th IAEA Fusion Energy Conference (FEC2016), Kyoto, Japan, 17-22 Oct., 2016, EX/P8-17.

[3] S. Ohshima, *et al.*, “Isotope Effect on Long Range Correlation and the Nonlinear Coupling with Turbulence in Heliotron J”, ibid., EX/P8-20.

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