



Contribution ID: 478

Type: Poster

EX/P2-15: ECRH Pre-ionization and Assisted Startup in HL-2A Tokamaks

Tuesday, 9 October 2012 14:00 (4h 45m)

ECRH pre-ionization and assisted startup is foreseen in ITER, because the electric field applied for ionization and ramp-up of plasma current is limited to a very low value about 0.3 V/m. Many data for ECRH pre-ionization and assisted startup have been obtained from C-Mod, ASDEX Upgrade, DIII-D, JT-60U, JET and KSTAR. This paper presents the experiment results in HL-2A Tokamak from 2010 to 2012, with emphasis on the following two new and better results. 1) The minimum loop voltage for successful plasma establishment is reduced up to 1V, corresponding toroidal electric field of 0.1V/m, which is 3 times smaller than the ITER value of 0.3V/m, and smaller than the best value of 0.15V/m ever obtained from DIII-D. 2) Plasma can be established successfully with ECRH second harmonic X mode (X2) switching on before or after application of the reduced loop voltage, which presents important experiment data to the answer of the open issue addressed in ITPA joint experiment IOS-2.3. IOS-2.3 focuses on the breakdown-assist experiment results with X2 mode ECRH when ECRH power is launched after application of the reduced loop voltage, which is the situation operating in ITER during its commissioning phase, and so far never performed before. In HL-2A experiments, ECW with the fundamental O mode (O1) or X2 is launched, and the toroidal injection angle can be changed from 00 to 200 in the equatorial plane. During 2010-2011 HL-2A experiment campaigns, the loop voltage can be reduced to 3V by O1 and X2 mode ECW, with minimum power 200 kW and 600kW, respectively. The effects of toroidal inclination, prefill pressure, wall conditioning and poloidal field null structure on X2 mode pre-ionization and assisted startup have been studied. During 2012 HL-2A experiment campaigns, the breakdown condition can be greatly improved with siliconization and lithiumization, and good results have been obtained. The loop voltage for successful plasma establishment is reduced up to 1V, and plasma can be established readily with X2 mode ECRH switching on 30 ms before or 30 ms after application the reduced loop voltage. The minimum ECRH power is about 500kW. The minimum loop voltage for successful pure ohmic breakdown is also presented, which is 3.4V.

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Session Classification: Poster: P2

Track Classification: EXW - Magnetic Confinement Experiments: Wave-plasma interactions; current drive; heating; energetic particles