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Overview of recent experimental results in the ADITYA-U Tokamak

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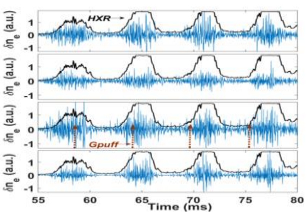
The ADITYA Upgrade (ADITYA-U) (R 0 = 75 cm, a= 25 cm) tokamak is capable of producing circular and shaped plasma with single and double null open divertor configurations. The foremost objective of ADITYA-U is to prepare the physics and the technological base for larger machine including ITER. Since obtaining its first circular plasma in December, 2016, plasma parameters close to the design parameters of circular plasmas in limiter configuration have been realized in ADITYA-U and the shaped plasma operation has been initiated in H_2 and D_2. Emphasis has been given to experiments on runaway electrons (REs), disruption studies using novel particle injection techniques, plasma rotation reversals, radiative-improved modes with Ne, Ar gas injection and MHD modes modification, cold-pulse propagation, plasma detachment using periodic fuel gas-puffs. Extensive wall conditioning using novel pulsed-GDC along with lithium coating resulted in consistent circular plasma discharges with plasma current ~ 180 kA, plasma duration of ~ 350 ms, Chord-averaged electron density ~ 3 – 6 x 10^{19} m^{-3} and central electron temperature ~ 500 eV at toroidal magnetic field ~ 1.2 - 1.4 T. The experiments on REs showed that the suppression and recovery of the HXR intensity strongly coincide with the suppression and recovery of turbulent edge fluctuations, which indicates a significant role of edge fluctuations on REs (Figure 1). Furthermore, the REs are confined using an electrostatic field induced by biasing an electrode placed in the edge region.

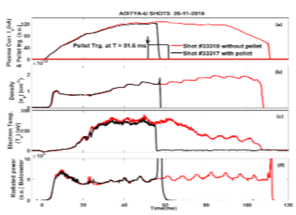
In a major development towards disruption mitigation techniques, faster current quench times have been obtained during particle injection using electromagnetically driven payloads, carried out for the first time in ADITYA-U. The impurity particles reached the core within ~ 1.25 ms and cause fast termination of plasma current in < 2 ms (Figure 2). Disruptive discharge analysis showed that the current quench time during disruption is inversely proportional to the pre-disruptive values of edge safety factor, q_a, and is strongly correlated with the prevailing pre-disruptive plasma MHD activities. In neon gas puffed discharges of ADITYA-U, reversal of toroidal rotation occurred at lower values (~ 1.8 x 10^{19} m^{-3}) of plasma density as compared to the H_2 puffed Ohmic discharges (~3 x 10^{19} m^{-3}), indicating lower electron density threshold for toroidal rotation reversal with neon seeding. The rotation reversal is not accompanied by usually observed turbulence reduction in the plasma edge. Neon & argon seeding also leads to radiative improved mode (doubling of energy confinement time). Periodic short hydrogen gas puffs are found to concomitantly decrease the drift-tearing mode rotation frequency and the mode amplitude leading to periodic modulation of the rotation frequency and amplitude of DT modes. This has been found to be due to flattening of plasma pressure in the edge region with gas puffs. BOUT++ code simulations support such a reduction in diamagnetic drift frequency. The SMBI fueling led to enhancement of magnetic field stochastization which increased the RE transport. 42 GHz ECR assisted low loop voltage (Electric field ~ 2 V/m) start-up has also been successfully achieved. This paper summarizes the experimental research of ADITYA-U tokamak in the key areas of thermo-nuclear fusion.

Figure 1



Correlation of HXR with densit fluctuation in presence of gas pu

Figure 2



Discharges with pellet (#33317, black curve) and without pellet (# 33318, red curve),

[1] Effect of periodic gas-puffs on drift-tearing modes in ADITYA/ADITYA-U tokamak discharges, Harshita Raj, J. Ghosh et al, Nucl. Fusion 60 (2020) 036012.

[2] Overview of Operation and Experiments in the ADITYA-U tokamak, R.L. Tanna, J. Ghosh, et al, Nucl. Fusion 59 (2019), Number 11, 112006