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Observation of efficient lower hybrid current drive at high density on Alcator C-Mod

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Efficient lower hybrid current drive (LHCD) at high plasma density has been demonstrated on Alcator C-Mod for the first time with the reduction in the Greenwald fraction by raising the plasma current.
In order to attain, steady-state advanced tokamak operation, efficient off-axis current drive is required. LHCD is highly desirable because it has the highest efficiency of all technologies presently available. However, the LHCD experiment on C-Mod has shown a loss of anomalous current drive efficiency above $\overline{n}_{crit}$ $1\times10^{20}\mathrm{m}^{-3}$, which prohibited an access to advanced tokamak operation [1]. Parasitic wave interactions in the edge/SOL region may account for the density limit behavior [2-4] because the scrape-off-layer density profile becomes broadened with an increased level of blobby transport with the increase in the Greenwald fraction [5].
In the most recent C-Mod experiments, the operating plasma current was raised up to 1.4 MA in order to minimize the SOL width at $\overline{n}_{crit}$ $1.4\times10^{20}\mathrm{m}^{-3}$. The injected LH power (600 kW) produced a loop voltage drop of 0.2 V, consistent with engineering efficiency found at low densities. The non-thermal Bremsstrahlung emission rate was increased by more than two orders of magnitude compared to the lower current case. Parasitic interactions of wave with the SOL plasma are largely suppressed, indicated by the spectrum measurement.
The new experimental results indicate that efficient current drive at a reactor density can be attained with proper management of the edge/SOL plasma. They support a proposal to place LH launchers at the high-field-side (HFS) of the tokamak in a double null configuration [6]. In this case, the density shoulders and blobby transport phenomena are absent in the HFS SOL. Efficient current drive may be attained even at high Greenwald fraction by avoiding parasitic edge/SOL wave interactions.
[1] G. M. Wallace, et al, PoP 17 (2010) 082508;[2] S. G. Baek, et al, Nucl. Fusion 55 (2015) 043009;[3] I. C. Faust, et al, PoP 23 (2016) 056115;[4] S. Shiraiwa, et al, AIP 1689 (2015) 030016;[5] B. LaBombard, et al, PoP 15 (2008) 056106;[6] B. LaBombard, et al, Nucl. Fusion 55 (2015) 053020; Work supported by the U.S. Department of Energy, Contract No. DE-FC02-99ER54512 on Alcator C-Mod, a Department of Energy Office of Science user facility.

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