First high-power results from the DIII-D helicon system

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Helicon current drive, also called fast wave current drive in the lower hybrid range of frequencies, has long been regarded as a promising current drive tool for reactor grade plasmas. A newly installed MW-level system [1] at DIII-D will be the first test of this technology in reactor-relevant plasmas, in the sense that full first-pass absorption is expected. A 30-module traveling wave antenna of the comb-line type was installed to launch a highly directive wave at 476 MHz and with $n_{\|} = 3$, optimized for DIII-D high-beta target plasmas. First high-power experiments in both L-mode and ELMy H-mode plasmas demonstrated high coupling efficiency, as well as load resilience as the reflected power remained low during L/H transitions and during ELMs. Approximately 0.3 MW of helicon power was coupled successfully to a highly reproducible L-mode target plasma, in quasi-steady RF pulses as long as 0.5 s. Clear conditioning progress was observed in repeated discharges. Power modulation experiments observed electron absorption in the relatively low-electron-beta L-mode plasma (not single-pass absorption) near the magnetic axis ($\rho < 0.3$) in qualitative agreement with ray-tracing calculations. Several dedicated helicon diagnostics obtained data for the first time. A prototype Doppler back scattering diagnostic sensitive to 476 MHz measured spectral broadening correlated with edge turbulence. High-frequency magnetic probe measurements revealed nonlinearly generated sidebands near 476 MHz, separated in frequency by harmonics of the deuterium ion cyclotron frequencies that may result from parametric decay instabilities. Additional novel diagnostics to measure wave propagation and antenna-region density profiles are coming online in 2022. In the near future, experiments will focus on raising the coupled power as well as targeting high-beta plasmas to quantify off-axis heating and current drive in plasmas with predicted full first-pass absorption.

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