Latest High-Power Helicon Experimental Results from DIII-D*

R.I. Pinsker[1], B. Van Compernolle[1], S.X. Tang[1], M. Porkolab[2], C. P. Moeller[1], J.P. Squire[1], C.C. Petty[1], A. Dupuy[1], A. Nagy[3], L. McAllister[1], E. Bagdy[1], S. Chowdhury[4], N.A. Crocker[4], G.H. DeGrandchamp[5], K. Gage[5], S.G. Baek[2], E. H. Martin[6]

[1]*General Atomics, PO Box 85608, San Diego, CA 92186-5608, USA*
[2]*Massachussetts Institute of Technology, Cambridge, MA 02139, USA*
[3]*Princeton Plasma Physics Laboratory, Princeton, NJ 08540, USA*
[4]*University of California Los Angeles, Los Angeles, CA 90095, USA*
[5]*University of California Irvine, Irvine, CA 92697, USA*
[6]*Oak Ridge National Laboratory, Oak Ridge, TN 37830, USA*

Fast wave current drive in the lower hybrid range of frequencies ("helicon") is a candidate technology for off-axis noninductive current drive in steady-state advanced tokamak reactors. To date the concept lacks experimental verification, which this work is intended to provide. Experiments with 1.2 MW of power at 476 MHz available from a single klystron have been underway at DIII-D since June 2021. To date, we have been able to apply up to 0.7 MW to the input of a 1.5-m-wide comb-line traveling-wave antenna structure with 30 antenna modules.

Square-wave-modulated pulse trains were used to observe power deposition in the core of the tokamak discharge. The power is absorbed on thermal electrons via electron Landau damping at a parallel index of refraction ($n_{||}$) of ~4 (launched $n_{||}$=3), according to ray-tracing studies. In the low-beta L-mode plasmas, ray-tracing predicts centrally peaked absorption, while the ultimate goal of these experiments is to couple power to high-β plasmas which yield single-pass absorption off-axis (and current drive there). In a relatively low-power example, 0.2 MW is coupled to the plasma with 50 Hz square-wave modulation, and of this power, about 20% is observed in the core. This fraction is comparable to the predicted first-pass absorption in multi-ray simulations, which predict a similar very centrally peaked profile in this low-beta case.

Observation of first-pass absorption suggests investigation of edge loss mechanisms that might lead to parasitic absorption in the scrape-off layer. Clear evidence of parametric decay instability (PDI) is obtained with a significantly lower threshold power level than expected from modeling with approximate values for the scrape-off layer plasma parameters [1], supporting the hypothesis that the PDI may result from parasitically excited slow lower hybrid waves in the antenna near-field region. In some cases, a Fast Ion Loss Detector mounted at the outboard midplane at a toroidal angle close to that of the antenna has observed energetic ions at high pitch angles that may result from the damping of the ion cyclotron quasi-modes in the PDI region. However, no indication of PDI at a level high enough to cause pump depletion and significant power loss has been observed to date on DIII-D.

*Work supported in part by US Department of Energy under DE-FC0204ER54698, DE-SC0016154, DE-AC02-09CH11466, DE-SC0020337, DE-NA0003525, DE-AC05-00OR22725, and DE-SC0020649.

[1] M. Porkolab, R.I. Pinsker, *et al.*, this conference