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Experiments on Helicons in DIII-D –Investigation of the Physics of a Reactor-relevant Non-Inductive Current Drive Technology

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Experiments have begun in DIII-D to evaluate non-inductive current drive by the Landau absorption of a toroidally-directive spectrum of helicon waves (also known as 'very high harmonic fast waves', 'fast waves in the lower hybrid range of frequencies', or 'whistlers'). Modeling has shown [1] that non-inductive current drive at mid-radius (ρ~0.5) should be achievable in DIII-D with fast waves at 0.5 GHz, with an efficiency twice as high as with non-inductive current drive tools currently available on DIII-D (neutral beams and electron cyclotron current drive) in high-beta conditions. An innovative Traveling Wave Antenna (TWA) of the 'comb-line' type with 12 radiating modules has been constructed, installed in DIII-D, and is currently being tested at very low power (<1 kW) to evaluate the antenna coupling in the linear regime, and to prototype technological aspects of such structures in the tokamak environment. Preliminary results indicate strong antenna/plasma coupling, with detailed 3D modeling underway to quantitatively compare the measurements with theoretical expectations. A key input to this model is the edge and far SOL electron density profile, which is being measured with a microwave reflectometer and with fixed and moveable Langmuir probes. An important issue for wave coupling in this regime is the degree to which (undesired) quasi-electrostatic slow waves are excited by the structure; evaluation of this is a point of emphasis in the ongoing work. A high-power system is presently being prepared for installation later in 2016 in which a single 1.2 MW klystron at 476 MHz will be used to power a TWA with ~36 radiating elements in a structure 2 m wide. The goals of the high-power experiments include evaluation of non-linear effects on excitation of the desired waves (ponderomotive effects, parametric decay) and measurements of the deposition profile and of the current drive efficiency. Ray-tracing predicts [1] an rf-driven current of ~60 kA per coupled MW of helicon power, which should result in an easily measurable driven current in DIII-D in high-beta discharges.
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[1] Prater, R. et al 2014 Nuclear Fusion 54 083024.

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