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Oral_12: ITER Toroidal Interferometer and Polarimeter (TIP) Development and Testing

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ITER will be equipped with a five channel combined toroidal interferometer and polarimeter (TIP) system to provide line-integrated density for feedback control and density profile reconstruction as well measurements of instability-induced core density fluctuations. In the current design, two-color vibration compensated interferometry is carried out at 10.59 µm and 4.6 µm using a CO2 and Quantum Cascade Laser (QCL) respectively while a separate polarimetry measurement of the plasma-induced Faraday effect is made at 10.59 µm. Because polarimeter phase shifts are expected to be less than 180 Deg., the inclusion of polarimetry allows the two-color system to recover unambiguously from fringe skips at all densities, up to and beyond the Greenwald limit as well as the potential to use the polarimeter itself for feedback density control. The system features five independent first mirrors and a common first wall hole to minimize penetration sizes and to reduce risks associated with deposition, erosion and neutron streaming. Alignment on the ~100 m beam paths will be maintained using an active feedback alignment system.

In support of the TIP design efforts, a full-scale prototype has been constructed and tested both in the laboratory and on the DIII-D tokamak. High-resolution TIP phase information is obtained using an FPGA based phase demodulator and precision clock source. Feedback alignment is accomplished using a dual mirror piezo tip/tilt stage active feedback alignment system which minimizes noise and maintains diagnostic alignment indefinitely through both simulated bake cycles on the laboratory prototype as well as through pulsed tokamak discharges on DIII-D. During DIII-D discharges, the measured phase resolution for the polarimeter and interferometer is 0.05 Deg. (100 Hz bandwidth) and 1.9 Deg. (1 kHz bandwidth), respectively. The corresponding line-integrated density resolution for the vibration-compensated interferometer is *nL* = 1.5x10¹⁸ m⁻², and the magnetic field-weighted line-integrated density from the polarimeter is *nBL* = 1.5x10¹⁹ Tm⁻². Both interferometer and polarimeter measurements during DIII-D discharges compare well with the expectations, are capable of meeting ITER measurement requirements and largely validate the approach for application to ITER. Remaining issues to be resolved were also identified throughout the course of testing including atmospheric interaction and dispersion which, in long discharges like those expected in ITER, can cause significant uncompensated interferometric phase shifts.

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