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## EX/P4-19: High Resolution Detection and 3D Magnetic Control of the Helical Boundary of a Wall-Stabilized Tokamak Plasma

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We report high-resolution detection of the time-evolving, three-dimensional (3D) plasma magnetic structure of wall-stabilized tokamak discharges in the HBT-EP device. Measurements and control experiments are conducted using a newly-installed adjustable conducting wall made up of 20 independent, movable, wall segments that have been precision located and equipped with 120 modular control coils and 216 poloidal and radial magnetic sensors. The control coils are energized with high-power solid-state amplifiers, and massively-parallel, high-throughput real-time feedback control experiments can be performed using low-latency connections between input and output CompactPCI modules and a GPU processor. The time evolution of unstable and saturated wall-stabilized external kink modes are studied in detail with and without applying magnetic perturbations with the control coils. The 3D dynamic structure of the magnetic field surrounding the entire plasma is defined with biorthogonal decomposition using the full set of magnetic sensors without the need to fit either a Fourier or a model-based basis. Naturally occurring external kinks are composed of independent helical modes, frequently having  $m/n = 3/1$  and  $6/2$  helicity, that are seen to modulate each other in time. When magnetic perturbations are applied by energizing the control coils, the resonant magnetic response can be either linear, saturated, or disruptive depending upon the amplitude of the applied perturbation and on plasma's current profile and rotation rate. Active feedback experiments have been conducted using 40 magnetic sensors and 40 control coils, and initial results show the closed-loop plasma response as a function of gain and phase.

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