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Overview of the TCV Tokamak Program: Scientific Progress and Facility Upgrades

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A broad upgrade program is underway at the TCV tokamak. A historic first step is the present commissioning of the first neutral beam injector (NBI), delivering 1 MW of power at energies in the 15-30 keV range. Four gyrotrons are also being added in 2016-2018 to bring the total ECRH power to 6 MW. A second, counter-injected, 1-MW neutral beam is also planned, in addition to the introduction of variable-configuration divertor baffles, to expand the role of TCV in preparing the grounds for both ITER and DEMO. TCV is now operating partly as a European Medium-Size Tokamak (MST) facility within the EUROfusion consortium.
In the realm of edge and exhaust physics, access to divertor detachment has been investigated through density ramps and nitrogen puffing, first revisiting the conventional single-null divertor, then proceeding through the variety of alternative geometrical divertor configurations that TCV can sustain, including the X-divertor, X-point target, and the snowflake minus and plus. Studies of scrape-off layer (SOL) transport are focusing especially on the enhanced convection that leads to profile broadening at high density and is generally attributed to intermittent filamentary structures; through a large scan in parallel connection length, no evidence for far SOL profile broadening is found. The double heat-flux scale length measured in limited L-modes in the TCV SOL, a possible concern for reactor start-up, has been reproduced by the 3D turbulent-transport GBS code. A wall cleaning solution based on ECRH-sustained, current-less helium discharges was recently tested on TCV for JT-60SA.
In the area of control, a generalized plasma shape and position controller, based on real-time, sub-ms equilibrium reconstruction was recently tested successfully. Considerable attention has been given to disruptions. In addition to exploring techniques for disruption mitigation or avoidance (by massive gas injection or ECCD, and with assistance from real-time modeling), the related problems of runaway electron generation, mitigation, and control, are also being tackled. Investigations of the density disruption limit are ongoing, in particular to explore its dependence on gas puffing and plasma shape. The possible “seedless”excitation of NTMs, mediated by neoclassical toroidal viscosity, has been successfully studied by modifying the rotation profile with ECRH.

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