Contribution ID: **355** Type: **Overview**

Physics research on the TCV tokamak facility: from conventional to alternative scenarios and beyond

Tuesday, 23 October 2018 17:05 (25 minutes)

The research program of the TCV tokamak ranges from conventional to advanced tokamak scenarios and advanced divertor configurations, to exotic plasmas driven by theoretical insight, exploiting the device's unique shaping capabilities. The facility is operated intensively both domestically and with EUROfusion support. The new 1-MW NBI has expanded the parameter range, now encompassing ELMy H-modes in an ITER-like shape, stationary non-inductive discharges sustained by ECCD and NBCD, and negative-triangularity diverted plasmas.
Disruption avoidance by real-time locked mode prevention or unlocking with ECRH was thoroughly documented, using magnetic and radiation triggers. Runaway generation with high-Z noble gas injection and runaway dissipation by subsequent Ne or Ar injection were studied for model validation.
Turbulence is reduced in the core at negative triangularity, consistent with increased confinement and in accord with global gyrokinetic simulations. The GAM, possibly coupled with avalanche events, has been linked with particle flow to the wall in diverted plasmas.
In H-mode, the pedestal pressure and plasma stored energy are insensitive to fueling, whereas nitrogen seeding moves the pedestal outwards and increases the stored energy. High fueling at high triangularity (0.54) is key to accessing the attractive small-ELM (type-II) regime.
Detachment, SOL transport, and turbulence were studied in L- and H-mode in both standard and alternative configurations (snowflake, super-X, and beyond). The L-H transition threshold is independent of the divertor topology. In the attached L-mode phase, an increase in flux expansion or divertor leg length reduces the power exhausted at the outer strike point and increases radiation. The detachment process is caused by power "starvation"reducing the ionization source, with volume recombination playing only a minor role. The SOL density shoulder observed at high collisionality is correlated with increased blob size.
A doublet plasma, featuring an internal X-point, was achieved successfully, if only transiently, and a transport barrier was observed in the mantle just outside the internal separatrix.
In the near future variable-configuration baffles and cryopumping will be introduced to investigate the effect of divertor closure on exhaust and performance, and 2-MW ECRH and 1-MW NBI heating will be added.

Country or International Organization

Switzerland

Paper Number

OV/5-2

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Session Classification: OV/5 Overview Magnetic Fusion

Track Classification: OV - Overviews