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European Integrated Programme in support to ITER: Overview of JET and Medium Size Tokamak results

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Europe has elaborated a Roadmap to the realisation of fusion energy in which 'ITER is the key facility and its success is the most important overarching objective of the programme'. EUROfusion has seized the unique opportunity to develop an integrated programme on devices of different sizes, i.e. on EU Medium-Size Tokamaks (MSTs), and, on JET in order to provide a step-ladder approach for extrapolation to ITER. In addition, the ITER Organization has issued a detailed analysis of the risks to ITER operation and has identified the main R&D needs to mitigate those risks in the revised ITER research plan. In this context, this paper will provide an overview of the recent coordinated contributions of the EU programme to optimise ITER operation.

Disruptions are considered as the highest operational risk in the ITER Research Plan. The high priority physics studies on JET and MSTs consist of disruption prediction, avoidance, mitigation and associated modelling (including multi-machine run-away electrons model validation). A new shattered pellet injection system is being installed on JET to compare with massive gas injection and elucidate the differences in run-away electrons beam mitigation in view of impacting the design of the ITER disruption mitigation system. The JET and the MSTs programmes have concentrated on the preparation of ITER operating scenarios and on providing a physics basis for optimising fusion performance operation with metallic first wall materials. It is found on JET and ASDEX Upgrade, that plasma performance is significantly affected when plasma boundary conditions are modified which will affect the strategy to achieve the fusion performance in the coming JET deuterium-tritium campaign and ITER QDT=10 main mission. In addition, preparation of the ITER non-active phase has been carried out in hydrogen on JET, and, in hydrogen and helium in the MSTs. The recent progress will be reviewed on plasma surface interaction with ITER first wall materials (e.g. beryllium and tungsten erosion/migration, helium and tungsten interaction), scaling of L to H mode power threshold, Scrape-Off-Layer physics, core and pedestal confinement with different hydrogen isotopes and helium, control of detached divertor scenarios using extrinsic impurity seeding, and options for ELMs control with pellets or with resonant magnetic perturbations, RMPs. ELMs control with RMPs has been established on ASDEX Upgrade in helium using methods developed for deuterium plasmas, addressing a ITER issue of the transferability of ELMs control methods.

To conclude, the success of ITER operation will also require integrating the experimental progress made in different fusion facilities through theory-based first principle and integrated modelling. The European Transport Simulator, ETS, for integrated modelling has undergone major development and has been benchmarked against TRANSP. The strategic movement towards the adoption of the ITER integrated modelling and analysis suite (IMAS) has been pursued by the continued support and validation of the IMAS infrastructure and extension of the EUROfusion experimental databases in IMAS.

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1 See author list of "X. Litaudon et al., 2017 Nucl. Fusion 57 102001"

2 See author list of "H. Meyer et al., 2017 Nucl. Fusion 57 102014"

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