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The first ITER tungsten divertor: what do we hope to learn?

Thursday 7 November 2019 09:00 (30 minutes)

On the eve of component procurement and with a substantially updated Research Plan [1] describing the pathway to achievement of inductive and steady state burning plasma operation on ITER, the present physics basis for the first ITER tungsten (W) divertor is outlined, focusing on the main design and operational driver: steady state and transient target power fluxes [2]. With the dimensions and shaping of the W monoblocks (MB) constituting the vertical targets (VT) now fixed, the operating space in allowable power flux density is more readily constrained, both from the physics and materials sides. The combination of MB front surface shaping and VT tilting for misalignment protection, fluid drifts and potentially very narrow near SOL heat flux channels (λq), push the operating space up to higher sub-divertor neutral pressures. This takes the divertor closer to full detachment, possibly approaching limits on both upstream density and pedestal radiation and presenting detachment control issues. A revised criterion for maximum tolerable loads based on the avoidance of W recrystallization [3] is being substantiated by expanded materials studies and does provide some room for manoeuvre on ITER, at least for the first divertor, for which the required lifetime is expected to be around 2000 hours of burning plasma.

Together with the existing database of SOLPS-4.3 simulations [2], the newest simulation results obtained with the SOLPS-ITER code package will be presented, including the most recent database of drift simulations and studies with reduced heat transport to examine the cost of low λq with extrinsic seeding. Work is now being performed to examine the potential gain of poloidally expanded equilibria, using new scenarios with the maximum such expansion possible at high current. A detailed divertor simulation study is also underway focusing on the much lower performance discharges which will characterize the early years of ITER operation.

Assessments have been made of the pellet and fuelling requirements compatible with control of detachment, core plasma W accumulation and H-mode operation at different phases of the Research Plan. Limits on allowable ELM energy losses are fixed both by accumulation and transient radiation under the assumption of no ELM-induced MB surface melting, but the real limit is likely to be fixed by the W material itself (surface cracking), or by the inevitable castellation edges which appear in any target comprising discrete heat flux handling elements. All of which drives the need for ELM suppression, the principal method for which on ITER is planned to be through 3D magnetic perturbations. A simulation programme is in place to examine the possibility for divertor heat load dissipation at high performance on ITER in regimes in which ELM suppression is expected.

In describing the current status of the first ITER divertor physics basis, the presentation will attempt to discuss what can be learned with respect to devices beyond ITER. It will also highlight the many areas in which more R&D is required to improve understanding for ITER in the remaining years before divertor operation begins.

[1] "ITER Research Plan within the Staged Approach", ITER Technical Report ITR-18-003 available at: https://www.iter.org/technical-reports

[2] R. A. Pitts et al., Nuclear Materials and Energy, in press.

[3] G. De Temmerman et al., Plasma Phys. Control. Fusion 60 (2018) 044018.

[4] A. R. Polevoi et al., Nucl. Fusion 58 (2018) 056020.

Affiliation

Country or International Organization

ITER Organization

Authors: PITTS, Richard (ITER Organization); BONNIN, X. (ITER Organization); CANIK, John (Oak Ridge National Laboratory); ESCOURBIAC, Frederic (ITER Organization); FRERICHS, Heinke (University of Wisconsin - Madison); GUNN, James Paul (CEA Cadarache); HIRAI, T, (ITER Organization); KAVEEVA, E. (Peter the Great St.Petersburg Polytechnic University); KUKUSHKIN, Andrei (NRC Kurchatov Institute); LOARTE, Alberto (ITER Organization); LORE, Jeremy (ORNL); Dr MOULTON, David (Cambridge Centre for Fusion Energy); PARK, Jae-Sun (Korea Advanced Institute of Science and Technology); POLEVOI, Alexei (ITER Organization); ROZHANSKY, Vladimir (St.Petersburg State Polytechnical University); SENICHENKOV, Ilya (Peter the Great Saint Petersburg Polytechnic University); SCHMITZ, Oliver (University of Wisconsin - Madison, Department of Engineering Physics); STANGEBY, Peter (University of Toronto); DE TEMMERMAN, G. (ITER Organization); VESELOVA, I. (Peter the Great St.Petersburg Polytechnic University)

Presenter: PITTS, Richard (ITER Organization)

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