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ASSESSMENT OF THE H-MODE POWER THRESHOLD REQUIREMENTS FOR ITER

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H. MEYER, F. RYTER, and the ITPA Topical Groups on Transport and
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Assessment of the H-mode Power Threshold Requirements for ITER

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This paper contains a comprehensive multi-machine assessment on accessing and maintaining H-mode plasmas in ITER. The scientific results are due to the combined activities of the ITPA Topical groups on Transport and Confinement (T&C) and Pedestal and Edge Physics (PEP). The results from these joint experiments address L-H transition power threshold issues which are not adequately included in the scaling from the ITPA H-mode power threshold database [1]. These results affect the ability to make accurate predictions for the H-mode threshold in ITER using the presently available H-mode scaling relationships and can be used to reduce the uncertainty in these predictions.

Table 1. The ratio of P_{TH}(H)/P_{TH} (D) and P_{TH} (He)/P_{TH} (D) determined in several devices using different auxiliary heating methods

Device	AUG	C-Mod	DIII-D	JET	MAST	NSTX
P_{TH}(H)/P_{TH}(D)	~1.8		~2	~2		
P_{TH}(He)/P_{TH}(D)	~1.0	1.6-2.0	1.0-1.6	1.0-1.3	1.4	1.0-1.4
Auxiliary heating	H-NBI, D-NBI, ECH	ICRH	H-NBI, He-NBI, D-NBI, ECH	H-NBI, He-NBI, D-NBI, ICRH	D-NBI	HHFW

H-mode threshold predictability is important for achieving H-mode plasmas in ITER, which is critical for the high fusion production and Q values required to satisfy the ITER objectives. For the non-nuclear operational phase in ITER with H and/or He plasmas, experiments have been performed in ASDEX Upgrade (AUG), C-Mod, DIII-D, JET, NSTX, and MAST. The latest assessment of the H-mode power threshold for H and He compared to D shown in Table 1, which shows the variation in the ratio of the power thresholds (not the absolute power thresholds).

The ratio of P_{TH}(H)/P_{TH}(D) appears to be relatively consistent at about a value of 2. However, for helium there is a large variation in P_{TH}(He)/P_{TH}(D) from 1.0-1.8. On detailed examination of the results from the many devices, the ratio of P_{TH}(He)/P_{TH}(D) varies with the

L-mode (or target) electron density as shown in Fig. 1. For example, in DIII-D, the ratio of P_{TH}(He)/P_{TH}(D) is about 1.6 at electron densities of 2.5x10^{19} m^{-3}, but moves towards unity as the target density increases to 4.5x10^{19} m^{-3}. Similarly, in JET, the H-mode power threshold for He is much higher than D at low densities of 2x10^{19} m^{-3}, but appears to be comparable as the target density increases towards 3x10^{19} m^{-3}. Similar variations are observed in other devices (e.g. C-Mod), in which the ratio of P_{TH}(He)/P_{TH}(D) becomes smaller as the target density is increased. However, in AUG, the ratio of P_{TH}(He)/P_{TH}(D) appears to remain constant at a factor of 1 over a larger range of target densities. The variation of P_{TH}(He)/P_{TH}(D) ratio with target electron density appears to be favorable for ITER operational scenarios at relatively higher target densities.

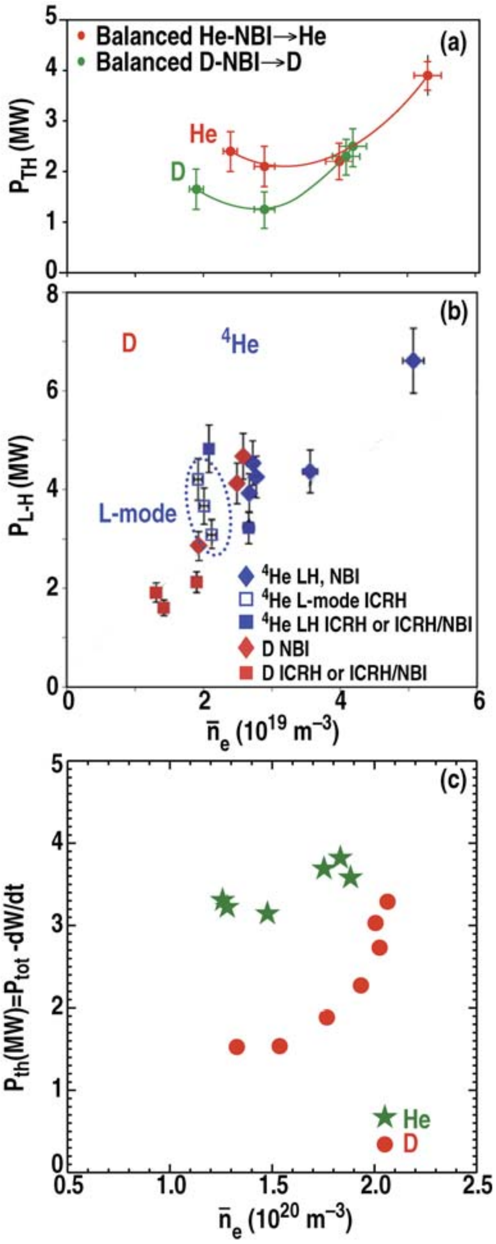

Fig. 1. The H-mode power threshold for He and D as a function of the target electron density in (a) DIII-D, (b) JET, and (c) C-Mod.

The application of resonant magnetic perturbation (RMP), for example using internal coils, can lead to clear changes in the H-mode power threshold. Results in this area have been obtained on AUG, DIII-D, JET, MAST and NSTX. Power scan studies in AUG, DIII-D, MAST and NSTX show increases in $P_{TH,}$ with clear thresholds in the RMP field strength (DIII-D, MAST, NSTX) or the target density (AUG), by up to a factor of 2 above the non-RMP threshold power. For JET, a reduction in P_{TH} is observed during the application of RMPs. However, in JET, the plasma shape is perturbed during the RMPs and the X-point is lowered, which is known to strongly reduce P_{TH}, so further analysis is underway to de-convolve the effect of the X-point to determine the true influence of the RMPs. The implications for ITER in cases where the available auxiliary heating power may be marginal over the H-mode power threshold are that careful timing of the ELM control coils may be required so that full activation is delayed till after achieving the H-mode transition.

Multi-machine results will also be presented on the H-mode confinement in He and also on modeling of ITER scenarios, based on the above results, and the predictions and implications for accessing H-mode plasmas in ITER.

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[1] Y.R. Martin *et al.*, J. Phys.: Conf. Ser. **123**, 012033 (2008).