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# Optimizing the H-Mode Transport Barrier-Advancing towards Fusion Energy

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The experimental discovery of the H-mode (the edge transport barrier), with its highly boosted energy confinement time, ushered in a new optimistic era in the controlled thermonuclear program via tokamaks. Ever since its discovery, the H-Mode has been pursued by every major experimental in the world resulting in a staggering knowledge and data base- It has been demonstrated that the H-Mode is a robust configuration and can be induced under hugely varying (fusion relevant) plasma conditions. It is generally accepted that the sharp gradients (pedestal) were created due to the suppression of a particularly virulent instability (the ITG mode) responsible for high energy transport in the core. The suppression of ITG, however, does not make the pedestal instability free- there are several classes of "residual" instabilities that control the pedestal dynamics and hence its fusion relevant "quality" – for instance, the energy confinement time, the temperature at the top of the pedestal (T-p).

This talk reports on the detailed study of the existence and consequences of these residual instabilities carried out in a major theory-simulation-experimental collaboration led by the IFS-UT pedestal group. The fulcrum for this groundbreaking research has been the gyrokinetic plasma turbulence code GENE, which has been developed by Prof. Jenko and his group at IPP-Garching. Following are some of the more important results that will be presented: 1) the identification of the microtearing mode (MTM) as a principal source of turbulent fluctuations in the JET pedestal, 2) Further confirmation of the key role of MTM in the pedestal dynamics by demonstrating a direct connection between GENE MTM simulations of DIII-D plasmas and measured magnetic fluctuations, 3) the elucidation of the temperature limitations that have plagued the JET pedestal since installation of its metal wall, 4) and a deeper investigation of the shear suppression of fluctuations

Perhaps the signature achievement of the GENE/theory driven research is the emergence of a comprehensive theory-computation-experimental framework that, *inter alia*, established the causality between the classes of fluctuations and the kind of transport they cause (Finger Print methodology). It becomes possible, e.g., to state with confidence that (1) MTM and ETG are typically the dominant heat transport mechanisms, and (2) kinetic ballooning modes, if present, will be limited mostly to the particle transport channel.

Finally, the striking interpretive and predictive powers of the assembled framework will be discussed – mechanisms to maximize the "quality" of the transport barrier will be suggested.