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Beneficial Effects of the Edge Harmonic Oscillation in Quiescent H-mode Plasmas*

K.H. Burrell

General Atomics, P.O. Box 85608, San Diego, California USA

In many ways, quiescent H-mode (QH-mode) is the ideal H-mode plasma since it exhibits H-mode levels of confinement while operating without edge localized modes (ELM) while maintaining constant density and radiated power. The essential feature which distinguishes QH-mode from standard ELMing H-mode is the presence of an edge-localized electromagnetic mode, the edge harmonic oscillation (EHO). The EHO provides the extra particle transport which prevents ELMs by keeping the edge pressure below the peeling-ballooning mode limit. Impurity transport measurements demonstrate that the edge particle transport is faster in QH-mode plasmas with the EHO than in similar ELMing plasmas. The EHO is nonsinusoidal oscillation with low toroidal mode number n in the range of 1 to 4. Fourier analysis reveals the mode has one dominant n, typically n = 1–3, with a several other toroidal mode numbers mixed in. Which mode number is dominant depends on plasma conditions including shape; however, the exact correlation has not yet been determined. In high triangularity, double-null discharges at the highest densities, the coherent EHO is replaced by broadband MHD which apparently still provides enough particle transport to allow the plasma to operate at constant density without ELMs. The EHO is spontaneously generated by the plasma itself and requires no external coils to generate a perturbed magnetic field as is necessary, for example, for ELM suppression via resonant magnetic perturbations. Addition of n=3 nonresonant magnetic perturbations has been shown to change the dominant n from 1 to 3. Edge stability calculations using the ELITE code show that the QH-mode operating point is near the peeling boundary. Much of the physics of the EHO is consistent with a model in which the EHO is an edge kink-peeling mode that is destabilized by shear in the edge toroidal rotation at an edge current density slightly below that on the standard ELM boundary.

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