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Advances in the understanding of the I-mode confinement regime: access, stationarity, edge/SOL transport and divertor impact

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The I-mode is an improved confinement regime of tokamak plasmas where an edge transport barrier is observed only in the heat transport but not in the particle transport. This is in contrast to H-mode confinement, which is characterized by transport barriers for both heat and particles. The I-mode does not exhibit any edge localizes modes. Since the particle confinement is low, the I-mode does not suffer from high impurity content. In I-mode, the edge turbulence spectrum is dominated by an instability called the weakly coherent mode (WCM). After substantial I-mode research by the fusion community in the last years, the mechanism which creates a transport barrier in only one of the transport channels is still not understood.

An overview of recent I-mode studies on ASDEX Upgrade is given, including L-I and I-H power thresholds, pedestal and confinement properties, extending previous studies to higher Greenwald fractions up to 0.7. The confinement improvement in I-mode is accompanied by a deepening of the edge radial electric field well and a reduction of turbulence with respect to L-mode. New investigations with poloidal correlation reflectometry and correlation electron cyclotron emission diagnostics detect the WCM in the L-mode phase before I-mode starts, showing that the WCM is not exclusive to the I-mode. A newly installed thermal Helium beam allows a precise radial determination of maximum impact of the WCM. A striking feature of I-mode edge turbulence is a reduction of low-amplitude density fluctuations, concomitant with the appearance of strongly intermittent high-amplitude density bursts in the plasma edge inside the separatrix. These density turbulence bursts are linked to the WCM. After their generation, they are expelled from the plasma and appear later in the divertor, observed by bolometry, infrared thermography and probes.

Moreover, stationary I-modes have been obtained recently with neutral beam injection heating. The stationarity allows the characterization of scrape-off layer (SOL) fall-off lengths of density and temperature. While the former are similar to L-mode plasmas, the latter are comparable to H-mode plasmas, indicating that I-mode properties are also found in the SOL. Infrared thermography data
yields information on the scrape-off layer power fall-off length and divertor loads, and implications for future devices are discussed.

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