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Plasma rotation caused by destabilized eigenmodes and improved plasma performance

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Spatial channelling (SC) is a phenomenon of the transfer of the energy and momentum across the magnetic field by destabilized eigenmodes [1-3]. Energy transfer deteriorates or improves plasma confinement, depending on the energy flux direction. In particular, inward SC of alpha-particle energy by fast magnetoacoustic modes (FMM) may have played a role in the improved confinement and anomalous ion heating [4], which took place in JET DTE1 experiments with D-T plasmas [5]. The momentum SC could be another mechanism favourable for plasma confinement in these experiments: The momentum transfer leads to sheared plasma rotation, tending to suppress turbulence in the region of mode location. In particular, our analysis of JET DTE1 data shows that the best parameters were achieved in the discharge where plasma rotation frequency was highest, except for the near-axis region (D-T discharge #42847). TAE activity was absent in these experiments, only ICE which presumably is associated with FMM was observed. This may support the assumption of Ref. [4] that FMM could be responsible for the SC (the structure of modes leading to ICE was not measured).

There are other experiments confirming improved plasma characteristics in rotating plasmas. In particular, high fusion performance at high T_i/T_e in JET-ILW baseline plasmas with high NBI heating power was observed, which correlated with high rotation frequency [6]. Correlation between high rotation frequency and confinement was also observed in DIII-D; furthermore, it was found in super H-mode experiments that high rotation, not high pedestal, plays the essential role in achieving very high confinement $H_{98y2} > 1.5$ [7].

We developed a theory of the momentum SC, which includes the study of momentum emission and its radial distribution. It is found that, the momentum SC, in contrast to the energy SC, can take place even in the absence of spatial mismatch of drive and damping during energetic-ion-driven instabilities. The developed theory is applied to the ITER 15 A baseline scenario, employing predictive calculation of drive /damping of TAEs in Ref. [8].

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