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# Toroidal gyrokinetic studies of the tearing mode in tokamak plasmas

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Our present understanding of the physics of the tearing mode (TM) still does not allow a quantitative prediction of TM evolution in fusion reactors. The early phase of a TM, in particular, is determined by a complex interplay of different processes. We investigate the physics of the TM via gyrokinetic (GK) simulations in toroidal geometry using the code GKW. Two routes are followed, namely simulating the response of the plasma to a prescribed magnetic island and addressing the complete problem of the growth of the TM in the presence of GK turbulence.

In simulations with prescribed magnetic perturbation, it is found that the density profile inside an island whose width does not exceed significantly the ion orbit width follows an adiabatic law (flattened for islands rotating at the ion diamagnetic frequency, unperturbed at the electron diamagnetic frequency) also in the presence of ITG turbulence, although the physics becomes more complex. The bootstrap current flowing in an island of this size is hence a function of the rotation frequency. Simulations performed to isolate the role of the island electric field show that for frequencies of the order of
the parallel ion streaming the perpendicular fluxes exhibit a linear scaling with the island frequency omega and a complex radial pattern, confirming drift-kinetic results. A polarization signal (quadratic with omega) can be identified only in a narrow range at higher frequencies.

In linear, self-consistent simulations, the TM rotates at the electron diamagnetic frequency at low collisionalities, but reverses direction at higher collisionality. The growth rate scales with 1/7-power of the resistivity in the semi-collisional regime. The growth of a TM embedded in GK electromagnetic turbulence shows, as in other (fluid) studies, that the turbulent fluctuations provide a seed for the magnetic island. They drive its growth at a rate significantly faster than the linear tearing growth rate. Depending on the value of the plasma beta, the subsequent evolution exhibits a Rutherford behaviour
largely independent of the turbulence, or a disruption of the Rutherford phase, with the TM growing at its linear growth rate even if the island width exceeds the singular layer width. The island rotation is also modified by the presence of the turbulence. Generally, the mode rotation slows as the island grows.

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