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Kinetic Modelling of the Edge of Fusion Plasmas

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A hybrid fluid-kinetic framework for studying large-amplitude fluctuations in the edge of tokamak plasmas is presented. We derive equations for the behaviour of a spatially-anisotropic plasma in the presence of both large fluctuations and steep gradients. The system of equations consists of kinetic equations for electrons and ions, supplemented with fluid equations for the electromagnetic fields. In this way, it builds upon both kinetic MHD [1] and upon the use of vorticity equations in gyrokinetics [2].

This framework, by including both Alfvénic (including current-driven modes [3]) and drift wave dynamics, can handle fully nonlinear perturbations such as erupting ELM filaments and blob-based turbulence. The relationship between this framework and existing collisional edge models is made clear [4,5].

We not only present equations for such fast behaviour, but also develop higher order equations that describe pedestal equilibria and slow scrape-off-layer dynamics. The large-aspect-ratio limit of this system of equations is explored, producing simplified models of edge equilibria.

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