Introduction to Neoclassical Tearing Modes and the Role of Rotation

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It is now well established from theoretical considerations and from several experimental observations of long pulse high β tokomak discharges that the limit on plasma pressure is not set by the ideal MHD modes but is rather due to the onset of low (*m, n*) resistive modes. These instabilities, which produce magnetic islands at the low order rational surfaces, appear to be well described by the neoclassical tearing mechanism [1,2]. In this mechanism, a seed magnetic island at a low (*m, n*) rational surface flattens the equilibrium pressure gradient locally, thereby switching off the bootstrap current; this results in a poloidal angle dependent negative current perturbation on the given rational surface which drives up the amplitude of the magnetic island by the Rutherford non-linear growth mechanism. If the island is allowed to grow and saturate at a large width, it can significantly degrade the overall performance of the discharge. Neoclassical tearing modes (NTMs) are thus a major concern for future steady state high β devices like ITER and means of controlling them are a subject of much current theoretical and experimental interest [3]. At present two schemes are considered particularly attractive for control of neoclassical tearing modes, namely through the use of electron cyclotron current drive (ECCD) and through resonant heating by electron cyclotron waves. In these methods, waves at the resonant electron cyclotron frequency are used to drive a current (directly or indirectly by local electron heating) at the O point of the magnetic island, thereby suppressing the drive due to current density perturbation induced by the neoclassical mechanism [3].

More recently there has also been considerable interest in exploring other means of controlling or suppressing the onset of NTMs through influencing the creation mechanism of seed islands and or limiting the size of the saturated island. Experimental data from a host of tokomaks (DIII-D, JET, AUG, NSTX etc.) indicate that the presence of toroidal flow (and flow shear) can significantly modify both the onset threshold β and the saturation size of the island [4]. Current theoretical investigations using analytic modeling and numerical simulations lend support to these findings but a good physical understanding of the underlying mechanisms has yet to be achieved [5].

In my talk I will provide a basic introduction to neoclassical tearing modes and also discuss some of the above-mentioned means of controlling their onset and nonlinear evolution.

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