FUNDAMENTALS OF MAGNETIC ISLAND THEORY IN TOKAMAKS

EXTENDED ABSTRACT

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R. FITZPATRICK*

Institute for Fusion Studies, University of Texas at Austin, Austin, Texas 78712

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Tearing modes[1] are magnetohydrodynamic (MHD) instabilities[2] that often limit fusion plasma performance in tokamaks.[3] As the name suggests, tearing modes tear and reconnect magnetic field lines, in the process converting nested toroidal flux surfaces into helical magnetic islands. Such islands degrade plasma confinement because heat and particles are able to travel radially from one side of an island to another by flowing along magnetic field lines, which is a relatively fast process, instead of having to diffuse across magnetic flux surfaces, which is a relatively slow process.[4,5]

According to the standard MHD theory of magnetic islands in large–aspect ratio, low-beta, circular–flux surface tokamak plasmas, the island width evolves resistively according to an evolution equation first obtained by Rutherford.[6] This equation was subsequently augmented in Refs. 7 and 8 to take island saturation into account. The Rutherford equation also contains a stabilizing term due to magnetic field line curvature,[9] a destabilizing term due to the perturbed bootstrap current,[10] and a term due to the ion polarization current that can be either stabilizing or destabilizing, depending on the island propagation frequency.[11,12] The island frequency is determined by cross-flux surface transport.[13–21]

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*E-mail: rfitz@farside.ph.utexas.edu