Magnetic islands and singular currents at rational surfaces in three-dimensional MHD equilibria

J. Loizu[1,2], S. Hudson[2], A. Bhattacharjee[2], P. Helander[1]

Max-Planck-Princeton Center for Plasma Physics
[1] *Max-Planck-Institut für Plasmaphysik, Greifswald, Germany*
[2] *Princeton Plasma Physics Laboratory, Princeton NJ, USA*

E-mail: `joaquim.loizu@ipp.mpg.de`

Abstract. Ideal MHD predicts the existence of singular current densities forming at rational surfaces in non-axisymmetric equilibria. These current singularities consist of a Pfirsch-Schlütter component that arises as a result of finite pressure gradient and a delta-function current that presumably prevents the formation of islands that would otherwise develop in a non-ideal plasma. While analytical formulations have been developed to describe such currents, a numerical proof of their existence has been hampered by the assumption of smooth functions made in conventional MHD equilibrium models such as VMEC. Recently, a theory based on the energy principle was developed that incorporates the possibility of non-smooth solutions to the MHD equilibrium problem and bridges the gap between Taylor's relaxation theory and ideal MHD. Leveraging a numerical implementation of this *multi-region, relaxed MHD* model, we provide a numerical proof of the formation of singular currents in non-axisymmetric ideal MHD equilibria. For each numerical result we perform careful convergence studies and analytical benchmarks. Finally, we discuss the implications for the MHD stability of non-axisymmetric, toroidally confined plasmas.