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**Magnetic islands and singular currents at rational surfaces in three-dimensional MHD equilibria** JOAQUIM LOIZU, Max Planck Institut fur Plasmaphysik, STUART HUDSON, AMITAVA BHATTACHARJEE, Princeton Plasma Physics Laboratory, PER HELANDER, Max Planck Institut fur Plasmaphysik, MAX-PLANCK-PRINCETON CENTER FOR PLASMA PHYSICS COLLABORATION — Ideal MHD predicts the existence of singular current densities forming at rational surfaces in non-axisymmetric equilibria. These current singularities consist of a Pfirsch-Schlüter 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.

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