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Single versus multiple helicity reconnection in fusion relevant plasmas

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Magnetic field line reconnection in collisionless regimes is of great relevance to both space and laboratory fusion plasmas. In present-day tokamak experiments, collisionless reconnection is believed to account for fast relaxation events (such as the sawtooth crash). In such devices the relaxation time can be shorter than the electron-ion collision time and electron inertia becomes the driving mechanism for the breaking of magnetic field lines. We treat this process with both 2D and 3D models. The main feature in the 2D approximation is that, while the magnetic field changes its topology, the topology of generalized fields is preserved. The process is characterized by the presence of very narrow scale lengths, and by current density and vorticity layers. The typical growth time is of the order of the linear growth time. When a magnetic island grows, interactions with neighboring islands of different helicities become more likely, signifying ultimately a 3D process. This allows magnetic field lines to follow chaotic trajectories. The questions we address here are whether the characteristic 2D small scale structures survive in a chaotic configuration, and the problem of the proper definition of reconnected flux in 3D. We find that the small scale structures obtained in 2D simulations persist and we propose a definition of the reconnected flux in 3D. Finally, we find that, even in a complex 3D setting, the characteristic growth time of the collisionless reconnection process is of the order of the exponential growth time found in the small-amplitude linear phase.