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Non-equilibrium formation and dynamics of fundamental plasma structures: importance of kinetic physics

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Fundamental magnetized plasma structures such as current sheets and flux tubes have textbook solutions for equilibrium, e.g., the Harris sheet and the Bennett pinch, which describe a balance between the magnetic and thermal forces in a plasma. However, in actual spacecraft measurements of these structures in space, various characteristics such as their magnetic profiles do not match the textbook solutions. For example, current sheets that have bifurcated structures have been observed for decades, with origins that have eluded scientists. In this talk, I will show how the details of these structures can be explained by considering the kinetic aspects of their formation process. Particle orbit transitions leave distinct footprints in the distribution function in phase space, which are translated to kinetic equilibrium profiles that cannot be explained by MHD. Particle-in-cell simulations are used to probe this evolution in real time, and the resulting plasma profiles are shown to agree strikingly with spacecraft observations.

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