Unveiling three-dimensional relativistic reconnection dynamics prompted by the ideal tearing mode instability

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Relativistic magnetic reconnection is recognized as a universal and efficient mechanism driving the burst-like emissions observed in many high-energy astrophysical sources. Among various reconnection scenarios, the ideal tearing mode instability (TMI) stands out as a compelling candidate for explaining the fast, spontaneous reconnection events seen in observations.

However, due to computational constraints, current 3D models often struggle to capture the onset of ideal TMI on dynamical timescales, especially when using traditional low-order numerical methods and CPU-based architectures.

In this talk, we present one of the first fully fourth-order accurate, GPU-accelerated, 3D simulations of ideal tearing dynamics within a resistive special relativistic MHD framework. Our simulations explore and compare two distinct initial equilibria: a pressure-balanced configuration and a force-free one.

In contrast to 2D models, which typically reach a saturation phase, our 3D simulations reveal significantly richer dynamics occurring after the main reconnection event. These include the emergence of secondary instabilities and the development of turbulence. In a first attempt to bridge the gap between fluid and PIC models, we analyze candidate regions for particle acceleration in the presented 3D fluid models and introduce the first results obtained in preliminary 2D simulations of relativistic reconnection with physically informed effective resistivity.