9th Asia-Pacific Conference on Plasma Physics, 21-26 Sep, 2025 at Fukuoka

Three-dimensional Magnetic Reconnection within Strongly Turbulent Solar Flare Current Sheets

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Magnetic reconnection is a fundamental mechanism of driving eruptive phenomena of different scales and may be coupled with turbulence as suggested by recent remote-sensing and in situ observations. However, the specific physics behind the complex three-dimensional (3D) turbulent reconnection remains mysterious. Here, we develop a novel methodology to identify and analyze multitudes of multiscale reconnection fragments within a strongly turbulent current sheet (CS) and apply it to a state-of-the-art numerical simulation of turbulent reconnection for solar flares. It is determined that the reconnection fragments tend to appear as quasi-2D sheets forming along local magnetic flux surfaces, and, due to strong turbulence, their reconnection flow velocities and reconnection rates are significantly broadened statistically but are scale independent. Each reconnection fragment is found to be surrounded by strongly fluctuated in/outflows and has a widely distributed reconnection rate, mainly in the range of 0.01–0.1. The results, for the first time, provide quantitative measurements of 3D magnetic reconnection in strongly turbulent flare CSs, offering insights into the cascading laws of 3D reconnection in other turbulent plasmas.

References

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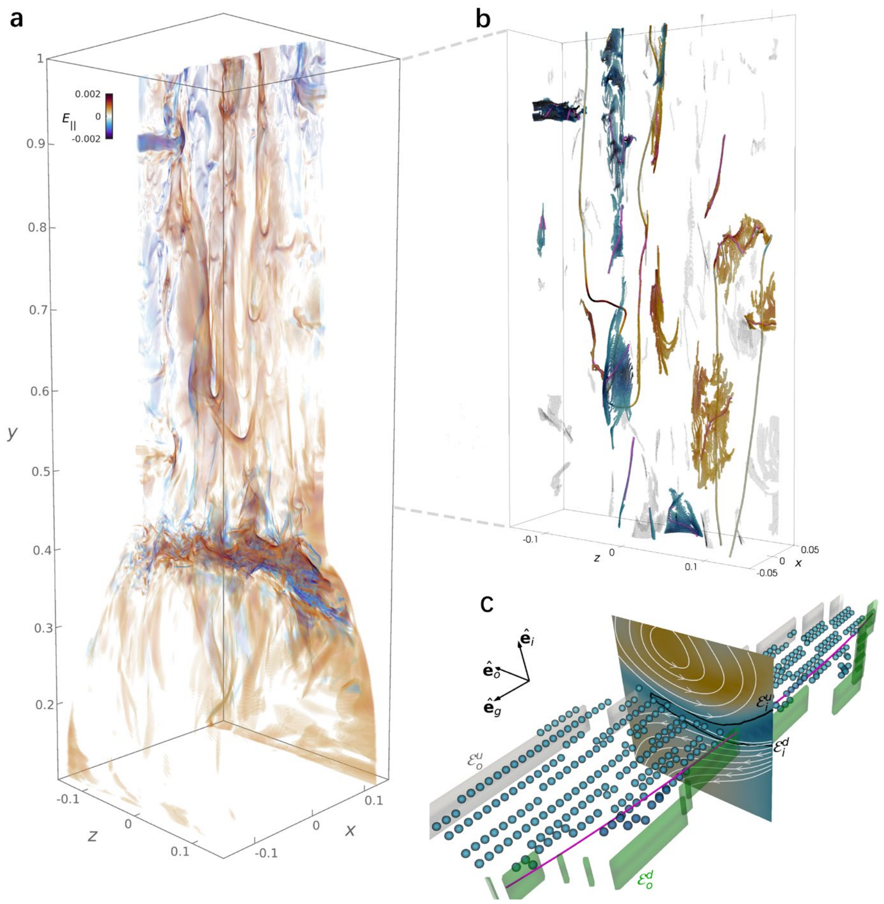

Figure 1. Diagram of reconnection regions within the strongly turbulent flare CS. (a) Distribution of reconnection regions indicated by the strong parallel electric field. (b) Typical reconnection kernels recognized by our method. (c) Intrinsic reconnection frame of a reconnection kernel which enables quantitative analysis of reconnection flows and rates.