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Identifying active magnetic reconnection in simulations and in situ observations of plasma turbulence using magnetic flux transport

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For decades, magnetic reconnection has been suggested to play an important role in the dynamics and energetics of plasma turbulence by spacecraft observations, numerical simulations and theory. Reliable approaches to study reconnection in turbulence are essential to advance this frontier topic of plasma physics. A new method based on magnetic flux transport (MFT) has been recently developed to identify reconnection activity in turbulent plasmas. Applications to gyrokinetic simulations of two- and three-dimensional (2D and 3D) plasma turbulence, and MMS observations of reconnection events in the magnetosphere have demonstrated the capability and accuracy of MFT in identifying active reconnection in turbulence. In 2D, MFT identifies multiple active reconnection X-lines; two of them have developed bi-directional electron and ion outflow jets, observational signatures for reconnection, while one of the X-line does not have bi-directional electron or ion outflow jets, beyond the category of electron-only reconnection recently discovered in the turbulent magnetosheath. In 3D, plentiful reconnection X-lines are identified through MFT, and a new picture of reconnection in turbulence results. In space, MMS observations have provided first evidence for MFT signatures of active reconnection under varying plasma conditions throughout the Earth's magnetosphere. MFT is applicable to in situ measurements by spacecraft missions, including PSP and Solar Orbiter, and laboratory experiments.