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3-D electron shear flow instabilities in collisionless magnetic reconnection

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In collisionless magnetic reconnection, electron current sheets (ECS) with thickness of the order of electron inertial length forms embedded inside an ion current sheet with thickness of the order of ion inertial length. These ECS's are susceptible to a variety of instabilities which have potential to affect the reconnection rate and/or the structures. We study three dimensional electron shear flow driven instabilities of an electron current sheet using an electron-magnetohydrodynamic model. Linear growth rate of the fastest mode drops with the thickness of ECS. The nature of the instability also changes with the thickness of ECS and presence of guide field. In the absence of a guide field and for the half thickness close to one electron inertial length, the fastest instability is two dimensional (no variations along flow direction) tearing mode and 3-D flux bundles are expected to form during the nonlinear evolution of the instability. For half thickness sufficiently larger or smaller than one electron inertial length, the fastest mode has finite variations along the direction of flow and is not tearing mode. Three dimensional nonlinear electron-magnetohydrodynamic simulations show the formation of flux ropes for the half thickness close to one electron inertial length. Effect of finite guide field on 3-D electron shear flow instabilities is also presented.