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Instability evolution of a reconnecting current-sheet in the full three-dimensional space: driving modes and turbulent configurations

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We provide an exhaustive three-dimensional picture of the reconnecting dynamics of a current-sheet. Recently, a two-dimensional non-steady reconnection dynamics has been proved to occur without the presence of any anomalous effect (Lapenta 2008, Bettarini and Lapenta 2009, Skender and Lapenta 2010) but such a picture must be confirmed in a full three-dimensional configuration wherein moreover all instability modes are allowed to drive the evolution of the system, i.e. to sustain a reconnection dynamics or to push the system along a different instability path. In fact, here we propose a full-space analysis allowing us to determine the longitudinal and, possibly, the transversal modes driving the different current-sheet disruption regimes, the corresponding characteristic time-scales and to study system's instability space-parameter (plasma beta, Lundquist and Reynolds numbers, system's aspect ratio). The conditions leading to an explosive evolution rather then to a diffusive dynamics as well as the details of the reconnection inflow/outflow regime at the disruption phase are determined. According to the two-dimensional case, the non-steady reconnection leads to a chaotic regime within the sheet and therefore the possible development of turbulent cascades in the cross-sectional planes are analyzed during the three-dimensional evolution. Such system embedded in a solar-like environment and undergoing a non-steady reconnection evolution may determine the formation both of jets and waves influencing the dynamics and energetic of the upper layers and of characteristic down-flows as observed in the low solar atmosphere.