Evolution of the thermal and tearing modes in a current sheet: Explosive reconnection and formation of plasmoids

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Thermal instability plays a major role in the condensation phenomena in the solar corona, e.g. coronal rain and prominence formation. Whereas, tearing instability in a current sheet may trigger the explosive reconnection and plasmoid formation. Hence, the study of the instability of a current sheet is important in the investigation of the magnetohydrodynamical behavior of pre-flare current layers, and in the condensation mechanisms in the solar corona. We explore how the thermal and tearing modes reinforce each other in the fragmentation of a current sheet in the solar corona through an explosive reconnection process, and in the formation of plasmoids. We use a resistive magnetohydrodynamic (MHD) simulation of a 2D current layer model by incorporating non-adiabatic effects of optically thin radiative energy loss and background heat using MPI-AMRVAC. Multiple levels of adaptive mesh refined grids are used for achieving a high resolution to resolve the fine structures during the evolution of the system. The parametric survey of different resistivities and plasma-β for estimating the instability growth rate in the linear and nonlinear regimes is explored. We notice that for the resistivity values within 10^{-4} - 5 x 10^{-3} (in dimensionless unit), we get explosive behavior where thermal instability and tearing behavior reinforce each other. We calculate the mean growth rate for the linear phase and different non-linear phases of the evolution. It is noticed that the non-linear growth rates follow weak power-law distributions with resistivity. The fragmentation of the current sheet and the formation of the plasmoids in the nonlinear phase of the evolution due to the thermal and tearing instabilities are obtained. The formation of the plasmoids is noticed for the Lundquist number (S_L) range 4.6 x 10^3 - 2.34 x 10^5. We estimate the temporal variation of the plasmoid numbers and the density filling factor of the plasmoids for different physical conditions. We also find that the maximum plasmoid numbers scale as $S_L^{0.223}$. The study infers that the instability growth rates become faster, and weaker with resistivity due to the additional effect of thermal instability as compared to only tearing mode.