# Structure of the ELM crash from numerical simulation

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New, higher resolution numerical simulations of the ELM crash provide a clearer picture of the ELM instability. Higher resolution has become possible because The extended MHD code M3D has been upgraded to use higher order finite elements and larger MPP computers (eg, the Cray XT4 at NERSC) allow regular runs at larger size. The simulations keep the full toroidal spectrum, rather than a low-$n$ toroidal periodicity. MHD nonlinear simulation shows that a classic Type I ELM crash, without RMP or plasma rotation, has a well-defined spatial and temporal development. A ballooning-type instability initially grows in a limited poloidal region around the outboard midplane, then spreads around the plasma edge towards the top and bottom. Localized density peaks build near the top and bottom of the plasma and may contact the divertor or adjacent wall there. The nonlinear saturation mechanism is still reduction of the plasma pressure gradient (primarily density) near the outboard midplane, but less density is expelled into the open field line region near the midplane and more transported away, up or down, along field lines in the plasma edge. The nonlinear perturbation has a significant $n = 1$ toroidal harmonic that may interact with RMPs or non-axisymmetric error fields. Plasma toroidal rotation without RMP increases the growth rate and size of the ELM.