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Manifold death: the implementation of controlled topological changes in thin sheets by the signature method

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A well-known drawback of the Volume of Fluid (VOF) method is that the breakup of thin liquid films or filaments is mainly caused by numerical aspects rather than by physical ones. The rupture of thin films occurs when their thickness reaches the order of the grid size and by refining the grid the breakup events are delayed. When thin filaments rupture, many droplets are generated due to the mass conserving properties of VOF. Thus, the numerical character of the breakup does not allow to obtain the desired convergence of the droplet size distribution under grid refinement. In this work, we present a novel algorithm to detect and perforate thin structures. First, thin films or ligaments are identified by taking quadratic moments of the VOF indicator function. Then, the breakup is induced by making holes in the films before their thickness reaches the grid size. We show that the method improves the convergence upon grid refinement of the droplets size distribution, as well as of enstrophy.