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2D and 3D thermal dendritic solidification modeling using the phase-field method and automatic adaptive meshing

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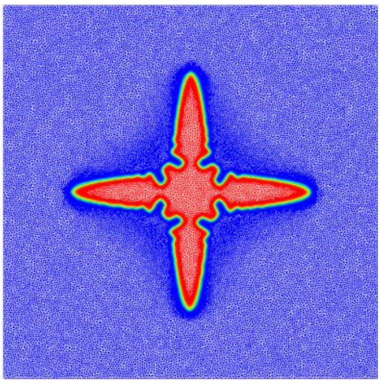
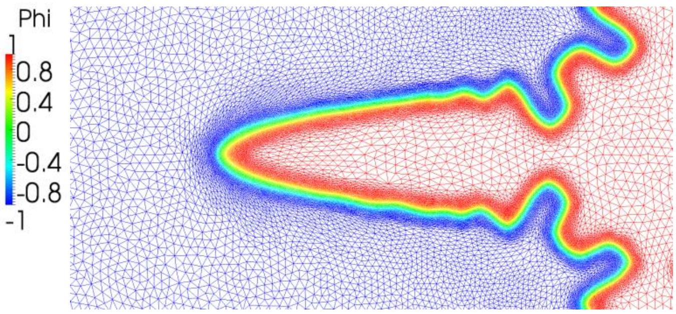
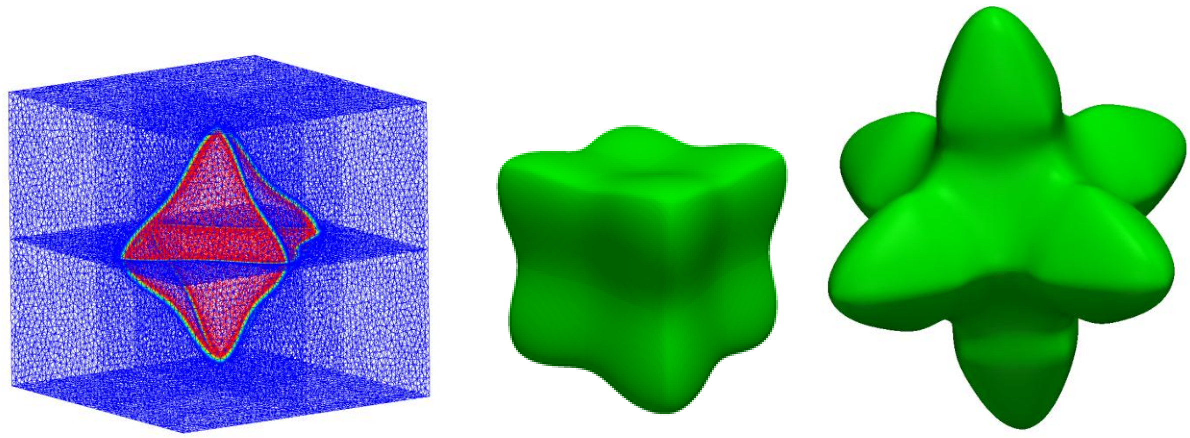
The evolution of dendritic solidification microstructures using a phase-field model is computed with an automatic anisotropic adaptive finite element mesh. The energy conservation equation is formulated for solid and liquid phases considering an interface balance that includes the Gibbs-Thomson effect. An equation for a diffuse interface is also developed by considering a phase field function with constant negative value in the liquid and constant positive value in the solid. Unknowns are the phase field function and a dimensionless temperature.

Linear finite element interpolation is used for both variables and, after discretization, stabilization techniques are used to ensure convergence towards a correct non-oscillating solution. In order to perform quantitative computations of dendritic growth on a large domain, two additional numerical ingredients are necessary: automatic anisotropic adaptive meshing [1] and parallel implementations [2], both made available with the numerical platform used (CimLib). Mesh adaptation is found to greatly reduce the number of degrees of freedom.

Results of phase-field simulations of the dendritic solidification of a pure material in two and three dimensions are shown, thus reproducing the pioneer original work [3][4]. We discuss the details of the algorithms and show that how it can be used to greatly reduce the computational cost.







Two and three-dimensional results of dendritic growth (showing the mesh and the solid/liquid interface).

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