

Application of POD and DEIM on Dimension Reduction of Nonlinear Miscible Viscous Fingering in Porous Media

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A Discrete Empirical Interpolation Method (DEIM) is applied in conjunction with Proper Orthogonal Decomposition (POD) to construct a nonlinear reduced-order model of finite difference discretized system used in the simulation of nonlinear miscible viscous fingering in a 2-D porous medium. POD is first applied to extract a low-dimensional basis that optimally captures the dominant characteristics of the system trajectory. This basis is then used in a Galerkin projection scheme to construct a reduced-order system. DEIM is then applied to greatly improve the efficiency in computing the projected nonlinear terms in the POD reduced system. DEIM achieves a complexity reduction of the nonlinearities which is proportional to the number of reduced variables while POD retains a complexity proportional to the original number of variables. Numerical results demonstrate that the dynamics of the viscous fingering in the full-order system of dimension 15000 can be captured accurately by the POD-DEIM reduced system of dimension 40 with the computational time reduced by factor of $\mathcal{O}(1000)$.