Accelerating numerical solvers using POD+Galerkin projection

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A method will be described to accelerate time-dependent numerical solvers that is based on the combined use of (i) a proper orthogonal decomposition (POD) of some sets of snapshots that are calculated using the numerical solver and (ii) a reduced order model obtained upon Galerkin projection of the governing equations on the POD modes calculated in (i). Now, steps (i) and (ii) are applied in interpersed time intervals. Switching between both is made using an a priori error estimate that provides quite good results. Several improvements will be commented that make the method both robust and computationally efficient. Application will be made to two problems, namely the Ginzburg-Landau equation in transient chaos conditions and the two-dimensional, pulsating cavity problem, which describes the motion of liquid in a box whose upper wall is moving back and forth in a quasi-periodic fashion. In the latter case, the numerical solver will be based on a rough (but quick) computational fluid dynamics (CFD) code that resembles those (industrial) codes that are usually used in Industry. Consequently, it is the numerical code and not the governing equations themselves that is projected into the POD modes. Several consequences of all these will be briefly discussed.