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# Nonsymmetric multigrid preconditioning for conjugate gradient methods

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We numerically analyze the possibility of turning off post-smoothing (relaxation) in geometric multigrid when used as a preconditioner in conjugate gradient linear and eigenvalue solvers for the 3D Laplacian. The geometric Semicoarsening Multigrid (SMG) method is provided by the hypre parallel software package. We solve linear systems using two variants (standard and flexible) of the preconditioned conjugate gradient (PCG) and preconditioned steepest descent (PSD) methods. The eigenvalue problems are solved using the locally optimal block preconditioned conjugate gradient (LOBPCG) method available in hypre through BLOPEX software. We observe that turning off the post-smoothing in SMG dramatically slows down the standard PCG-SMG. For the flexible PCG and LOBPCG, our numerical results show that post-smoothing can be avoided, resulting in overall acceleration, due to the high costs of smoothing and relatively insignificant decrease in convergence speed. We numerically demonstrate for linear systems that PSD-SMG converges nearly identical to flexible PCG-SMG if SMG post-smoothing is off. A theoretical justification is provided.