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PSH3D fast Poisson solver for petascale DNS DARREN ADAMS, University of Illinois, NCSA, MICHAEL DODD, ANTONINO FERRANTE, University of Washington, Seattle — Direct numerical simulation (DNS) of high Reynolds number, $Re \geq O(10^5)$, turbulent flows requires computational meshes $\geq O(10^{12})$ grid points, and, thus, the use of petascale supercomputers. DNS often requires the solution of a Helmholtz (or Poisson) equation for pressure, which constitutes the bottleneck of the solver. We have developed a parallel solver of the Helmholtz equation in 3D, PSH3D. The numerical method underlying PSH3D combines a parallel 2D Fast Fourier transform in two spatial directions, and a parallel linear solver in the third direction. For computational meshes up to 8192^3 grid points, our numerical results show that PSH3D scales up to at least 262k cores of Cray XT5 (Blue Waters). PSH3D has a peak performance 6× faster than 3D FFT-based methods when used with the 'partial-global' optimization, and for a 8192^3 mesh solves the Poisson equation in 1 sec using 128k cores. Also, we have verified that the use of PSH3D with the 'partial-global' optimization in our DNS solver does not reduce the accuracy of the numerical solution of the incompressible Navier-Stokes equations.

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