DFD07-2007-000935

Abstract for an Invited Paper
for the DFD07 Meeting of
the American Physical Society

DNS of incompressible turbulence in a periodic box with up to 4096^3 grid points

YUKIO KANEDA, Nagoya University

Turbulence of incompressible fluid obeying the Navier-Stokes (NS) equations under periodic boundary conditions is one of the simplest dynamical systems keeping the essence of turbulence dynamics, and suitable for the study of high Reynolds number (Re) turbulence by direct numerical simulation (DNS). This talk presents a review on DNS of such a system with the number $N^3$of the grid points up to 4096^3, performed on the Earth Simulator (ES). The ES consists of 640 processor nodes (=5120 arithmetic processors) with 10TB of main memory and the peak performance of 40 Tflops. The DNSs are based on a spectral method free from alias error. The convolution sums in the wave vector space were evaluated by radix-4 Fast Fourier Transforms with double precision arithmetic. Sustained performance of 16.4 Tflops was achieved on the 2048^3 DNS by using 512 processor nodes of the ES. The DNSs consist of two series; one is with $k_{max}\eta\cong 1$ (Series 1) and the other with$k_{max}\eta\cong 2$ (Series 2), where k_{max} is the highest wavenumber in each simulation, and η is the Kolmogorov length scale. In the 4096^3 DNS, the Taylor-scale Reynolds number $R_\lambda \cong 1130$ (675) and the ratio L/η of the integral length scale$L$ to η is approximately 2133(1040), in Series 1 (Series 2). Such DNS data are expected to shed some light on the basic questions in turbulence research, including those on (i) the normalized mean rate of energy dissipation in the high Re limit, (ii) the universality of energy spectrum at small scale, (iii) scale- and Re- dependences of the statistics, and (iv) intermittency. We have constructed a database consisting of (a) animations and figures of turbulent fields (b) statistics including those associated with (i)-(iv) noted above, (c) snapshot data of the velocity fields. The data size of (c) can be very large for large N. For example, one snapshot of single precision data of the velocity vector field of the 4096^3 DNS requires approximately 0.8 TB.