TEST CASE: LES of particle-laden turbulent channel flow

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Equation of particle motion (with drag and inertia)

$$\frac{d\mathbf{x}_i}{dt} = \mathbf{v}_i \ , \quad \frac{d\mathbf{v}_i}{dt} = \frac{\hat{\mathbf{u}}(\mathbf{x}_i,t)-\mathbf{v}_i}{\tau_p}(1+0.15Re_p^{0.687}),$$

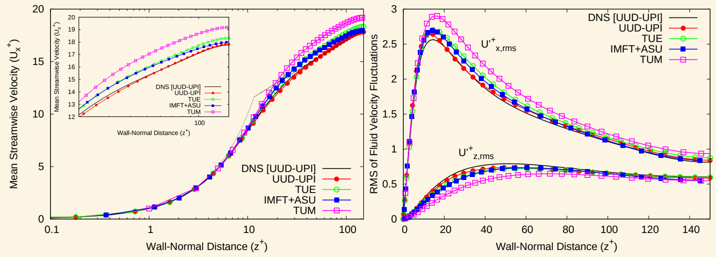
$\mathbf{x}_i$, $\mathbf{v}_i$ and τ_p: particle position, velocity and relaxation time.
$\hat{\mathbf{u}}(\mathbf{x},t)$: filtered fluid velocity (issued by LES).

Method (LES of particle-laden flow)

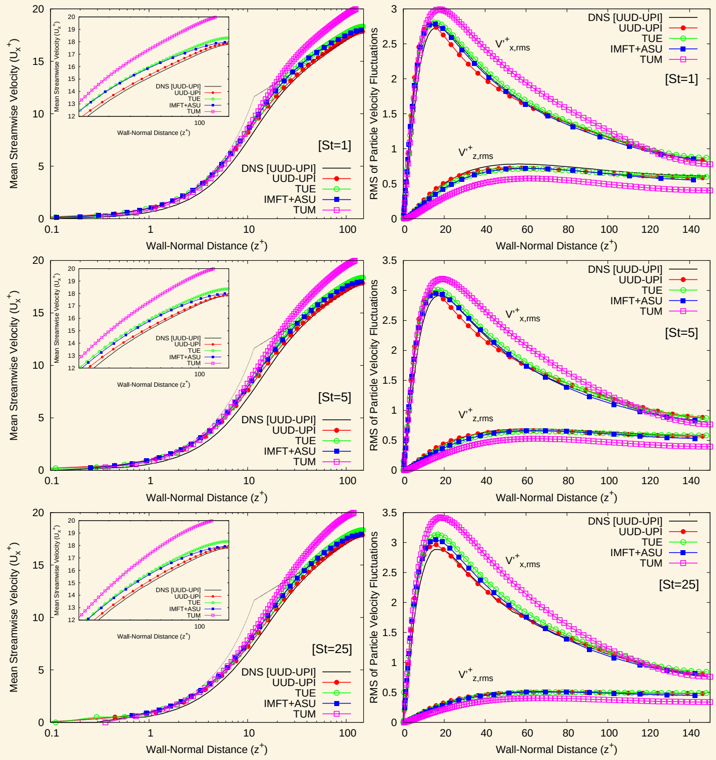
- COMMON BASE-SIMULATION PARAMETERS
  - Shear Reynolds number (based on half channel height) : $Re_\tau = 150$
  - Particle Stokes number: $St = 1$, 5 and 25
  - Size of the computational domain (streamwise, wall-normal, spanwise): $L_x \times L_z \times L_y = 4\pi h \times 2h \times 2\pi h$
  - Grid resolution: $N_x \times N_z \times N_y = 64 \times 65 \times 64$
  - Tracked particles: $N_p = 10^5$ particles for each St
- GROUP UUD-UPI (Marchioli, Soldati, Salvetti)
  - Flow solver: Fourier-Galerkin (streamwise-spanwise) and Chebyshev collocation method (wall-normal)
  - SGS model: dynamic eddy-viscosity model
  - Time integration of fluid: 2^{nd}-order Adams-Bashforth (nonlinear terms), implicit Crank-Nicolson (linear terms)
  - Time integration of particles: 4^{th}-order Runge-Kutta
  - Fluid velocity interpolation: 6^{th}-order Lagrange polyn.
- GROUP TUE (Kuerten)
  - Flow solver: Fourier-Galerkin (streamwise-spanwise) and Chebyshev collocation method (wall-normal)
  - SGS model: dynamic eddy-viscosity model
  - Time integration of fluid: 3^{rd}-order Runge-Kutta (non-linear terms) and implicit Crank-Nicolson (linear terms)
  - Time integration of particles: 2^{nd}-order Heun method
  - Fluid velocity interpolation: 4^{th}-order Lagrange-Hermite
- GROUP IMFT-ASU (Konan, Fede, Simonin, Squires)
  - Flow solver: fractional-step method for the NS equations. Spatial derivatives evaluated using 2^{nd}-order centered differences
  - SGS model: eddy-viscosity model with wall damping
  - Time integration of fluid: 2^{nd}-order Adams-Bashforth (nonlinear terms) and Crank-Nicolson (linear terms)
  - Time integration of particles: 2^{nd}-order Adams-Bashforth
  - Fluid velocity interpolation: 4^{th}-order Lagrange polyn.
- GROUP TUM (Gobert, Manhart)
  - Flow solver: finite-volume method for the NS equations. Spatial derivatives evaluated using 2^{nd}-order centered differences
  - SGS model: dynamic Lagrange Smagorinsky eddy-viscosity model
  - Time integration of fluid: 3^{rd}-order Runge-Kutta
  - Time integration of particles: 4^{th}-order adaptive linear-implicit Runge-Kutta (Rosenbrock-Wanner scheme)
  - Fluid velocity interpolation: 4^{th}-order Lagrange polyn.

Results

Mean and RMS Fluid Velocities:



Mean and RMS Particle Velocities:



Particle Concentrations: