TIFR Centre for Interdisciplinary Sciences, Narsingi, Hyderabad 500075

Colloquium

A Stochastic Model for High Stokes Number Particle Pair Dynamics in Isotropic Turbulence

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Abstract: The Probability Density Function (PDF) describing the relative motion of high Stokes number particles in a turbulent flow is a function of both spatial separation and relative velocity vectors of particle pairs. In a Direct Numerical Simulation (DNS) study of particle-laden isotropic turbulence by Sundaram & Collins (1997), it was observed that the marginal PDF of particle-pair relative velocity was Gaussian at pair separations of the order of the turbulent integral length scale, but this PDF became increasingly non-Gaussian with a sharp peak and a long tail at smaller separations. In this study, we derived the Fokker-Planck equation governing the joint PDF of pair separation and relative velocity vectors of high Stokes number particles. The Fokker-Planck equation contains a particle-pair diffusion coefficient in 2 relative velocity space, which is shown to be $1/\tau_v$ times the time-integral of the two-time correlation of fluid relative velocities along the pair trajectory; here, τ_v is the particle viscous relaxation time. We developed an analytical theory to predict this pair diffusion coefficient in the limit of particle Stokes number $\gg 1$. Using the diffusion coefficient, Langevin-equation-based stochastic simulations were performed to evolve pair relative velocities and separations in isotropic turbulence for Kolmogorov time scale (τ_η)-based particle Stokes numbers, $St_\eta = 1, 2, 4, 10$, and, 20 at a Taylor micro-scale Reynolds number, $R_\lambda = 75$. The Langevin simulations capture the transition of the relative velocity PDF from a Gaussian PDF at separations of the order of the integral length scale to a non-Gaussian PDF at smaller separations. The pair radial distribution functions (RDFs) computed from our Langevin simulations show reasonable quantitative agreement with the RDF predictions of Zaichik & Alipchenkov (2003). However, even at higher Stokes numbers ($St_\eta = 4, 10$, and, 20), our RDFs continue to exhibit preferential concentration marked by a power law dependence on separation at the sub-Kolmogorov length scale, while the moments-approach-based RDFs of Zaichik & Alipchenkov (2003) plateaued at small separations. This behaviour of our RDFs can be attributed to our theory's ability to capture the non-Gaussian relative velocity PDF at separations smaller than the integral length scale, as seen in the DNS of Sundaram & Collins (1997).

***Date*: Friday, June 7th 2013**
***Time*: 04:00PM (Tea/Coffee at 03:30PM)**
***Venue*: Conference Hall, TCIS**

All are cordially invited