

## Fully Resolved Simulation of Particulate Flows: Macro to Microscales

Neelesh A. Patankar

Northwestern University, Department of Mechanical Engineering  
2145 Sheridan Road, Evanston, IL 60208, USA  
n-patankar@northwestern.edu

**Keywords:** Multiphase, particulate flow, direct numerical simulation, Brownian motion

A formulation will be presented for fully resolved numerical simulation of freely moving rigid particles in fluids (Patanekar 2001, Sharma & Patankar 2005). The idea is to assume that the entire fluid-particle domain is a ‘fluid’ and then to constrain the particle domain to move with a rigid motion. It is suitable for fast computations and could potentially be employed for DNS, LES or RANS type approaches.

We have also shown that the same approach can be successfully applied to the fully resolved simulation of Brownian particles (Sharma & Patankar 2004, Chen, Sharma & Patankar 2006). In our Brownian motion technique, named Fluctuating Immersed MATerial (FIMAT) dynamics, the thermal fluctuations are included in the fluid equations via random stress terms. Solving the fluctuating hydrodynamic equations coupled with the fluid-particle solution scheme results in the Brownian motion of the particles. The random stress in the fluid equation is easy to compute unlike the random terms in the conventional Brownian/Stokesian dynamics type approaches. FIMAT finds application in variety of bio-mechanics problems. Thus, we provide a framework for fully resolved simulation of particulate flows that range from macroscale flow systems to mesoscale Brownian systems.

The same methodology is now being extended to develop algorithms to simulate freely swimming fish; some preliminary results of which will be presented.

### References

- Chen, Y., Sharma, N. & Patankar, N.A. Fluctuating immersed material (FIMAT) dynamics for the direct simulation of the Brownian motion of particles. In IUTAM symposium on computational approaches to multiphase flow (Eds. S. Balachandar and A. Prosperetti), 119-130, Springer (2006).
- Patanekar, N.A. A formulation for fast computations of rigid particulate flows. Center Turbul. Res., Ann. Res. Briefs, 185–196 (2001).
- Sharma, N. & Patankar, N.A. Direct numerical simulation of the Brownian motion of particles by using fluctuating hydrodynamic equations. J. Comp. Phys., Vol. 201, 466–486, (2004).
- Sharma, N. & Patankar, N.A. A fast computation technique for the direct numerical simulation of rigid particulate flows. J. Comp. Phys., Vol. 205, 439-457 (2005).