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Using 3D Printing and Stereoscopic Imaging to Measure the Alignment and Rotation of Anisotropic Particles in Turbulence

GUY MARCUS[1], Johns Hopkins University

We have developed a general methodology to experimentally measure the time-resolved Lagrangian orientation and solid body rotation rate of anisotropic particles with arbitrary aspect ratio from standard stereoscopic video image data. We apply these techniques to particles advected in a $R_\lambda \approx 110$ fluid flow, where turbulence is generated by two grids oscillating in phase. We use 3D printing technology to design and fabricate neutrally buoyant rods, crosses (two perpendicular rods), and jacks (three mutually perpendicular rods) with a largest dimension of 7 times the Kolmogorov length scale, which makes them good approximations to tracer particles. We have measured the mean square rotation rate, $\dot{p}_i\dot{p}_i$, of particles spanning the full range of aspect ratios and obtained results that agree with direct numerical simulations. Our measurements of the full solid-body rotation of jacks, in particular, are of broad experimental relevance because they demonstrate a new and extensible way to directly probe the Lagrangian vorticity of a fluid. Lastly, we will present our direct measurements of the alignment of crosses with the direction of their solid body rotation rate vector, demonstrating how turbulence aligns particles along their longest dimension.

[1]This work was completed while at Wesleyan University