Turbulent transport of non-spherical suspended particles: particle shape and rotation

Evan A Variano (1), Margaret Byron (1), Bernhard Mehlig (2), Jonas Einarsson (2), Kristian Gustavsson (2), Helge Andersson (3), Lihao Zhao (3), Niranjan Challabotla (3), and Greg Voth (4)

(1) University of California Berkeley, USA
(2) University of Gothenburg, Sweden
(3) Norwegian University of Science and Technology, Trondheim, Norway
(4) Wesleyan University, Connecticut, USA

Abstract:
Natural particles suspended in surface water are often non-spherical. We explore the ways in which particle shape affects particle motion, focusing specifically on how particle rotation is divided among the principle axes of non-spherical particles. This, in turn, will effect particle collision, clustering, and settling rates. We focus on idealized axisymmetric particles shaped as rods, discs, and spheroids. Their size, shape, and inertia are chosen so as to explain the physics of aspherical-particle motion that will be relevant for natural particles such as plankton, sediment, or aggregates. We find that shape has only a very weak effect on particle angular velocity, which is a quantity calculated with respect the global reference frame (i.e. east/north/up). If we analyze rotation in a particle's local frame (i.e. the particle's principle axes of rotation), then particle shape has a strong effect on rotation. In the local frame, rotation is described by two components: tumbling and spinning. We find that rod-shaped particles spin more than they tumble, and we find that disc-shaped particles tumble more than they spin. Such behavior is indicative of how particles respond to the directional influence of vortex tubes in turbulence, and such response has implications for particle motion other than rotation. Understanding particle alignment is relevant for predicting particle-particle collision rates, particle-wall collision rates, and the shear-driven breakup of aggregates. We discuss these briefly in the context of what can be concluded from the rotation data discussed above.

Short biography:

Dr. Variano is an Associate Professor in Civil & Environmental Engineering. Before joining UC Berkeley as faculty in 2008, he studied at Columbia, Cornell, and Princeton Universities. His work addresses environmental fluid dynamics, focusing on mass transport, plankton, and wetlands.