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Lagrangian triangle and tetrad statistics in isotropic turbulence[1]

JASON F. HACKL, P.K. YEUNG, Georgia Tech, BRIAN L. SAWFORD, Monash University, Australia, MICHAEL S. BORGAS, CSIRO, Australia — We study the displacement statistics of three- and four-particle clusters extracted from direct numerical simulations of three-dimensional isotropic turbulence at Reynolds numbers ranging from $R_\lambda \approx 240$ to 650. These statistics determine the third and fourth moments, respectively, of scalar concentration fields. Our focus is on the nature of non-Gaussian dynamics expressed via the shape factors $I_i = g_i/R^2, (i = 1, 2, 3)$ which are defined in terms of the eigenvalues g_i of the moment-of-inertia tensor and the radius of gyration R, which represents the linear size of the cluster. Shape factors computed from clusters with initial sizes in the inertial sub-range approach constant values at intermediate times. The average values obtained, $\langle I_1 \rangle \approx 0.83$, $\langle I_2 \rangle \approx 0.16$ and $\langle I_3 \rangle \approx 0.015$ for four-particle clusters, are insensitive to Reynolds number in the present data range, possibly indicating an approach to self-similar inertial sub-range behavior. These results differ from their respective Gaussian values of 0.75, 0.22 and 0.03. High-order statistics conditioned on cluster size are used to explore the nature and origins of these departures from Gaussian behavior and guide development of maximum-entropy theories of cluster shape.

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