Three-dimensional kinetic energy spectrum analysis of homogenous turbulence using Shake-The-Box LPT

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The kinetic energy spectrum of incompressible turbulence has been studied extensively using both DNS and experimental approaches. However, generating three-dimensional information of the turbulent energy spectra near the dissipation range is challenging. The aim of this contribution is to present an approach to obtain this information using Lagrangian Particle Tracking. The basis of the presented procedure is a measurement of fluid particle trajectories in homogenous turbulence at $Re_\lambda=370$ in a van Karman flow between two counter rotating propellers[1,2]. The algorithm used for this purpose is Shake-The-Box (STB), with which it is possible to resolve even densely seeded flows and thus to obtain velocity and acceleration information simultaneously at small and large scales. The scattered particle trajectory data has been interpolated via the data assimilation scheme FlowFit to recover the continuous flow field using 3D-B-Splines and Navier-Stokes constraints. Sampled velocity information has been processed using a constant memory streaming mean algorithm to compute the autocorrelation functions shown in Figure 1 and its corresponding velocity spectrum tensor components. Hence, a computation of the three-dimensional energy spectrum without assuming isotropy is possible. Assessing this spectrum allows a direct investigation of the hump in the transition zone between inertial and dissipative scale. This phenomenon is called the bottleneck effect and has been shown in DNS turbulent flow data. An experimental investigation of the effect in the three-dimensional spectrum is still pending.

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[1] Schröder et al, 20th Lisbon Symposium, Portugal (2022).

[2] Buchwald et al, 20th Lisbon Symposium, Portugal (2022).

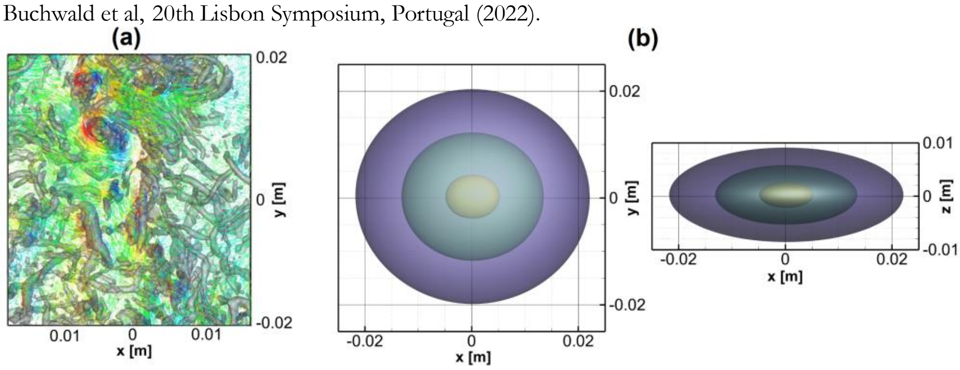

Figure 1: (a) x-component of measured particle acceleration and isosurfaces of Q-criterion at $Q=2{,}500s^2$ from FlowFit, (b) Isosurfaces of standardized velocity autocorrelation function $R_{11}(\mathbf{r})$ at a value of 0.5, 0.7 and 0.9.