Measurements of spinning and tumbling rates of Kolmogorov scale micro-plastic fibres

V. Giurgiu[1], G. C. A. Caridi [1], M. De Paoli[1,2], and A. Soldati[1,3]
[1] Institute of Fluid Mechanics and Heat Transfer, TU Wien, 1060 Vienna, Austria
[3] Physics of Fluids Group, University of Twente, 7500AE Enschede, The Netherlands
[4] Polytechnic Department, University of Udine, 33100 Udine, Italy

We measure the effect of the wall-normal location of micro-plastic fibres on spinning and tumbling rates in wall-bounded turbulence. The measurements are performed in a turbulent water channel at Re_τ 720. Fibres are 1.2mm long and 10μm in diameter (aspect ratio 120). Their length ranges from 4 to 12 Kolmogorov length scales. They are neutrally buoyant, inertial-less, and rigid in these flow conditions. Six high-speed cameras image the fibres at the channel centre and in a near-wall region. We employ and further refine a technique of tomographic fibre reconstruction and tracking. Their curved shape is used to define a fibre-fixed reference frame and measure its time-resolved orientation. Thus measurements of tumbling and spinning rates are enabled. We provide a discussion about the uncertainty on the rotation rates based on their shape and angular displacement between time-steps. Based on converged statistics, we observed that the mean and mean square spinning are higher than tumbling rates at both channel centre and near-wall region. Our results are original, because previous measurements are restricted to rotation rates of longer rods in homogeneous isotropic turbulence or to tumbling rates only.

References

Alipour, M., De Paoli, M. and Soldati, A. *Influence of Reynolds number on the dynamics of rigid, slender and non-axisymmetric fibres in channel flow turbulence.* J. F. M., **934**, 2022.

Ross, P. S., Chastain, S. et al. *Pervasive distribution of polyester fibres in the Arctic Ocean is driven by Atlantic inputs.* Nat. Comm., **12**, 106, 2021.

Thorp, I. R., Lister, J. R. *Motion of a non-axisymmetric particle in viscous shear flow.* J. F. M., **872**, 532-559, 2019.

Alipour, M. *Orientation and rotation rates of non-axisymmetric fibers in turbulent channel flow.* [PhD Thesis, TU Wien].

Oehmke, T. B., Bordolo, A. D., Variano, E., and Verhille, G. *Spinning and tumbling of long fibers in isotropic turbulence.* Physical Review Fluids, **6**, 044610, 2021.

Parsa, S. and Voth, G. A. *Inertial Range Scaling in Rotations of Long Rods in Turbulence.* Physical Review Letters, **112**, 024501, 2014.

Zhao, L., Challabotla, N. R., Andersson, H. I., Variano, E. A. *Rotation of nonspherical particles in turbulent channel flow.* Physical Review Letters, **115**, 244501, 2015.