Chair: Physics of Fluids group

Rotational and Lagrangian statistics of oddly-shaped particles in turbulence

Description

We would like to study the influence of particle shape and chirality on their Lagrangian dynamics, orientation (dynamics), and clustering in a turbulent flow. To these ends, we will use the new Dodecahedron facility, which can produce homogeneous isotropic turbulence. Its excellent optical accessibility allows for a range of measurement techniques such as Particle Image Velocimetry (PIV), Particle Tracking Velocimetry, and Laser Doppler Anometry (LDA).

Figure 1: Top-left: Examples of some particles. Top-right: rendering of possible 3D-printed particles (platonic solids). Bottom-Left: typical chiral particle. Bottom-right: Dodecahedron with a volume of ≈ 210 L.

Master assignment

We will use Dodecahedron to study the dynamics and orientation of 3D-printed particles in high turbulent flow conditions. We will use our own 3D-printing facilities and external suppliers to 3D-print particles with varying amount of symmetries. Examples of such particles are shown in Figure 1. Our unique facility allows for continuous flow measurements at high Reynolds numbers. The dodecahedral chamber has 20 engines with impellers attached to the corners to make the flow turbulent. The faces of the dodecahedron are made from acrylic allowing for ample optical access to the flow inside. We will use imaging with up to 4 high-speed cameras to track the particles in the flow and to measure the flow around it. We will use advanced image analysis techniques to extract the position and orientation of the particles.

The Lagrangian dynamics of the particles can be described in several ways: velocity and acceleration, but it can also be decomposed in terms of 'tangent', 'normal', and 'binormal' components (TNB, or Frenet–Serret frame). Autocorrelation of and cross-correlation between these quantities (and the velocity of the surrouning flow) are unknown. Also we can study the rotational statistics of the particles. We are interested how these statistics change with the turbulent intensity (Reynolds number), the particle size, and particle (a)symmetry.

Skills learned:

- Multi-camera high-speed imaging
- Image analysis to extract 3D location
- Image analysis to extract orientation
- Particle tracking velocimetry
- Statistical methods like autocorrelation, crosscorrelation, decompositions, and so on
- Turbulence theory to predict scalings for orientation, acceleration, and velocity statistics

If you are interested, feel free to send us an email; we will gladly explain you the project in more detail.

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