



## Seminar/Talk

# Physics and computations of turbulent dispersed flows: Macro- Consequences from Micro

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Host: Björn Hof

Turbulent fluids and small particles or droplets or bubbles are common to a number of key processes in energy production, product industry and environmental phenomena. In modelling these processes, the dispersed phase is usually assumed uniformly distributed. Indeed, it is not. Dispersed phases can be focused by turbulence structures and can have a time-space distribution which barely resembles prediction of simplified averaged modelling. Preferential distribution controls the rate at which sedimentation and re-entrainment occur, reaction rates in burners or reactors and can also determine raindrop formation and, through plankton, bubble and droplet dynamics, the rate of oxygen-carbon dioxide exchange at the ocean-atmosphere interface. In this talk, we will review a number of physical phenomena in which particle segregation in turbulence is a crucial effect describing the physics by means of Direct Numerical Simulation of turbulence. We will elucidate concepts and modeling ideas derived from a systematic numerical study of the turbulent flow field coupled with Lagrangian tracking of particles under different modeling assumptions. We will underline the presence of the strong shear which flavors wall turbulence with a unique multiscale aspect and adds intricacy to the role of inertia, gravity and buoyancy in influencing particle motion. We will describe the role of free surface turbulence in dispersing and clustering the light particles such as plankton and the role of the distribution of dissipation in non-homogeneous turbulence to control breakage rates of brittle and ductile aggregates. Through a number of physical examples of practical interest such as boundary layers, free-surface and stratified flows, we

will show that a sound rendering of turbulence mechanisms is required to produce a physical understanding of particle trapping, segregation and ultimately macroscopic flows such as surfacing, settling and re-entrainment.

Figure 1. Light particles floating on a flat shear-free surface of a turbulent open water. This configuration mimics the motion of buoyant matter (e.g. phytoplankton, pollutants or nutrients). Correlation between floater clusters and surface divergence  $\nabla^2 D$ . Floaters segregate in  $\nabla^2 D < 0$  regions (in blue, footprint of sub-surface downwellings) avoiding footprint of sub-surface upwellings). Particle buoyancy induces clusters that evolve towards a long-term fractal distribution in a time much longer than the Lagrangian integral fluid time scale, indicating that such clusters over-live the surface turbulent structures which produced them?.

#### REFERENCES

- Lovecchio, S., Zonta, F. and Soldati, A., 2015 Upscale energy transfer and flow topology in free surface turbulence, Phys. Rev. E, Vol. 91 033010.
- Marchioli, C. and Soldati, A., 2015 Turbulent breakage of ductile aggregates, Phys. Rev. E, Vol. 91 053003.
- Lovecchio, S., Marchioli, C., and Soldati, A. 2013 Time persistence of floating particle clusters in free-surface turbulence, Phys. Rev. E, Vol. 88 033003.
- Marchioli, C., and Soldati, A., 2002 Mechanisms for Particle Transfer and Segregation in Turbulent Boundary Layer, J. Fluid Mech., Vol. 468, pp. 283-315.
- G.A. Voth, A. Soldati 2017 Anisotropic particles in turbulence, Annu. Rev. Fluid Mech., 49, 249-276.

**Wednesday, March 29, 2017 03:00pm - 04:00pm**

Seminar Room, Lab Building East



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