Droplet growth and collisions due to turbulence and gravity

Rama Govindarajan[1], Moumita Bhowmik[3], Manpreet Singh[1], S Ravichandran[2], Jason Picardo[1], and Bipin Kumar[3]

[1]International Centre for Theoretical Sciences, Tata Institute of Fundamental Research, Bengaluru, India;

[2]Nordita, KTH Royal Institute of Technology and Stockholm University, Stockholm, Sweden;

[3]Indian Institute of Tropical Meteorology, Pune, India

rama@icts.res.in

This lecture is dedicated to the memory of Jason Reese.

Droplets in a turbulent flow are known to get centrifuged out of vortical regions, and cluster in straining regions. If the flow is accompanied by evaporation and/or condensation, the dynamics may become significantly different. This was shown in two dimensions in a supersaturated ambient [1], where, due to their inertia, solid particles and droplets are rapidly centrifuged out of vortical regions. Due to low availability of condensation nuclei, and hence lower heating from condensation, vortical regions end up slightly colder than straining regions. Interestingly, regions of high strain often lie just outside vortical regions, forming a sleeve around the vortex, and we show that collisions between droplets often occur in such regions, at a rate well in excess [2] of their local number density. We then perform three-dimensional simulations of homogeneous isotropic turbulence in a cubic domain, including inertial droplets and phase change. Initially droplets are distributed homogeneously in a supersaturated environment. We use the second invariant of velocity gradient, Q, to distinguish between straining (negative Q) and vortical (positive Q) regions. In three-dimensional turbulence too, vortical regions are cooler than their surroundings, but the temperature difference is small.

ACKNOWLEDGEMENTS: RG thanks the organisers of Droplets2019 for support to attend this meeting.

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