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TURBULENT COAGULATION OF AEROSOL PARTICLES: NEW INSIGHTS FROM DIRECT NUMERICAL SIMULATIONS AND HOLOGRAPHIC IMAGING EXPERIMENTS

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Particle collisions driven by turbulent fluctuations play a key role in such diverse problems as cloud formation, aerosol powder manufacturing and inhalation drug therapy to name a few. In all of these examples (and many others) turbulent fluctuations increase the rate of collisions relative to the background collision rate driven by Brownian motion. Furthermore, turbulence can spontaneously generate very large fluctuations in the particle concentration field. This "clustering" is caused by the inertial mismatch between the heavy particles and the lighter surrounding gas; vortices in the flow "centrifuge" the heavier particles out of vortex cores and into the straining regions that lie in between the vortices. Because collision is a binary process, concentration fluctuations further enhance the turbulent coagulation rate by as much as two orders of magnitude. An effect of this size must be accounted for in a rational model of turbulent coagulation.

Sundaram & Collins (*J. Fluid Mech.* 1997) showed that the radial distribution function (RDF) of the particle population, evaluated at contact, precisely corrects the collision kernel for clustering. Subsequent work has explored the dependence of the RDF on the system parameters (e.g., particle size, concentration, response time and Reynolds number) using direct numerical simulations. These results have improved our understanding and ability to predict the effect of the first three parameters; however, owing to the limited range of Reynolds number that can be reached in a numerical simulation, questions remain over the scaling of the RDF with Reynolds number. This is a critical issue for high-Reynolds-number applications such as cloud physics, where values of the Reynolds number can be 1–2 orders of magnitude greater than can be simulated. We will present our highest Reynolds number simulations to date and show our attempts to resolve this issue.

Recently, the ability to measure three-dimensional particle positions using holography has been realized (e.g., Meng & Pu, *J. Opt. Soc. Am.* 2003). With holography, the optical image that is produced contains fringes that, upon inverting the laser, reproduce the original image in three dimensions. The hologram can then be scanned using a digital camera to obtain the particle positions. An important consideration with this study is the need to differentiate *individual* particles.We developed a search algorithm that locates particle centers, even in the presence of optical aberations and speckle noise. The algorithm has been used to obtain the first experimental RDF measurements to date. Thus far we see good agreement between the experimentally obtained RDF and the simulations. Besides validating the simulations, experiments can span a much broader range of Reynolds numbers, providing critical data that may help resolve the open questions associated with this parameter.

Keywords: Turbulence, aerosol, coagulation, preferential concentration, direct numerical simulation, holographic imaging.