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I) **Lognormal and spherical Ornstein-Uhlenbeck Processes in fluids**

This lecture consists in two parts. In the first part, we will develop the multiplicative random processes, leading to the log-normal distribution. Such processes describe variable variations in many fields of science, including fluid mechanics and scalar transfers - such variables as atmospheric aerosol size, droplets produced by liquid jet atomization, turbulent dissipation rate, pollutants in ambient air and indoor air quality appear to be log-normally distributed. Therefore, we are going to discuss on fundamental properties of log-normal distributions and corresponding stochastic processes. The second part of this lecture is devoted to another interesting and important stochastic process – it is diffusion on the unit sphere. The related phenomena are for example a sphere tumbling in a turbulent fluid, the acceleration direction in turbulence, the magnetic relaxation of ferrofluids, the nuclear magnetic and dielectric relaxation of nematic liquids, etc. Here the focus will be put on different methods of simulation of such spherical process. The both parts will also represent the technical tools for the following three lectures.

II) **Stochastic subgrid acceleration models in Large-Eddy Simulations** (LES-SSAM)

It was recently recognized that the turbulence at a high Reynolds number is characterized by quick peaks in the velocity signal, and the corresponding velocity gradients may attain intermittently the extreme values. This is the manifestation of intense and long-lived flow structures at small spatial scales. In turbulent flows with combustion, such events of intermittency in the flow structure may provoke the spontaneous extinction or ignition. In turbulent two-phase flows, these events may strongly impact on the dynamics of particles or droplets. As to those latter, the evaporation rate and the atomization process may be also affected strongly by the events of strong velocity gradients. However, in practical computations of highly turbulent flows, referred to as Large-Eddy Simulation, the smallest scales are filtered, and consequently, the effects of intermittency are mainly neglected. In this talk we propose to discuss the recently developed approach (LES-SSAM), which in the stochastic way, takes into account the sub-filtered effects of intermittency. After preliminaries and motivation, we will briefly discuss the observations of intermittency in the local flow structure, with the focus put on the following key-parameters: the Reynolds-dependency of intermittent flow structure and the long tails in statistical distributions, the direction of vortical structures and the intimate correlation between smallest and large scales in turbulent motions. Then we will formulate the LES-SSAM approach in which these key-parameters are included as stochastic models. The validation and application of this approach will be shown for different one-phase and two-phase flows.

III) **Stochastic drag and evaporation of droplets in the under-resolved turbulence**: introduction of intermittency on subgrid scales

In the abstract written for the previous lecture on LES-SSAM approach, it was mentioned that in practical simulations, if the turbulent Reynolds number is high, the microscale flow structure with “jumps” of the velocity is under-resolved, and thereby the interactions between inertial particles and turbulence is not well-presented. This motivated to include in LES equations the stochastic models accounting for effects of intermittency on residual scales. Another approach is to induce the new stochastic equation of the motion of inertial particle in the framework of standard LES. This is the main issue of this lecture. The models include the motion of particles above and below the Kolmogorov length-scale, and these models are coherent with provided recently statistical properties of the fluid particle acceleration “seen” by the droplet along its path. On the other hand, the phase transition process may also be significantly changed due to the presence of under-resolved turbulent structures. Thus in the second part of this talk, we will discuss on stochastic simulations of the droplet evaporation in which the intermittency is also taken into account. What are the physical key-parameters of the flow which may contribute essentially to fluctuations of the evaporation rate – this question is also addressed in this part of the talk.

IV) **Fragmentation and the kinetic view on drop breakup**

Fragmentation, defined as production of random fragments (or particles) by continuous breakup of clusters, plays a key role in a variety of physical, chemical and geological processes, including turbulence, spray atomization, clouds fragmentation, solid particle decomposition, rock crushing, polymer degradation and network branching. Usually, each individual event of fragmentation is a complex microphysical process, with long-range fluctuations and uncertainties, but thereby the frequency of such events is high. Then it is natural to abstract an ‘effective’ fragmentation scenario, and to simulate this scenario as a stochastic process. In this talk we will discuss such a framework in the case of drop breakup in the highly turbulent conditions. After illustration of fragmentation, we will discuss the phenomenology of fragmentation under the scaling symmetry. The focus will be mostly put on the fragmentation at the constant frequency. Then the different stochastic models of drop breakup will be described and illustrated. We will finish this talk by discussions on size distributions of raindrops.