PROPERTIES OF STOCHASTIC MODELS OF TURBULENT DISPERSION

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Turbulent dispersion can be described using stochastic Lagrangian models based on the Langevin Equation.
Broadly speaking, two forms are used in the literature:
a non linear drift term and a Gaussian random forcing or a linear drift and a non Gaussian random forcing.
Whereas the properties of the first form are well known, those of the second one were only partially studied and are systematically investigated in this work, referring to the mathematical requirements that are necessary in order to fulfill some relevant physical properties of an ensemble of trajectories of fluid particles. These properties are the continuity, the Markovianity and the local structure of the process. In particular the first moments of the velocity in the inertial subrange are shown to be weakly related to the inhomogeneities of the turbulence. Thus the model appears particularly suitable to describe dispersion on spatial scales of the order of , or larger than, the integral scale of turbulence.

THE TURBULENT DIFFUSION AT THE PRESENCE OF SPILLING BREAKERS

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The breaking waves are one of the most of powerful gears of turbulence generation and render the essential influence on character of admixture distribution in subsurface layer of ocean. From two types of breaking waves on deep water more often occur the spilling breakers. In the spilling breakers during of collaps air-water mixture is formed. The penetrating under surface of this mixture is interpretated like a motion of two-phase jet. Corresponding system of equations used and numerical solution resived for a plane task, where axial velocity, coefficient of turbulent exchange, kinetic energy of jet and the concentration of air bubbles are determined. Nesessary for calculations the empirical coefficient is finded from comparision with the experimental date about bubbles distribution under spilling breaker. As quasystationar process the breaking is observed at the coordinate system, moving with the wave crest, in this case falling liquid enter into across stream, that has a speed, approximately equivalent to the phase wave speed. By virtue of it the depth of the direct vertical penetration of falling liquid is estimated. Coefficient of turbulent exchange in the collaps zone is calculated in accodance to Prandtl's hypothesis. From empirical dependences the share of surface, engaged by breaking waves and "background" coefficient of turbulent exchange, stipulated by nonlinear effects of nonbreaking surface waves are determined. With account of it the coefficient of turbulent diffusion, means of area is calculated.

TWO-DIMENSIONAL SPIN-UP IN A RECTANGULAR CONTAINER

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Two-dimensional spin-up of fluid in a rectangular container with large aspect ratio is investigated numerically with a pseudospectral element code in order to study two aspects of the flow evolution. The first aspect is the study of the flow evolution in a tank with aspect ratio five as function of the Reynolds number which is defined as $Re = 2B^2\Omega/\nu$, with B the short side of the container, $\Delta\Omega$ the change of rotation of the container, and ν the kinematic viscosity of the fluid. We will show an interesting series of intermediate flow configurations. It ranges from a three cell structure in the low Reynolds number limit, via a five cell structure for $Re = 5.000$, to a seven cell structure when the Reynolds number is of the order 10.000 and then back to a five cell structure for $Re \cong 20.000$. The flow evolution depends on the appearance of typical flow features as small vortices separated from the boundary layers along the side walls. For some Reynolds numbers and aspects ratios the flow evolution is critical in the sense that slight changes in parameters result in a totally different flow structure. The second aspect is the unsteady behaviour of the counter-clockwise rotating vortices. This unsteadiness is relevant to *the transport processes and chaotic advection* in arrays of vortices. It has been found that the vortices show a slight oscillatory decay at intermediate and higher Reynolds number; this is due to an oscillatory compression and decompression of the cells and elliptical deformations, both caused by boundary layer perturbations. All the cells seem to oscillate in phase, and the frequency is related to the eddy turn-over time.

NONLOCAL MIXING IN THE TURBULENT BOUNDARY LAYER

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A novel analysis of the Reynolds stress is presented to model nonlocal turbulence transport. The theory involves a sample path space and a stochastic hypothesis. A scaling relation maps the path space onto the boundary layer. The near-wall behaviour (i.e. $y_+ \to 0$) of fluctuations agrees with direct numerical simulations. Analytical sampling rates are shown to model mixing by exchange. Nonlocal mixing involves a scaling exponent ε ($\varepsilon \to \infty$ in the local limit), with significance of a Cantor set dimension (if $\varepsilon < 1$). The resulting transport equation represents a Kubo-Anderson (or kangaroo) type stochastic process. With $\varepsilon \approx 0.58$ the ensuing mean velocity profile $\bar{U}_+ = f(y_+)$ is found to be in excellent agreement with the experimental data.

TWO-WAY INTERACTION IN PARTICLE-LADEN FLOWS.

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Evolution of 2D regular flows laden with solid heavy particles is studied analytically and numerically. The particulate phase is assumed to be dilute enough to neglect the effects of particle-particle interactions. The solutions obtained show that the particulate concentration field becomes strongly nonuniform due to the flow advection and the particles inertia. The drag forces stemming from the local slip velocity between the fluid and particles bring about the modification of the flow (hence, the two-way interaction). As a result, concentrtion of particles is reduced at the vortex centers, while sheets of increased concentration are produced at the peripheries of the vortices. The flow vorticity is reduced at the vortex centers, while flow gradients are enhanced at the concentration sheets. (This work was supported by the Basic Research Foundation of Russia).

MIXING OF A PASSIVE TRACER BY HIGH REYNOLDS NUMBER BUBBLES

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We examine the mixing of a passive tracer by high Reynolds no. bubbles both experimentally and theoretically. Mixing is understood by examining the perturbation to the concentration of a dye by the passage of bubbles. Since the dye is passive, the contours of iso-concentration behave as material surfaces. Therefore examining the deformation of material surfaces will tell you information about mixing. We have examined experimentally the deformation of a material surface by a single bubble, and compared it with Darwin's (1953) analysis, the flow exterior to the bubble is assumed to be irrotational. The experiments consisted of injecting bubbles into a thin channel and observing the deformation of a fluid-fluid interface, which behaves like a material surface. Close to the point of crossing, fluid is displaced forward, and far the point of crossing fluid is displaced backwards. The agreement with the theoretical predictions is good. The distortion of the material surface leads to the dispersion of material in the direction of travel of the bubble, and stretching leads to a significant increase in concentration gradients behind the bubble. The theoretical model is applied to examine the deformation of a material surface by an assemblage of bubbles. Using this model we calculate the mixing of a concentration field, from which a dispersion coefficient due to bubble mixing can be calculated. The method of analysis and results are applicable to analysing mixing by vorticities, such as Hill's or Lamb's vortex, where the exterior flow is irrotational.

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