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Dynamics and Advection in a Vortex Parquet on the Plane

Authors : Filimonova Alexanra

Abstract : Inviscid incompressible fluid flows are considered. The object of the study is a vortex parquet – a structure consisting of distributed vortex spots of different directions, occupying the entire plane. The main attention is paid to the study of advection processes of passive particles in the corresponding velocity field. The dynamics of the vortex structures is considered in a rectangular region under the assumption that periodic boundary conditions are imposed on the stream function. Numerical algorithms are based on the solution of the initial-boundary value problem for nonstationary Euler equations in terms of vorticity and stream function. For this, the spectral-vortex meshless method is used. It is based on the approximation of the stream function by the Fourier series cut and the approximation of the vorticity field by the least-squares method from its values in marker particles. A vortex configuration, consisting of four vortex patches is investigated. Results of a numerical study of the dynamics and interaction of the structure are presented. The influence of the patch radius and the relative position of positively and negatively directed patches on the processes of interaction and mixing is studied. The obtained results correspond to the following possible scenarios: the initial configuration does not change over time; the initial configuration forms a new structure, which is maintained for longer times; the initial configuration returns to its initial state after a certain period of time. The processes of mass transfer of vorticity by liquid particles on a plane were calculated and analyzed. The results of a numerical analysis of the particles dynamics and trajectories on the entire plane and the field of local Lyapunov exponents are presented.

Keywords : ideal fluid, meshless methods, vortex structures in liquids, vortex parquet.
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