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Vortex generation due to inhomogeneous turbulent helicity

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Effects of helicity (velocity–vorticity correlation) in inhomogeneous turbulence are investigated with special reference to a global flow generation. Turbulence is expected to play important roles in effective transports, leading to enhanced mixing. In addition to the usual transport enhancement, in the presence of symmetry breakage arising from a rotation, density stratification, magnetic field, etc., turbulence may play essential roles also in transport suppression. By analysing a non-mirror-symmetric turbulence, it is shown that the turbulent helicity enters the Reynolds-stress expression in a gradient form as the coupling coefficient for the absolute vorticity. This expression suggests that the inhomogeneous helicity effect may suppress the enhanced momentum transport due to the turbulent or eddy viscosity, and that large-scale vortical motion can be generated through the coupling between rotation and inhomogeneous turbulent helicity. These predictions are confirmed through a closure or turbulence model simulations of swirling flow, and direct numerical simulation of a rotating flow with inhomogeneous helicity. Through these numerical validations, it was shown that a large-scale vorticity can be generated through the vortex dynamo due to the inhomogeneous turbulent helicity, without resorting to any baroclinicity (obliqueness between the density and pressure gradients) effect. Physical origin of this flow induction by inhomogeneous helicity is also discussed.