Experimental Investigation of the Interaction of a Vortex Dipole with a Cantilevered Plate

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The impact of a vortex dipole with the tip of a rigid and compliant cantilevered plate is investigated experimentally, using flow visualization and time-resolved particle image velocimetry (PIV). Experiments are performed in shallow, density stratified salt water, which is known to reduce three-dimensional effects and maintain dipole stability through the action of buoyancy forces. The flow visualization, in which florescent dye is used to trace both the dipole and the fluid in the vicinity of the plate, is performed to elucidate the vortex dynamics, while PIV is employed to characterize the initial dipole, as well as the secondary structures that form upon impact with the plate. As the dipole approaches the plate, positive vorticity is produced on the impact face, while negative vorticity is produced at the tip of the plate. On impact, the dipole splits in two and combines with surface-generated vorticity of opposite sign to form two secondary dipoles. The secondary dipoles follow circular trajectories and may return for subsequent impacts with the plate. By analyzing the results obtained from rigid and compliant plate, the effect of compliance on the attendant vortex dynamics is investigated. In the compliant case, plate deflection is extracted from sequential flow field images, and is used to estimate the plate strain energy. The results are compared with previously published numerical simulations and conclusions are drawn with regards to vortex dynamics and energy transfer from the fluid to the structure.