Decay or Collapse: Aircraft Wake Vortices in Grid Turbulence

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Trailing vortices are naturally shed by airplanes and they typically evolve into a counter-rotating vortex pair. Downstream of the aircraft, these vortices can persist for a very long time and extend for several kilometers. This poses a potential hazard to following aircraft, particularly during take-off and landing. Therefore, it is of interest to understand what effects control the decay rate in strength of the trailing vortices.

The decay of the aircraft wake vortices is strongly dependent on weather conditions. To simulate an environment of atmospheric turbulence, homogeneous isotropic turbulence is introduced next to localized vortical structure. In this contribution, the effect of external turbulence on the vortex decay will be investigated numerically, using a DNS method, and experimentally. Wind tunnel experiments are carried out using a smoke visualization technique, as shown in Figure 1 (a), and a Particle Image Velocimetry(PIV) method, Figure 1 (b).

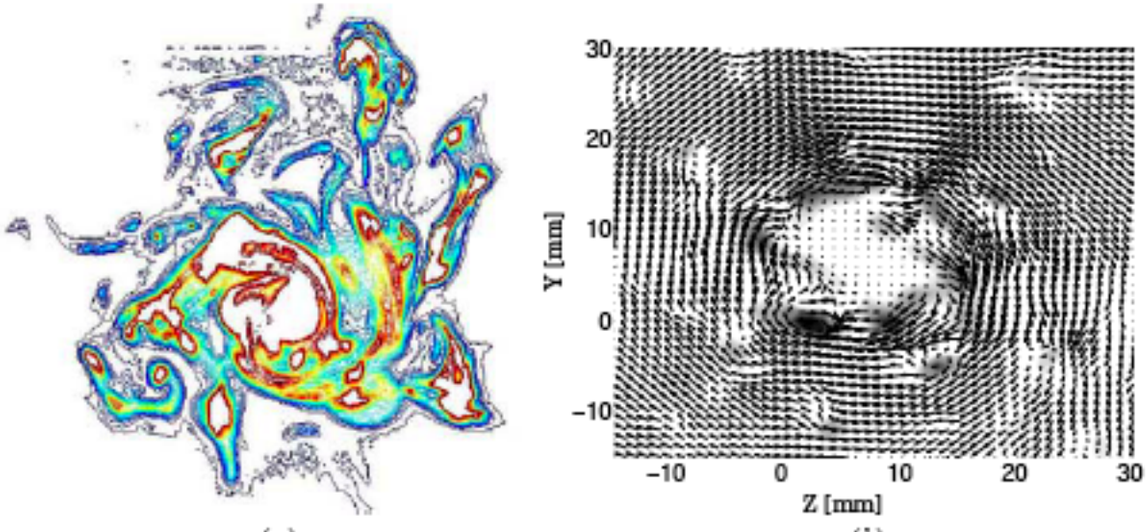

Figure 1: Wing-tip vortex in grid turbulence at a cross-section well behind a wing (a) smoke visualization with main velocity $U_\infty = 2\,[\mathrm{m/s}]$ and (b) velocity field with main velocity $U_\infty = 13\,[\mathrm{m/s}]$ using PIV technique, color indicates the strength of the axial vorticity.

From the measurement observations, it appears that external turbulence accelerates the decay process of the vortex pair by increasing the diffusion of vorticity. This tends to destroy the wake by enhancing the mixing with the surrounding fluid. The aim of this contribution is to quantify the effect of external turbulence on the decay of the wing-tip vortices.

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