EFFECT OF A WALL ON THREE-DIMENSIONALLY UNSTABLE TRAILING VORTICES FROM A DELTA WING

S. E. Morris & C. H. K. Williamson

Fluid Dynamics Research Laboratories, Cornell University

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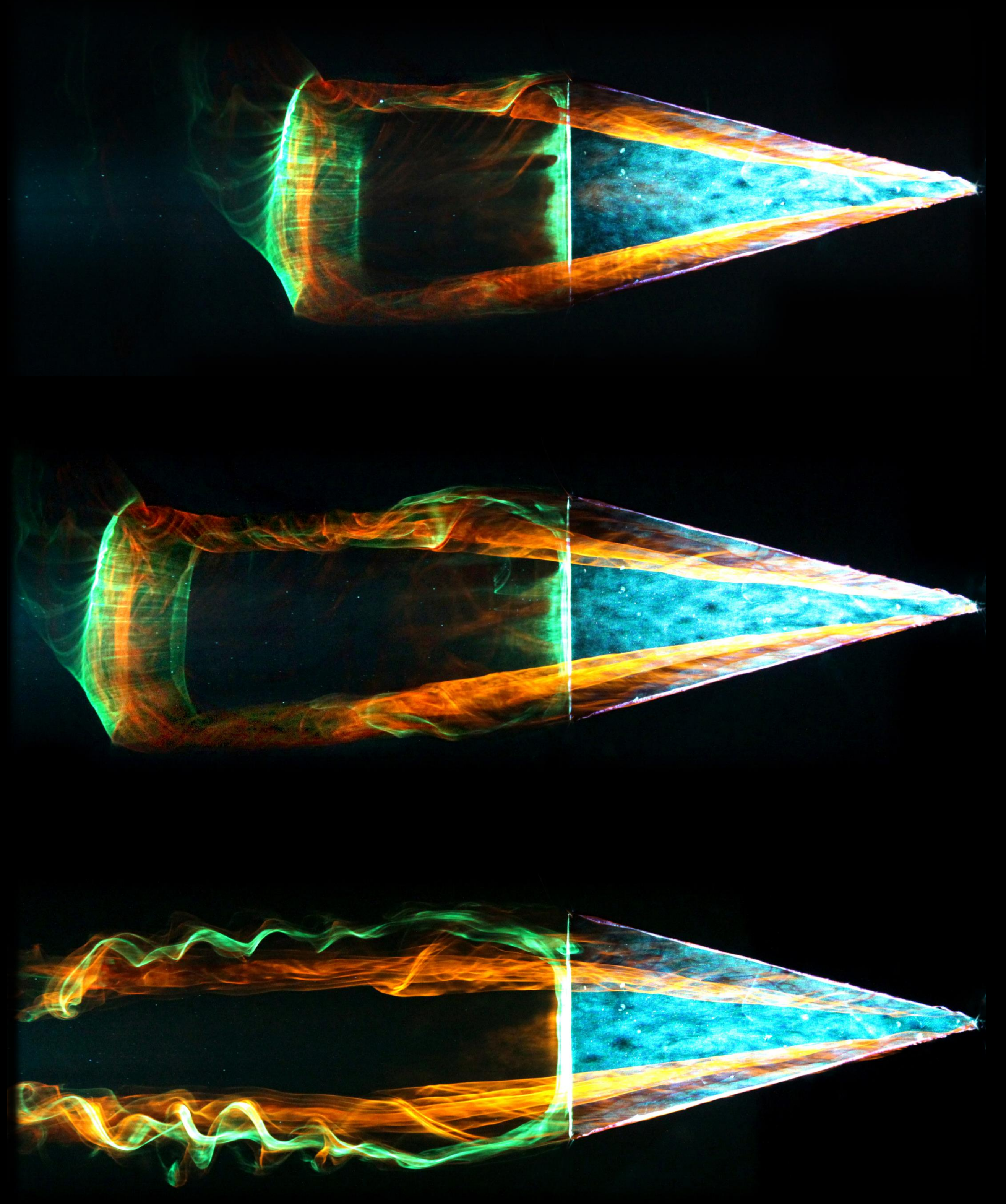
Understanding vortex-wall interactions has applications in fundamental turbulence, as well as being of interest in the context of airplane trailing vortices. In this work, a delta wing is towed in an XY-Towing Tank, generating a spatially developing vortex pair with streamwise (axial) flow in the vortex core. Although seemingly simple, counter-rotating vortex pairs can produce complex three-dimensional dynamics. Vortex pairs out of ground effect can become unstable to a long-wave (Crow 1970) instability, wherein each vortex tube initially bends in a sinusoidal fashion, growing in amplitude until the vortices reconnect into a series of descending vortex rings. Figure 1 shows the development of the Crow instability in the far-wake of the delta wing more than 20 chord-lengths downstream of the trailing edge. For our delta wing of span = 6cm, this equates to over 2m downstream! The vortex pair is made visible by painting the delta wing with **fluorescein dye** prior to the experiment, and illuminating the flow with an argon ion laser.

Figure 2 shows a plan view of the starting vortex behind the delta wing. **Fluorescein dye** is applied to the trailing edge, and **rhodamine dye** is applied to the apex. The top and bottom surfaces are left untouched. As the wing reaches its steady state velocity, the **fluorescein dye** originating from the trailing edge wraps around the vortex core, which is made visible by the **rhodamine dye**.



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The delta wing is shown in side view in figure 3. A braid wake (Miller & Williamson 1995) forms behind the trailing edge in the form of a von Kármán vortex street, marked by the **fluorescein dye**. The braid wake matches the wavelength of the structure wrapping around the **rhodamine dye** vortex core.

When the vortex pair impinges on a wall, the boundary layer that forms on the surface between the vortices and the wall separates, generating secondary vorticity and causing the primary vortex pair to 'rebound'. Vorticity isocontours generated from particle image velocimetry (PIV) data show the spatial generation of secondary vorticity in figure 4. A primary vortex (e.g. **P_1**) with **clockwise** signed vorticity will generate a secondary vortex (e.g. **S_1**) with **counter-clockwise** rotation, and vice versa. The initial generation of secondary vorticity is observed at the very surface of the wall; in the far-wake, the secondary vortex is seen to roll up around the primary vortices. Figure 5 shows a vortex pair in ground effect. **Fluorescein dye** from the trailing edge has wrapped around the vortex core (**rhodamine dye**) and no longer has a defined structure. We measure the axial flow in the vortex core more than 20 chord-lengths downstream of the trailing edge, and find it to be a Gaussian velocity profile, the shape of which is a function of time (distance downstream).

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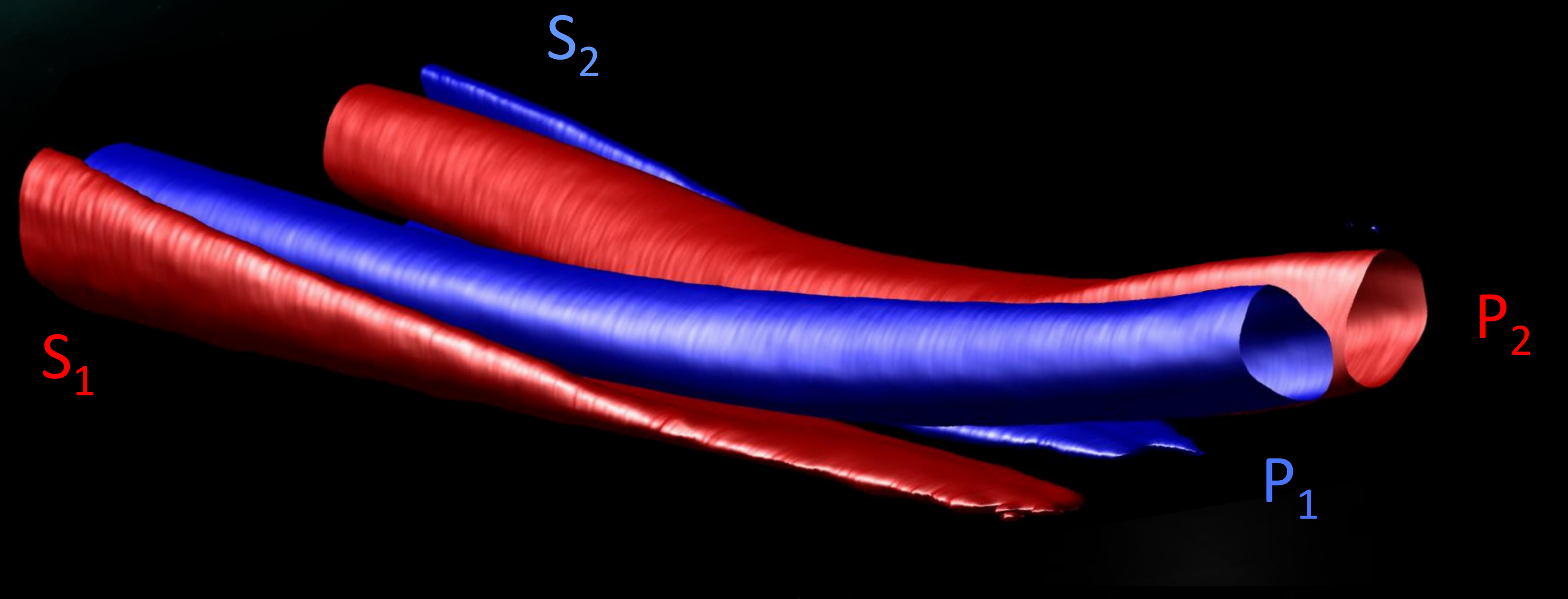

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