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Modelling leading edge vortices on finite wings with low order methods

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Abstract

Leading edge vortices (LEVs) form when separation occurs at the leading edge of a wing. The resulting shear layer rolls up on itself creating a large vortex. Consequently, it results in significant loads on the wing.

Nature makes extensive use of LEVs. They're central to insect flight, the low speed flight of birds and the manoeuvring of aquatic organisms. Humanity is still playing catch-up.

Headway has been made for 2D problems. Potential flow models can be augmented with LEV shedding criteria which account for aerodynamic non-linearities. Whilst this is still a very active research area, robust methods exist which have good accuracy. They provide a viable alternative to computational fluid dynamics (CFD).

However, for practical purposes finite wings are of vital importance. The LEVs that form on finite wings have internal spanwise flow and interact with the wing's tip vortex. Their 3D nature is believed to be important in the way nature applies them.

Again, CFD can be used, but 3D problems typically require high performance compute resources. This stifles the abilities of engineers to design and optimize, and rules out real-time and control system uses altogether. The creation of a low computational cost model capable of modelling LEVs on finite wings would be valuable for engineers designing both wind and tidal turbines, oscillating energy harvesting mechanisms, flexible aeroplanes, and micro air vehicles.

This paper aims to investigate low-order methods for modelling LEVs on finite wings.