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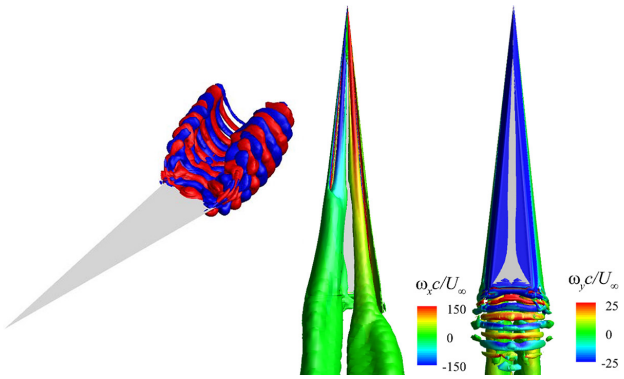
Studies of the physical nature of vortex flow asymmetries around supersonic aircraft wings inform new suggestions for controlling flow, thereby improving plane aerodynamic characteristics.



Vortex flow fields over the slender delta wings of supersonic aircrafts influence aerodynamic performance, especially during landing and takeoff when flow is at a high angle of attack. Vortex pairs can become time-averaged asymmetric over slender wings at high angles of attack, but the cause of this asymmetry is still unclear. Natural perturbations, or microbumps, occur on the apex of wings due to machining tolerance, and Luo et al. used numerical simulations and experimental measures to consider if such a microperturbation is responsible for symmetry breaking.

The vortex flow was initially considered over a perfectly symmetric model in large-eddy simulations, calculated based on full 3-D incompressible Navier-Stokes equations. The simulations showed that with a perfect model no asymmetries were long-lived; however, introduction of an apex microperturbation caused spatial growth of local disturbances. The authors confirmed these spatial instabilities in experiments, where they placed an aluminum wing with an artificial apex perturbation in a closed loop water tunnel.

The numerical and experimental data revealed that apex perturbations cause local time-averaged vortex flow asymmetries, but the team went further to examine unsteady aspects of the flow before vortex breakdown. To study the ordinary global oscillatory flow, they applied dynamic mode decomposition to the entire flow field. Periodic fluctuations in flow oscillations significantly contributed to variations in aerodynamic forces and moments.

“Based on these findings, we will seek some control measures, for example, using apex perturbations, to control the flow field around the delta wing,” said co-author Bao-Feng Ma, who hopes that steadying vortex flow will improve the aerodynamic performance of supersonic aircraft.

Source: “Time-averaged asymmetries and oscillatory global modes of vortex flows over a slender wing,” by Heng Luo and Bao-Feng Ma, *Physics of Fluids* (2018). The article can be accessed at https://doi.org/10.1063/1.5040571.