Aerodynamic Instabilities on Small Scale Wings

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Despite much research effort, the aerodynamics of small-scale flight systems, such as birds and hand-held model airplanes, are still poorly understood. For an important class of these systems, the chord Reynolds number, which measures the ratio of the inertial forces to the viscous forces, lies in the range of $10^4 – 10^5$ where the flow is very sensitive to the boundary conditions, such as airfoil shape, surface roughness, and freestream turbulence. Laboratory experiments are difficult to perform and to repeat from facility to facility. Numerical simulations that correctly resolve the boundary layer and the time and space scales of its instabilities are very expensive and almost never performed. A series of careful measurements in a low turbulence wind tunnel has been conducted at chord Reynolds numbers of $1 \& 2 \times 10^4$. Force balance and flow field measurements were made for both 2D and aspect ratio 6 rectangular planform wings. The results demonstrate the sensitivity of aerodynamic performance to airfoil shape and confirm that thin plates perform better than smooth airfoils. Comparisons between laboratory data and numerical experiment were made and similarities and differences will be discussed. The characteristic instability frequencies indicate how future control strategies can be designed.