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Wakes behind wings (I & II)

A lifting surface (wing) moving through a fluid sheds a vortex sheet into its wake, which rolls up into a set of concentrated vortices persisting for a relatively long time after the passage of the wing. We will first recall a few basic ingredients of vortex dynamics, such as self-induced motion and mutual induction and deformation of vortices, which determine the formation and further evolution of the wing wake vortex system. We then present a review of vortex phenomena and instabilities observed to occur in these flows. They include: vortex merging, vortex meandering, long-, medium- and short-wavelength instabilities, and vortex reconnection. Most examples will deal with the wake of fixed wings consisting initially of two or more rectilinear parallel vortices. Some elements concerning the wakes of rotating wings (helicopter or wind turbine rotors), made up of helical vortices, will also be addressed. For a helicopter in steep descent, the rotor wake is known to undergo a transition to a so-called Vortex Ring State, causing a potentially hazardous unsteadiness and loss of lift. Recent results concerning a vortex pairing instability in helical wakes will be presented, which may shed some light on the physical origin of this transition.

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