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"Aspects of Near Wall Adjoint Fluid Flow"

The presentation is concerned with near wall Navier-Stokes flow from an adjoint perspective. The talk focuses on two aspects.

First, a continuous adjoint complement to two-dimensional, incompressible, first-order boundary-layer equations for a flat plate boundary-layer is presented. Subsequently, similarity parameters are derived, which turn the Partial-Differential-Equation (PDE) problem into a boundary value problem described by a set of Ordinary-Differential-Equations (ODE) and support the formulation of an adjoint complement to the classical Blasius equation. It is shown, that the advective fluxes, which are frequently debated in the literature, vanish for the investigated self-similar b.l. flows and an analytical expression for the shape sensitivity to shear driven drag objectives can be derived.

The second part is devoted to an adjoint complement to the universal Law of the Wall (LoW) for fluid dynamic momentum boundary layers which typically follows from a strongly simplified, unidirectional shear flow under a constant stress assumption. The adjoint companion of the simplified momentum equation is derived. Using mixing-length arguments, it is demonstrated that the frozen turbulence strategy and a LoW-consistent (differentiated) approach provide virtually the same adjoint momentum equations, that differ only in a single scalar coefficient controlling the inclination in the logarithmic region.

Numerical results for primal/adjoint Navier-Stokes simulations verify the predictive agreement between the different Blasius and LoW solutions. The talk closes with the presentation of shape optimization applications that refer to two- and three-dimensional shape optimizations of internal and external engineering flows.