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Nonlinear models for the indicial force response on an airfoil in unsteady conditions SCOTT DAWSON, Illinois Institute of Technology, STEVEN BRUNTON, University of Washington — This work presents a methodology for modeling the transient response in lift on an airfoil subject to a sudden change in conditions, for both idealized and more realistic flows. For idealized flows, from classical unsteady aerodynamic theory the response of an airfoils lift subject to a change in angle of attack or freestream velocity is encapsulated by the Wagner function. While this function is well known, an explicit expression is difficult to obtain, as its formulation requires the computation of an inverse Laplace transform (or similar inversion) of a non-rational function. This has led to numerous proposed approximations to the Wagner function (or equivalently, to the Theodorsen function), which facilitate convenient and rapid computation. While these approximations are sufficient for many applications, common linear approximations do not capture the correct asymptotic behavior over large time horizons. We show that the Wagner function is more naturally approximated by the response of a nonlinear scalar ordinary differential equation, which can be identified through sparsity-promoting identification methods. We also show that this methodology can be applied to model the lift response for more realistic aerodynamic flows, incorporating nonplanar wakes and viscous effects.

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