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A realistic model of a wall-transpiration actuator for boundary layer control[1] NILS TILTON, LUCA CORTELEZZI, McGill University — Experimental studies of boundary layer control using continuously distributed wall-suction usually implement suction by applying a pressure gradient to a layer of porous material via an underlying plenum chamber. Theoretical studies, however, usually neglect the penetration of fluid into the porous layer and plenum chamber by forcing the base flow and velocity perturbations to vanish at the interface with the porous layer. We present a realistic model of a wall-transpiration actuator which implements suction through a fluid saturated, rigid, homogeneous, isotropic, porous layer stretched over a semi-infinite plenum chamber. We test our model on the asymptotic suction boundary layer (ASBL) and perform a linear stability analysis. We take account of the full coupling between the flow fields in the boundary layer, porous layer, and plenum chamber using boundary conditions derived by Ochoa-Tapia and Whitaker (Int. J. Heat Mass Transfer, Vol. 38, 1995, pp 2635-2646). We illustrate the impact of wall-permeability, porous layer thickness, and the plenum chamber on the critical Reynolds number and the stability of the Tollmien-Schlichting wave. We use our model to find the optimal operating conditions of an ASBL which minimize the skin friction drag and power required to apply the suction.

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Luca Cortelezzi
McGill University

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