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Linear Stability Analysis of a Channel Flow with Porous Walls

NILS TILTON, LUCA CORTELEZZI, McGill University — This study is motivated by the extensive use of wall-transpiration in numerical studies related to inhibition and control of wall-turbulence. In general, wall-transpiration has been implemented by providing the wall-normal velocity and imposing a no-slip condition on the wall-tangential velocity. Physically, however, the pores cannot be infinitesimally small and, consequently, it is important to address how the presence of the pores affects the slip velocity at the wall and the stability of the boundary layer. Moreover, our work is motivated by the existence of only few studies on the linear stability of channels with porous walls. Our study considers a parallel-plate channel with porous walls such that a longitudinal pressure gradient induces a laminar flow in both the open channel region and the porous walls. Simplified counterparts to the Orr-Sommerfeld and Squire equations are derived for the porous regions that are valid for small permeablities. The linear stability analysis takes account of the coupling between the three disturbance fields through boundary conditions recently derived by Ochoa-Tapia and Whitaker (Int. J. Heat Mass Transfer, Vol. 38, 1995, pp 2635-2646). The resulting Orr-Sommerfeld spectrum and eigenfunctions reduce to those for Poiseuille flow as the permeability of the walls tends to zero, but are altered for greater values. We discuss symmetrical flows where parameters at both porous walls are identical as well as skewed flows where parameters at the two walls differ.

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