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Competing disturbance amplification mechanisms in two-fluid boundary layers SANDEEP SAHA, IIT Kharagpur, JACOB PAGE, Imperial College London, TAMER ZAKI, John Hopkins University — The linear stability of boundary layers above a thin wall film of lower viscosity is analyzed. Appropriate choice of the film thickness and viscosity excludes the possibility of interfacial instabilities. Transient amplification of disturbances is therefore the relevant destabilizing influence, and can take place via three different mechanisms in the two-fluid configuration. Each is examined in detail by solving an initial value problem whose initial condition comprises a pair of appropriately chosen eigenmodes from the discrete, continuous and interface modes. Two regimes are driven by the lift-up mechanism: (i) The response to a streamwise vortex and (ii) the normal vorticity generated by a stable Tollmien-Schlichting wave. Both are damped due to the film. The third regime is associated with the wall-normal vorticity that is generated by the interface displacement. It can lead to appreciable streamwise velocity disturbances in the near-wall region at relatively low viscosity ratios. The results demonstrate that a wall film can stabilize the early linear stages of boundary-layer transition, and explain the observations from the recent nonlinear direct numerical simulations of this configuration by Jung & Zaki (J. Fluid Mech., vol 772, 2015, 330-360).

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