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Spectrum of Blasius-flow instabilities excited by thermal noise

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Abstract

The commonly accepted description of spatial transition to turbulence in a convectively unstable boundary layer involves as one of its stages the permanent excitation of instabilities by external noise (receptivity).
The idea that thermal fluctuations of microscopic origin provide a sufficient amount of permanent noise to play a role in this process has made only scant and isolated appearances in the literature. Yet, the contribution of thermal noise to receptivity has its amplitude determined from physical first principles; it provides the lower bound beyond which disturbances cannot be reduced (and the upper bound beyond which transition cannot be delayed) lest thermodynamics is violated.
As it is also not significantly harder to compute than a typical N-factor plot, thermal-noise receptivity can be adopted as a standard against which to compare other forms of receptivity through a noise figure analogous to the one that is of commonplace use in electronics. Elaborating on previous computations of the effect of thermal noise upon the two dimensional boundary layer past a flat plate, it is shown by a few real-world examples that the receptivity to thermal noise of the crossflow boundary layer over a swept wing is even larger, and by a substantial amount.

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