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Kelvin-Helmholtz-like instability of turbulent flows over riblets[1]

RICARDO GARCÍA-MAYORAL, JAVIER JIMÉNEZ, U. Politecnica Madrid and CTR Stanford — The turbulent drag reduction due to riblets is a function of their size and, for different configurations, collapses well with a length scale $l_g^+ = (A_g^+)^{1/2}$, based in the groove cross-section A_g. The initially linear drag reduction breaks down for $l_g^+ \approx 11$, which agrees in our DNS with the previously reported appearance of quasi-two-dimensional spanwise rollers immediately above the riblets. They are similar to those found over porous surfaces and plant canopies, and can be traced to a Kelvin-Helmholtz-like instability associated with the relaxation of the impermeability condition for the wall-normal velocity. The extra Reynolds stress associated with them accounts quantitatively for the drag degradation. An inviscid model for the instability confirms its nature, agreeing well with the observed perturbation wavelengths and shapes. The onset of the instability is determined by a length scale L_w^+ that, for conventional riblet geometries, is proportional to l_g^+. The instability onset, $L_w^+ \geq 4$, corresponds to the empirical breakdown point $l_g^+ \approx 11$.

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