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Hydro-acoustic instabilities in compressible turbulent channel flow with porous walls CARLO SCALO[1], IMAN RAHBARI[2], Purdue University — C. Scalo, J. Bodart, and S. K. Lele, Phys. Fluids (2015) manipulated wall-bounded compressible turbulence by applying impedance boundary conditions (IBC) acoustically tuned to the characteristic time scale of the large-scale eddies. Near-wall turbulence was overhauled by hydro-acoustic instabilities – comprised of coherent spanwise Kelvin-Helmholtz rollers driven by Helmholtz-like acoustic resonance – while outer-layer turbulence was left structurally unaltered. We discuss linear modeling results of the observed flow response, supported by new high-fidelity simulations up to transonic bulk Mach numbers. For IBCs with zero reactance, corresponding to a Darcy-like formulation for porous walls, two dominant modes are identified whose Reynolds stress distributions overlap with the impermeable-wall turbulent buffer layer, directly affecting the near-wall turbulence cycle. For the range of wavenumbers investigated, the transition from subcritical to supercritical permeability does not significantly alter the structure of the unstable modes, showing that wall-permeability accentuates pre-existing, otherwise stable, modes. Implications on flow control strategies for compressible boundary layers over porous walls are discussed.

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