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Analysis of vortical structures in highly compressible turbulent boundary layers[1] MATTEO BERNARDINI, SERGIO PIROZZOLI, FRANCESCO GRASSO, University of Rome "La Sapienza" — The coherent vortical structures in spatially developing supersonic turbulent boundary layers are analyzed by means of direct numerical simulation of the compressible Navier-Stokes equations. Three Mach numbers, M=2,4,6 are investigated to get some insight into the effect of flow compressibility on the size, orientation, and strength of the structures. To capture even the finest scale structures a very small grid spacing is used, corresponding to 4.5 wall units both in the streamwise and the spanwise directions. For all test conditions the same qualitative behavior is observed: consistent with incompressible dynamics, the near-wall layer is found to consist of quasi-streamise vortices strongly associated with meandering, low-speed streaks. In the outer layer, the vortex orientation statistics are consistent with the occurrence (at least in statistical sense) of ring-like vortices oriented at a shallow angle with respect to the wall plane. Good scaling of the vortex with wall properties is observed, even for the stronger Mach numbers. The analysis of the dilatation field show the onset of turbulence shocklets starting at M=4. Shocklets are found to be more intense in the very-near wall region, and to be statistically associated with sweeps of high-momentum fluid towards the wall.

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