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Spectral Behavior of Weakly Compressible Aero-Optical Distortions[1] EDWIN MATHEWS, KAN WANG, MENG WANG, ERIC JUMPER, University of Notre Dame — In classical theories of optical distortions by atmospheric turbulence, an appropriate and key assumption is that index-of-refraction variations are dominated by fluctuations in temperature and the effects of turbulent pressure fluctuations are negligible. This assumption is, however, not generally valid for aero-optical distortions caused by turbulent flow over an optical aperture, where both temperature and pressures fluctuations may contribute significantly to the index-of-refraction fluctuations. A general expression for weak fluctuations in refractive index is derived using the ideal gas law and Gladstone-Dale relation and applied to describe the spectral behavior of aero-optical distortions. Large-eddy simulations of weakly compressible, temporally evolving shear layers are then used to verify the theoretical results. Computational results support theoretical findings and confirm that if the log slope of the 1-D density spectrum in the inertial range is $-m_\rho$, the optical phase distortion spectral slope is given by $-(m_\rho+1)$. The value of m_ρ is then shown to be dependent on the ratio of shear-layer free-stream densities and bounded by the spectral slopes of temperature and pressure fluctuations.

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