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Acoustics of Low Mach Number Nozzles with Area Expansions

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The acoustic wave equation for quasi–one–dimensional propagation is obtained, along a cylindrical duct with a significant area expansion and containing a low Mach number mean flow. The motivation is the study of the reflection in cross-sectional expanding area. The ray approximation, which holds only for wavelengths which are short compared with the length scales of the variation of the cross-section and mean flow velocity, is used as a factor to reduce the wave equation to a Schrodinger form, in a nozzle with a hyperbolic tangent expansion. The exact solutions are obtained, without restriction, as power series solutions around the middle of the duct; since this solution fails to converge at the two ends of the duct it is matched to the other solutions there, by application of the causality principle. In this way it is possible to calculate everywhere the pressure and velocity perturbation profiles, for both the transmitted and reflected waves, as well as the reflection and transmission coefficients. These are plotted as a function of the longitudinal coordinates along the duct for several values of the three dimensionless parameters in the problem, *viz.* (*i*) the area expansion ratio , *ii*) the Mach number of the mean flow at the central section and *iii*) the wavenumber.