DIRECT MEASUREMENT OF A GREEN'S FUNCTION SUITABLE FOR PREDICTION OF SUBSONIC JET NOISE

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INTRODUCTORY REMARKS

An analytical formulation of a suitable Green's function has eluded jet noise researches to date. This paper explores the possibility of direct measurement of a Green's function. To this end a point source is placed in the jet flow and the amplitude and phase of radiated signal are extracted. In principle, this information leads to a semi-empirical model Green's function.

JET NOISE REFRACTION (SHIELDING)

Lighthill's acoustic analogy[1,2] yields less than satisfactory predictions when source and fluid motion are not accounted for. Whereas source motion can be dealt without great difficulty[3,4,5], the interaction of the acoustic field and the hydrodynamic field poses far greater challenges. The influence of flow and temperature gradients on sound was demonstrated by a rather elegant set of experiments, wherein a small point source, emitting a single tone, was placed in a jet flow[6,7]. Schubert[8], Mani[9], Lilley[10], Balsa[11], and others have added their perspectives on refraction (or fluid shielding) effects.

GREEN'S FUNCTION FOR JET FLOWS

Ribner[12] described a 'road-map' for dealing with all the key features of jet noise including source convection and refraction by flow and temperature gradients, but no explicit solution was provided. It is assumed that the Green's function $G(x-y,t-t',M) = G_N\, Go(x-y,t-t')$ is the product of G_N, the normalized Green's function and Go the free field Green's function (M=0). GN is measured for discrete frequencies, at it is possible to determine both amplitude and phase quite accurately using a lock-in amplifier technique.

For discrete frequencies $G_N = |G_N|e^{i\delta\phi}$ applies. $|G_N|$ is expected to be less than one whenever the field point x subtends a small angle with respect to the jet axis, At right angles to the jet axis the numerical value should tend to unity and the phase angle $\delta\phi$ to zero. There is no reason to expect that the normalized Green's function is invariant with the source location **y**. Both source location in the jet as well as the source-observer vector are parameters. (viz. $G_N(\mathbf{y},\mathbf{x}-\mathbf{y},\omega)$).

PRELIMINARY RESULTS

Measurements were performed in the anechoic room at the University of Toronto Institute for Aerospace Studies. A 'point source' was placed in the flow of a 1.9 cm diameter model air-jet. The radiated sound was measured by a condenser microphone mounted on a boom which is centered on the jet exit[13].

Measured values of $|G_N|$ are shown in figure 1. Figure 2 illustrates the phase shift induced by the flow. The effects is quite small at low Mach numbers, but become more significant at moderate Mach numbers (M = 0.28).

CONCLUDING REMARKS

A means of obtaining a Green's function appropriate for sound radiated from subsonic jet flows has described. The data available to date is not sufficient to permit one to deduce an appropriate empirical model.

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Figure 1. Measured Normalized Green's Function |GN|, y/D=6,r/D=0.5

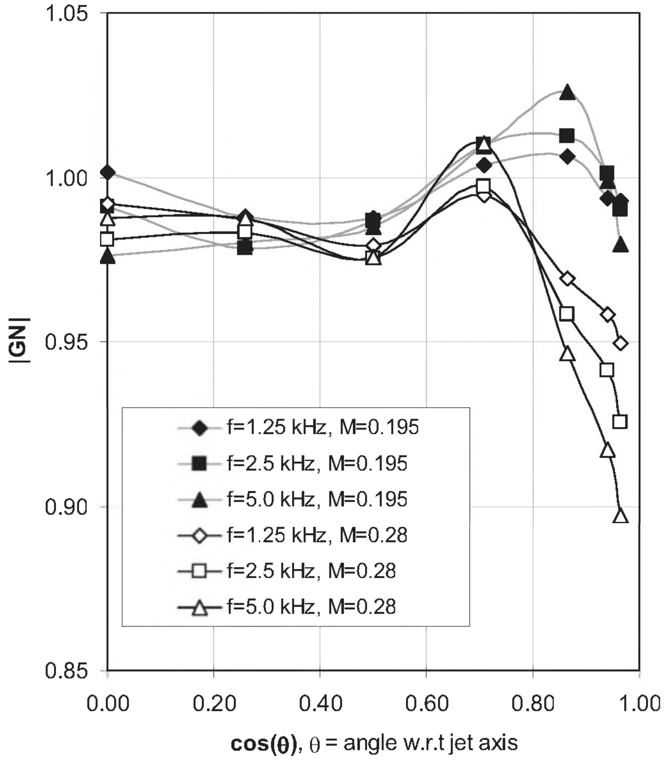

Figure 2. Measured Phase Shift (δϕ) y1/D=6, y2/D=0.5, R/D=60