

X. PHYSICAL ACOUSTICS

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Our research in acoustics is focused on noise generation by turbulent flow, and interaction of sound with flow and structures, with particular emphasis on acoustically induced flow instabilities and structural instabilities. Specifically, we are investigating analytically and experimentally interaction of jet noise with acoustical modes in ducts, and acoustically induced instabilities of control valves.

1. EFFECT OF FLOW ON THE ACOUSTIC RESONANCES OF AN OPEN-ENDED DUCT

Uno Ingard, Vijay K. Singhal

We have analyzed the effect of flow on the acoustic resonances of an open-ended, hard-walled duct. The flow produces acoustic losses both in the interior of the duct and at the ends. Unless the duct is very long, typically 100 times the diameter, the losses at the ends dominate. At flow Mach numbers in excess of 0.4 the losses are so large that axial duct resonances are almost completely suppressed. The plane wave Green's function for the duct with flow is expressed in terms of the (experimentally determined) pressure reflection coefficients at the ends of the duct, and the flow dependence of the complex eigenfrequencies of the duct is obtained. Some observations concerning the noise produced by the flow in the duct have been reported.¹

2. FLOW EXCITATION AND NONLINEAR COUPLING OF ACOUSTIC MODES IN A SIDE BRANCH CAVITY IN A DUCT

Uno Ingard, Vijay K. Singhal

For the first time we have observed nonlinear coupling of acoustic modes in side branch cavities in ducts excited acoustically by flow. As part of a broader study of flow noise in ducts, we have investigated the excitation by flow of the acoustic modes of a side branch cavity in a duct. Under certain conditions, we found evidence of coupling between the different cavity modes and the axial modes of the main duct. A paper on this work is being prepared for publication in the Journal of the Acoustical Society of America.

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3. A NEW APPROACH TO ACOUSTIC FILTERING WITH LINED DUCTS

Uno Ingard, William P. Patrick

In a different area, we have devised a new method of acoustic filtering at low frequencies. We consider a lined duct divided into two parallel branches by means of a rigid partition. The phase speed of the fundamental mode in each branch depends on the liner configuration and can differ markedly from the free-space phase speed. If the liners in the two branches are not the same, the corresponding phase speeds will be different and a relative phase lag between the waves in the two branches results. This, in turn, leads to interference between these wave components (and their reflections) both at the exit and the entrance of the parallel branch pair. We have demonstrated both analytically and experimentally that this interference can be exploited for the purpose of obtaining a low-frequency attenuation which is substantially larger than the attenuation of the unpartitioned duct. A paper on this subject was presented at the Acoustical Society of America Meeting, in San Francisco, November 1975.² We are now preparing this paper for publication in the Journal of the Acoustical Society of America.

References

1. U. Ingard and V. K. Singhal, "The Effect of Flow on the Acoustic Resonances of an Open-Ended Duct," J. Acoust. Soc. Am. 58, 788-793 (1975).
2. U. Ingard and W. P. Patrick, "A New Approach to Acoustic Filtering with Lined Ducts," J. Acoust. Soc. Am. 58, Supplement No. 1, p. S6 (1975).