DLR's Laser Sound Source, a Status Review

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Because of the growing interest in noise abatement through the shielding of aircraft component noise (including engine noise), there has been, in the past few years, an increased necessity for the development of appropriate evaluation methodologies for the shielding properties of new aircraft designs. Progress in this domain is necessary to develop technologies which allow the accurate prediction of the noise reduction potential of an aircraft design. Part of DLR's effort, in this respect, is focused on the development and application of a laser-generated reference sound source. While most applications of this type of sound source deal with very high intensity, non-linear, shock-like phenomena, here the focus is on generating an isentropic sound source as a valuable tool to realize dedicated shielding experiments in a non-intrusive manner. Due to its small size, its non-intrusiveness and its monopole character, the laser source is also very well suited for the assessment of sensors transfer function in a wind tunnel environment. Its application in hybrid anechoic wind tunnels also provides appealing prospects.

The laser sound source was shown to display the characteristics of a moving monopole i.e. a sound source convecting with the surrounding medium [1]. Experimental evidences presented revealing that the laser sound source displays, in fact, the characteristics of a moving monopole i.e. a sound source convecting with the surrounding medium are presented. A solution to the convected wave equation for a moving point heat source in a uniform subsonic flow is derived, providing i) means for an appropriate scaling of experimental results and ii) an appropriate closed-form sound source easily reproducible in numerical simulations.

In order to establish a sound aeroacoustic shielding database for a firsthand validation of acoustic prediction codes, a set of interrelated aeroacoustic shielding tests were planned and executed [2]. The emphasis was put on an extensive 2D diffraction study of NACA 0012 airfoil. These studies laid the groundwork for which the characterization of acoustic shielding properties of actual aircraft geometries was done. The 2D shielding tests presented herein were conducted in DLR's Acoustic Wind Tunnel Braunschweig (AWB), ONERA's F2 Low-Speed Wind Tunnel and NASA's Quiet Flow Facility (QFF)[3] for nominally the same test conditions in order to learn about the measurement scatter across different facilities. A major objective of this study was to determine how consistent the measured data would be across the three facilities, since each has a different test section configuration. The AWB and QFF have, respectively, a fully open and partially open test section, while the F2 tunnel has a closed hard-wall test-section.

The aim of this oral presentation is thus to give an overview of the current development status of the laser sound source methodology developed at DLR. Aspects of numerical and experimental realizations as well as analytical representation will be discussed. The content of this oral contribution was already, in part, presented at the 21st and 24th AIAA/CEAS Aeroacoustics Conferences [1][2] and at the STAB symposium 2018 [4].

References

[1] Rossignol, K.-S., Delfs, J. W. and Boden, F. "On the Relevance of Convection Effects for a Laser-Generated Sound Source", 21st AIAA/CEAS Aeroacoustics Conference, AIAA Aviation Forum (AIAA-2015-3146), Dallas, TX, USA, https://doi.org/10.2514/6.2015-3146

[2] Rossignol, K.-S., Delfs J. W., Gély, D., Bulté, J. and Hutcheson, F. "Experimental Investigations on Noise Shielding: Dependency on Reference Noise Source and Testing Environment", 24th AIAA/CEAS Aeroacoustics Conference, AIAA Aviation Forum, (AIAA-2018-2820), Atlanta, GA, USA, https://doi.org/10.2514/6.2018-2820

[3] Hutcheson, F. V., Bahr, C. J., Thomas, R. H. and Stead D. J. "Experimental Study of Noise Shielding by a NACA 0012 Airfoil" (AIAA-2018-2821), Atlanta, GA, USA, https://doi.org/10.2514/6.2018-2821

[4] J. Delfs, M. Mößner, and K.-S. Rossignol, "Influence of flow on noise shielding", STAB congress, Darmstadt, Germany, October 2018