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Near-field scattering of ducted fan noise using a boundary element method

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The noise emitted by rotating machinery is a concern in many applications, such as aeroengines, wind turbines, and cooling devices for IC engines or electronic appliances. A specific derivation of the Ffowcs Williams and Hawkings analogy for the tonal noise emitted by a fan was presented by Goldstein (1976), under the assumption that the listener is placed in the acoustical and geometrical far field. That formulation accounts for the modulation of the Doppler frequency shift during the fan revolution, but neglects near field effects. This work presents the application of an alternative derivation, introduced by Roger (2007), which preserves the near-field features of the sound field. This analytical method is compared with a second method in which the fan is modelled by a fixed azimuthal distribution of dipoles. A validation is performed for the case of a generic fan located in an infinite circular duct. The sound field within the duct is obtained by two means: i) calculating the sound field emitted by the fan, modelled by the above mentionned approaches, and scattered by the duct through the application of a Boundary Element Method, ii) computing the sound field by projecting the source in the duct modes.