Towards Large-Scale Boundary Element Simulations for Viscothermal Acoustics

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For frequency-domain analysis of acoustics in inviscid fluids the Helmholtz equation is solved in a discretized manner. Fluids, however, are not inviscid but suffer from viscous and thermal dissipation. These viscothermal losses form primarily in the transition region between the fluid and its solid skeleton – the acoustic boundary layers – and affect the sound propagation behavior in such. Including the losses proves necessary in structures with acoustic cavities of similar size as the boundary region. Recent advances focus on incorporating the viscosity- and temperature-related effects in acoustic boundary element methods (BEM). While limiting the discretization process to the domain boundary requires significantly fewer degrees of freedom than equivalent finite element approaches it also causes fully populated coefficient matrices that pose a high computational burden for handling large-scale applications. This work proposes a revised BEM formulation that makes use of the Schur complement and approximation techniques such as the fast multipole method to lower the computational costs. We demonstrate that the fast viscothermal BEM is capable of improving the algorithmic complexity, both in terms of runtime and storage requirements. The results show good performance of the method indicating its usability for applications of practical relevance.

Keywords: Boundary Element Method; Fast Multipole Method; Schur Complement; Viscous and Thermal Losses.

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