# The 12th International Conference on Theoretical and Computational Acoustics

## ICTCA 2015

## Hangzhou, Zhejiang, China

## October 11–16

## Program and Book of Abstracts

interest area increases, and almost increases as the frequency increases. And the room mode characteristics cause the truncation error fluctuating. In the low frequency, acoustic modes of room influence the fluctuation error magnitudes considerably largely than that in the high frequency. In the high frequency, more activated acoustic modes achieve more flat frequency responses,which results amplitudes of fluctuation reduced.

## A hierarchical boundary element method based on multipole expansion of Green's function for acoustic problems

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The matrices of boundary element method (BEM) are fully dense and even populated which require special techniques for the efficient treatment in order to extent its ability of handling large-scale problems. Hierarchical matrix ($\mathcal{H}$-matrix) is one of the popular matrix compression techniques which can be applied to improve the performance of boundary element method (BEM). Adaptive cross-approximation(ACA) is a widely adopted algorithm to obtain the $\mathcal{H}$-matrix, which is a purely algebraic approach. ACA needs a general iteration process to form low- ranked matrix based on the assumption that the kernel is degenerate and asymptotically smooth. In this paper, a $\mathcal{H}$-matrix by exploring the explicit multiple expansion of the kernel isdeveloped to build a fast BEM for large-scale acoustic problems. In the proposed approach, the rank of sub-matrix is predictable based on an oct-tree structure of the model, thus can speed up achievement of low-rank representation of the matrix. The proposed $\mathcal{H}$-matrix is applied in conjunction with an iterative solver, GMRES, to solve large-scale acoustic problems. Numerical examples demonstrate that theproposed algorithm is more robust even for some cases ACA may fail or not be efficient in the iterative searching for the low-ranked representation of a matrix. Accuracy, ratios of speedup as well as memory reduction are investigated to illustrate the merits and potential of our approach for the analysis of large-scale acoustics problems.

## Non-exponential sound energy decay analysis of a monumental worship space by diffusion equation modeling in a finite element medium

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In this work, a finite-element framework involving particle diffusion theory is applied to a real-size monumental worship space for investigations of sound energy distributions and decays. The contribution of different volumetric and material attributes of the monument to its sound field are also investigated using in-situ acoustical measurements and geometrical acoustics (ray- tracing/ image sources) simulation methods. Relevant acoustical parameters including decay rates and decay times are computed by applying the Bayesian decay analysis. Initial results indicate double- or triple-slope decay characteristics for specific measurement configurations. In order to support and explain the probable reasons/mechanism of multiple decay formation as observed in such a single space enclosure, sound field of the monument is numerically assessed within finite-element framework by a diffusion equation model (DEM). Spatial energy density and flow vector analysis are conducted through the DEM solutions. Subsequently, field measurements using sound intensity probe are utilized to validate the DEM-based room-acoustic simulations. Results indicate good agreement for overall energy decay time estimations between the experimental field and the DEM results. The energy flow vector and energy distribution analysis indicate the upper central dome-structure to be the potential energy accumulation/ concentration zone, contributing to the later energy decays.

## Analysis of the influence on waveguide invariant by oceansediments in shallow water

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The influence on the waveguide invariant β from the geoacoustic parameters was analyzed in this paper. The waveguide invariant was then used to analyze the influence on the motion parameter estimation of the moving target usingvector hydrophone from different ocean sediments.
First, the theory of the waveguide invariant based on the sound pressure, vibration velocity and sound acoustic energy flow was analyzed, respectively; Then, the motion parameter estimation of the moving target was estimated from the waveguide invariant, which was calculated from the simulated time-frequency figure by using the image processing tools, just like the Hough transform. Further, the relation between parameters of nine typical ocean bottoms (density, sound speed and absorption coefficient) and the waveguide invariant was analyzed, which based on the shallow water waveguide. Finally, the relationship between the ocean sediment and motion