

Technical University of Denmark



## An Acoustic Hypersingular Boundary Element Formulation Including Viscous and Thermal Losses

Andersen, Peter Risby; Cutanda Henriquez, Vicente; Aage, Niels; Marburg, Steffen

*Publication date:*  
2017

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*

Andersen, P. R., Cutanda Henriquez, V., Aage, N., & Marburg, S. (2017). An Acoustic Hypersingular Boundary Element Formulation Including Viscous and Thermal Losses. Abstract from 13th International Conference on Theoretical and Computational Acoustics, Vienna, Austria.

### DTU Library

Technical Information Center of Denmark

---

#### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

ICTCA  
2017  
VIENNA

13th International  
Conference on  
Theoretical and  
Computational  
Acoustics

# Book of Abstracts

30. Juli - 03. August 2017



**Editors:**

Piotr Borejko  
Manfred Kaltenbacher  
Florian Toth

**Published by:**

Institute of Mechanics and Mechatronics, Faculty of Mechanical and Industrial Engineering  
Institute of Building Construction and Technology, Faculty of Civil Engineering  
TU Wien  
Vienna, Austria  
<http://ictca2017.conf.tuwien.ac.at>

**ISBN:**

978-3-200-05210-9

**Credits:**

Cover design: Ruth K. Tscherne  
L<sup>A</sup>T<sub>E</sub>X editors: F. Toth, C. Junger, S. Floss, S. Gombots, I. Lazarov, S. Schoder, F. Egner

Printed in Vienna by Druck & Medienwerk GmbH

July 2017

## An Acoustic Hypersingular Boundary Element Formulation Including Viscous and Thermal Losses

Peter Risby Andersen<sup>1</sup>, Vicente Cutanda Henríquez<sup>1</sup>, Niels Aage<sup>1</sup>, Steffen Marburg<sup>2</sup>

<sup>1</sup> Centre for Acoustic-Mechanical Micro Systems, Technical University of Denmark, Kgs. Lyngby, Denmark

<sup>2</sup>Vibroacoustics of Vehicles and Machines, Technical University of Munich, Garching b. München, Germany

To correctly estimate the behavior of small complex acoustic devices, the inclusion of viscous and thermal losses becomes necessary. Practically all domain losses in small setups take place in very thin layers near boundaries. Finite Element formulations including losses exist where boundary layers need to be properly discretized, adding to the computational cost [1]. On the other hand, meshing of boundary layers can be avoided by using the Boundary Element Method [2,3]. However, the existing Boundary Element formulation with losses relies on the use of tangential finite difference pressure derivatives, which might lead to computational difficulties at low frequencies where the element size is much smaller than the wavelength.

This work presents a new implementation of the acoustic Boundary Element Method with losses, where by means of an extra set of hypersingular tangential derivative Boundary Element equations, it is possible to avoid the use of the troublesome first and second finite difference pressure derivatives in the coupling of the fundamental equations. The new proposed formulation introduces, however, hypersingular integration kernels that require nodal  $C^1$  continuity [4]. These difficulties will be discussed and the new implementation will be evaluated through simple test cases.

### References

- [1] P. Risby Andersen, V. Cutanda Henríquez, N. Aage and S. Marburg, *Numerical Acoustic Models Including Viscous and Thermal losses: Review of Existing and New Methods*, Proc. DAGA 2017, 6-9 March 2017, Kiel, Germany.
- [2] V. Cutanda Henríquez and P. M. Juhl, *An axisymmetric boundary element formulation of sound wave propagation in fluids including viscous and thermal losses*, Journal of the Acoustical Society of America **134**(5) (2013), 3409–3418.
- [3] V. Cutanda Henríquez and P. M. Juhl, *Implementation of an acoustic 3D BEM with visco-thermal losses*, Proc. Internoise 2013, 15–18 September 2013, Innsbruck, Austria.
- [4] R. Gallego and A. E. Martínez-Castro, *Boundary integral equation for tangential derivative of flux in Laplace and Helmholtz equations*, International journal for numerical methods in engineering, **66** (2005), 334-363

Thursday, 11:15, **GM3** Vortmann Lecture Hall, Building BD