

A closed-form solution to estimate space-dependent parameters in heat and mass transport

Citation for published version (APA):

van Kampen, R. J. R., Das, A., Weiland, S., & van Berkel, M. (2021). *A closed-form solution to estimate space-dependent parameters in heat and mass transport*. Poster session presented at Physics@Veldhoven 2021, .

Document status and date:

Published: 19/01/2021

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

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 the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

A closed-form solution to estimate space-dependent parameters in heat and mass transport

R.J.R. van Kampen, A. Das, S. Weiland, M. van Berkel

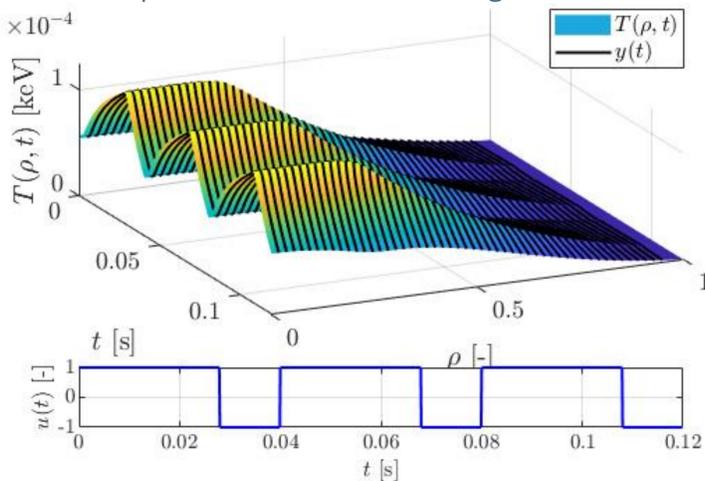
SCIENCE FOR FUTURE ENERGY

Introduction

Heat and mass transport are important for various problems [1-3]. We consider the partial differential equation (PDE) that governs heat and mass transport in a cylindrical geometry

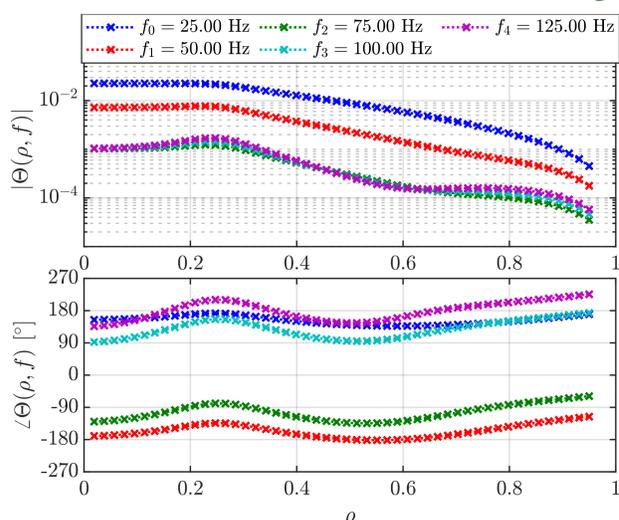
$$\frac{\partial T(\rho, t)}{\partial t} = \frac{1}{\rho} \frac{\partial}{\partial \rho} \left(\rho D(\rho) \frac{\partial T(\rho, t)}{\partial \rho} + \rho V(\rho) T(\rho, t) \right) + P(\rho) u(t)$$

with the state (e.g. temperature) T , that depends on the time and spatial coordinate t and ρ , respectively. The unknown space-dependent parameters, are the diffusion D , convection V and source profile P . To estimate $\{D, V, P\}$, data is generated by (periodically) perturbing the system via the input $u(t)$ and measuring the state at M spatial locations ρ_m , $m = 1, \dots, M$, resulting in $y(t) = \text{col}(y_1, \dots, y_M)$, with $y_m(t) = T(\rho_m, t)$. An example of data generated by such an experiment is shown in the figure below.



Filtering and Frequency domain

Only the forced response is considered by applying advanced filtering techniques that remove noise, drifts and transients (i.e. dependency on the initial condition) [4]. Furthermore, the PDE is considered in the frequency domain such that it is sufficient to only consider the base frequency and a few of its harmonics that are above the noise floor. Such data is shown in the figure below.

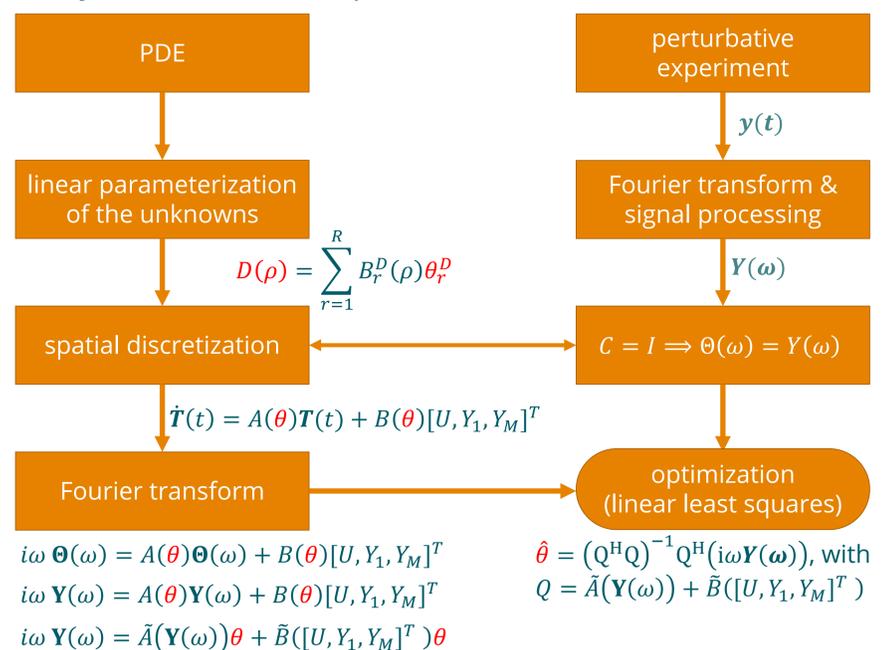


Methodology

We consider the PDE in the frequency domain

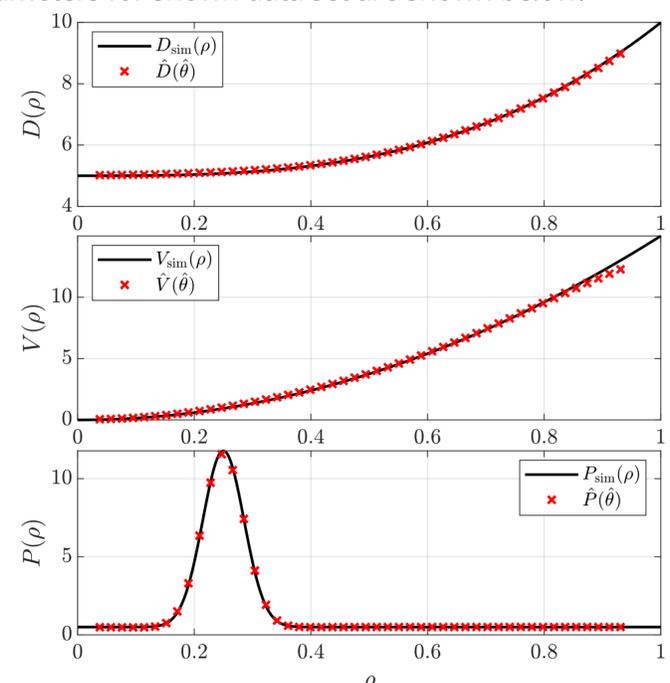
$$i\omega \Theta(\rho, \omega) = \frac{1}{\rho} \frac{\partial}{\partial \rho} \left(\rho D(\rho) \frac{\partial \Theta(\rho, \omega)}{\partial \rho} + \rho V(\rho) \Theta(\rho, \omega) \right) + P(\rho) u(\omega)$$

and follow the methodology from [5] such that the inverse problem is rewritten as a linear least square problem which has an analytic solution for the optimum. This method is visualized below.



Results

Due to the availability of the analytic solution, it guarantees the global minimum and does not require computational expensive optimization methods! The simulated and the estimated parameters for shown data set are shown below.



References

- [1] M. van Berkel et al., *Proc. IEEE Conf. Decis. Control*, pp. 3220-3226, 2019
- [2] U. Schneidewind et al., *Water Resour. Res.*, vol. 52, no. 8, pp. 6596-6610, 2016
- [3] M. Irsyad et al., *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 60, p. 012028, 2017
- [4] M. van Berkel et al., *Plasma Phys. Control. Fusion*, vol. 62, no. 9, p. 094001, 2020
- [5] R. van Kampen et al., *IEEE Control Systems Letters*, 2020

Acknowledgements

DIFFER is part of the institutes organisation of NWO. This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.