Data-driven identification of non-linear distributed parameter systems

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Introduction

Data-driven identification of non-linear distributed parameter systems is still in its infancy. However, given the need in industry (thermal expansion), chemistry (catalytic behavior), and physics (nuclear fusion) for the non-linear analysis of such systems (see for example [1] and figures below from [1]). New techniques would allow for pushing the boundaries of understanding and control of such systems.

A new method based on harmonic balancing in combination with a Volterra based approach has been developed which allows the estimation of non-linear transport parameters [1]. However, the method is largely untested and many extensions and questions are open with respect to identifiability of non-linear parameter dependencies.

Therefore, in this project a non-linear simulation model needs to be built to simulate the temperature evolution of known non-linearity’s. This can be done by for instance using implicit finite difference schemes/finite element methods/spectral methods. Hence, the first part of this project is the development of a code which allows the simulation of such a distributed non-linear system. This can be done with some support from the numerical department at the TU/e (CASA). The second part is estimating the data-driven Volterra kernels from experimental data and compare those to the Volterra kernels following from the analytic expressions of the non-linear distributed system. Finally, identify, if possible, the unknown non-linear parameter dependencies.

Problem statement

In this project, the goal of the student is to:

1. Obtain in-depth knowledge of frequency domain system identification, Volterra series, and distributed parameter systems (DPS)
2. Familiarize him/herself with the developed method of harmonic balancing, Volterra series, DPS
3. Build a simulation code which allows to simulate a non-linear dependency of the diffusion coefficient on temperature or its gradient
4. Compare Volterra series expansions to data-driven based estimates of Volterra series
5. Try to identify the non-linear dependencies based on Volterra series

Requirements

Basic knowledge on DPS and system identification, creativity and willingness to explore new domains. Type of work: 50% theory and 50% computer simulations.

References: