Skalenkaskaden in komplexen Systemen

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Multiscale tensor decomposition methods with application to turbulent channel flow data

Project B04

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Abstract:

Novel hierarchical tensor product methods currently emerge as an important tool in numerical analysis and scientific computing. One reason is that these methods often enable one to attack high-dimensional problems successfully, another that they allow for very compact representations of large data sets. These representations are in some sense optimal and by construction at least as good as approximations by classical function systems like polynomials, trigonometric polynomials, or wavelets. Moreover, the new tensor-product methods are by construction able to detect and to take advantage of self-similarities in the data sets. They should therefore be ideally suited to represent solutions of partial differential equations that exhibit certain types of multiscale behavior.

The aim of project B04 is both to develop methods and algorithms that utilize these properties and to check their applicability to particular problems as they arise in the

collaborative research centre. The xerus library, developed at TU Berlin, [1], allows for numerical calculations with higher order tensors and Tensor-Train-Decompositions. The reconstruction capabilities of this approach are tested against 3D DNS data of a turbulent channel flow computed for an incompressible, isothermal fluid at Reynolds number $Re_\tau = 590$, [2].

[1] B. Huber and S.Wolf. Xerus - A General Purpose Tensor Library. URL: https://libxerus.org, 2014-2015.

[2] M. Uhlmann. Generation of a temporally well-resolved sequence of snapshots of the flow-field in turbulent plane channel flow. URL: http://www-turbul.ifh.unikarlsruhe.de/uhlmann/reports/produce.pdf, 2000.