Markus Bachmayr

Academic career

2012	Dr. rer. nat., RWTH Aachen
2012 - 2016	Postdoc at RWTH Aachen, TU Berlin, UPMC Paris 6 (France)
Since 2016	Professor (W2, Bonn Junior Fellow), University of Bonn

Honours

2007	Erwin Wenzl Preis
2013	John Todd Award, Oberwolfach Research Institute for Mathematics (MFO)
2014	Borchers-Plakette, RWTH Aachen

Research profile

My research focuses on the numerical analysis of high-dimensional partial differential equations. Such problems arise, for instance, in quantum physics and in the deterministic treatment of uncertainty quantification. I am especially interested in understanding the computational complexity of nonlinear approximation methods such as low-rank tensor decompositions, which can exploit particular structural features beyond classical smoothness. Results in this direction include solvers of near-optimal complexity with adaptive discretizations [6], [3], iterative solvers with quasi-optimal rank bounds based on soft thresholding [2], recovery of tensors by point samples [7], and low-rank approximability of parametric PDEs [1]. Another approach that is well established for problems with stochastic coefficients are sparse tensor product polynomial expansions. In [4], [5], we have obtained new results that demonstrate the dependence of convergence rates on the type of parametrisation of the given random fields.
These recent results are an example of the central role that choices of coordinates, or choices of basis expansions for function spaces, often play in the treatment of high-dimensional problems. In the case of differential equations with stochastic coefficients, I intend to pursue questions in this direction that have a flavour of harmonic analysis. Moreover, for highly irregular coefficients, challenging problems concerning numerical solvers need to be addressed, and relations to methods for stochastic homogenisation also remain to be explored. In the case of low-rank tensor methods, in many cases one needs to achieve a tradeoff between preserving separable structures and accommodating the topologies prescribed by the mapping properties of the considered operators. Building on the developments in [3], I plan to study such issues in particular in the context of second quantised formulations of quantum-physical models.

Selected publications

[1] Markus Bachmayr and Albert Cohen. Kolmogorov widths and low-rank approximations of parametric elliptic pdes. *Math. Comp.*, 86(304):701–724, 2017.

[2] Markus Bachmayr and Reinhold Schneider. Iterative methods based on soft thresholding of hierarchical tensors. *Found. Comput. Math.*, 2016.

[3] Markus Bachmayr and Wolfgang Dahmen. Adaptive low-rank methods: problems on sobolev spaces. *SIAM J. Numer. Anal.*, 54(2):744–796, 2016.

[4] Markus Bachmayr, Albert Cohen, and Giovanni Migliorati. Sparse polynomial approximation of parametric elliptic pdes. part i: affine coefficients. *ESAIM Math. Model. Numer. Anal.*, 2016. to appear.

[5] Markus Bachmayr, Albert Cohen, Ronald DeVore, and Giovanni Migliorati. Sparse polynomial approximation of parametric elliptic pdes. part ii: lognormal coefficients. *ESAIM Math. Model. Numer. Anal.*, 2016. to appear.

[6] Markus Bachmayr and Wolfgang Dahmen. Adaptive near-optimal rank tensor approximation for high-dimensional operator equations. *Found. Comput. Math.*, 15(4):839–898, 2015.

[7] Markus Bachmayr, Wolfgang Dahmen, Ronald DeVore, and Lars Grasedyck. Approximation of high-dimensional rank one tensors. *Constr. Approx.*, 39(2):385–395, 2014.

[8] Markus Bachmayr, Huajie Chen, and Reinhold Schneider. Error estimates for hermite and even-tempered gaussian approximations in quantum chemistry. *Numer. Math.*, 128(1):137–165, 2014.
[9] Markus Bachmayr. Integration of products of gaussians and wavelets with applications to electronic structure calculations. *SIAM J. Numer. Anal.*, 51(5):2491–2513, 2013.
[10] Markus Bachmayr and Martin Burger. Iterative total variation schemes for nonlinear inverse problems. *Inverse Problems*, 25(10):105004, 26, 2009.