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 [9, 8], iterative solvers with quasi-optimal rank bounds based on soft thresholding [1], and low-rank approximability of parametric PDEs [4, 7]. Another approach that is well established for problems with stochastic coefficients are sparse tensor product polynomial expansions. In [2, 3, 6], 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 pursue questions in this direction that are crucial for highly irregular coefficients, where also challenging problems concerning numerical solvers need to be addressed. 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 [8], I study such issues in particular in the context of second quantised formulations of quantum-physical models.

¡b¿Research Area J¡/b¿
Here I contribute my expertise on adaptive solvers for sparse and low-rank approximations of high-dimensional problems, as well as on related approximability questions.
Since starting in Bonn in September 2016, we have obtained new results on the deterministic numerical treatment of random PDEs, in particular on fully discrete sparse approximations [6]. We have also considered related questions on expansions of Gaussian random fields [5] and on low-rank methods for multi-parametric PDEs [7].

Selected publications

[1] Markus Bachmayr and Reinhold Schneider. Iterative methods based on soft thresholding of hierarchical tensors. *Found. Comput. Math.*, 17(4):1037–1083, 2017.

[2] Markus Bachmayr, Albert Cohen, and Giovanni Migliorati. Sparse polynomial approximation of parametric elliptic pdes. part i: Affine coefficients. *ESAIM Math. Model. Numer. Anal.*, 51(1):321–339, 2017.

[3] 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.*, 51(1):341–363, 2017.

[4] Markus Bachmayr and Albert Cohen. Kolmogorov widths and low-rank approximations of parametric elliptic pdes. *Math. Comp.*, 86(304):701–724, 2017.
[5] M. Bachmayr, A. Cohen, and G. Migliorati. Representations of gaussian random fields and approximation of elliptic pdes with lognormal coefficients. *J. Fourier Anal. Appl.*, 2017.
[6] M. Bachmayr, A. Cohen, Dũng Dinh, and C. Schwab. Fully discrete approximation of parametric and stochastic elliptic pdes. *SIAM J. Numer. Anal.*, 55:2151–2186, 2017.
[7] M. Bachmayr, A. Cohen, and W. Dahmen. Parametric pdes: Sparse or low-rank approximations? *IMA J. Numer. Anal.*, 2017.
[8] Markus Bachmayr and Wolfgang Dahmen. Adaptive low-rank methods: problems on sobolev spaces. *SIAM J. Numer. Anal.*, 54(2):744–796, 2016.
[9] Markus Bachmayr and Wolfgang Dahmen. Adaptive near-optimal rank tensor approximation for high-dimensional operator equations. *Found. Comput. Math.*, 15(4):839–898, 2015.
[10] 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.