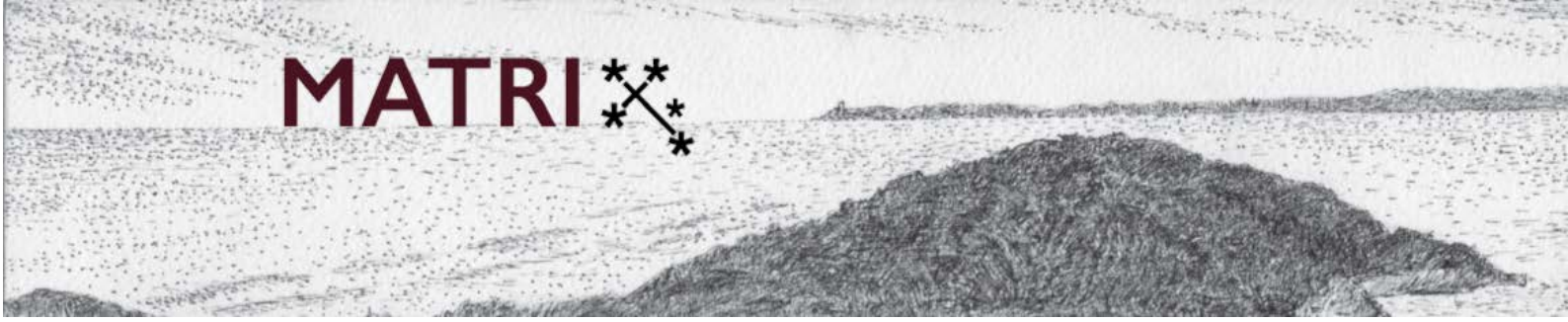
ON THE FRONTIERS OF HIGH DIMENSIONAL COMPUTATION

4 - 15 June 2018

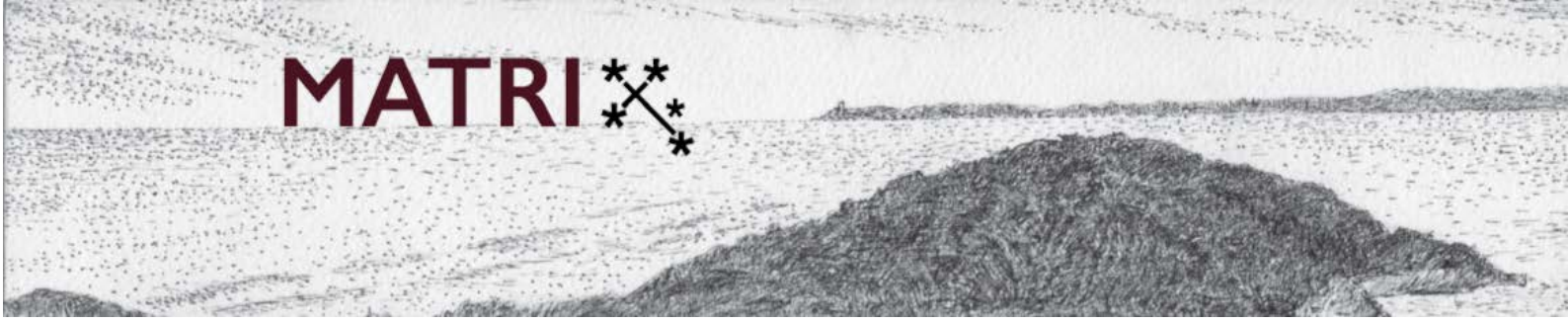
Creswick, Victoria, Australia

TALK LIST/ABSTRACTS



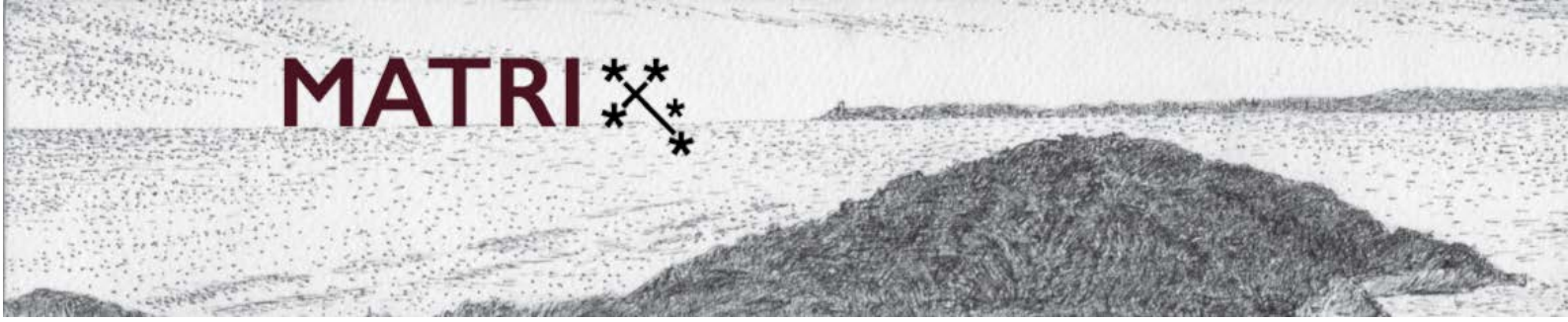
Research seminars and discussions in Week 1

Name	Title	Abstract
Tiangang Cui	Subspace Acceleration for Large-Scale Bayesian Inverse Problems.	Algorithmic scalability to high-dimensional models is one of the central challenges in solving large-scale Bayesian inverse problems. By exploiting the interaction among various information sources and model structures, we will present a set of certified dimension reduction methods for identifying the intrinsic dimensionality of inverse problems. The resulting reduced dimensional subspaces offer new insights into the acceleration of classical Bayesian inference algorithms for solving inverse problems. We will discuss some old and new algorithms that can be significantly accelerated by the reduced dimensional subspaces.
Fred Hickernell	Quasi-Monte Carlo Community Software	Practitioners may wish to try our new quasi-Monte Carlo (qMC) algorithms on their own problems without having to write their own qMC software. Several of us have developed quasi-Monte Carlo software to demonstrate the advantages of our new algorithms. Is it time to combine our efforts into a qMC software library with shared ownership by our community? The goal would be to make research code accessible and to make production code reliable. I will share some thoughts on the decisions to be made, the structures to be set in place, and some possible next steps. Discussion will be encouraged and those interested will be invited to meet to make concrete plans.
Johann Brauchart	Discrepancy and Hyperuniformity of Point Set Sequences on the Sphere or the Unit Cube.	Discrepancy quantifies the deviation from uniform distribution. For point sets and point set sequences for the unit cube many results and celebrated results are known. The story is full of gaping holes in the setting of a sphere. The talk will survey known results and will present fundamental unresolved research questions. Hyperuniformity provides a measure for the fine structure of point sets along a sequence of point sets taken from a compact set like the sphere. We will report on recent results of joint work with P. Grabner (TU Graz), W. Kusner (Vanderbilt University), and J. Ziefle (University of Tuebingen).
Bishnu Lamichhane	Finite element approaches to some data smoothing techniques	I want to discuss finite element approaches to some multivariate splines. The special focus will be on the high dimensional extension of the newly proposed multivariate spline.
Jerome Droniou	Some possibly interesting topics in high-dimensional analysis for numerical PDEs.	This is not so much a formal presentation than an open discussion/workshop on topics in numerical partial differential equations (PDEs) that could involve interesting (and open, to my knowledge) questions in high-dimensional analysis (HDA). I will briefly present two or three research fields in numerical methods for PDEs, that will form the basis for a discussion around how HDA could be plugged onto these topics.

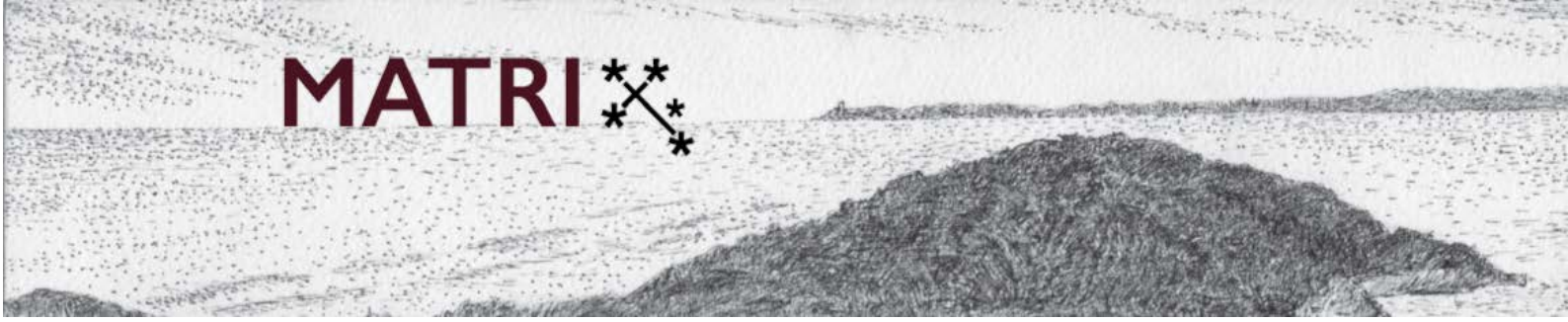


Workshop talks in Week 2

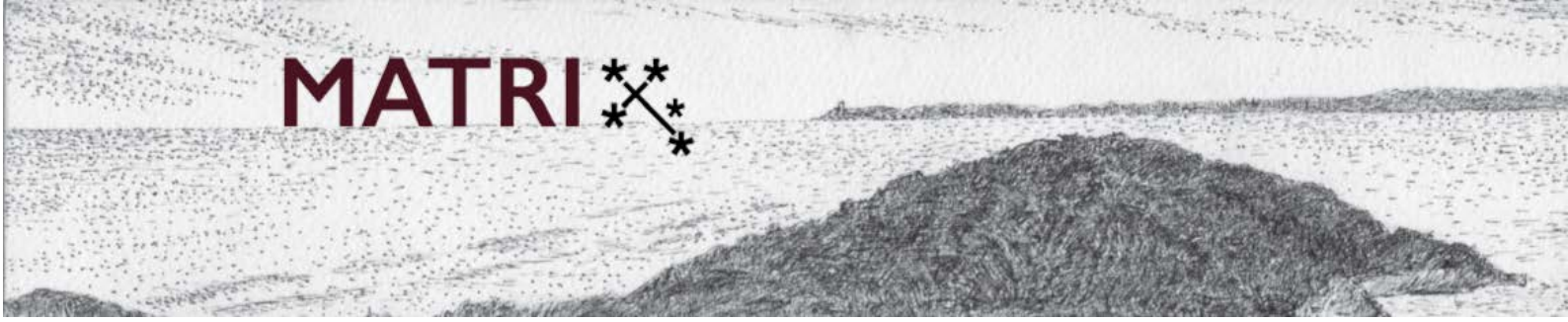
Name	Title	Abstract
Henryk Wozniakowski	Notes on Tractability Conditions for linear multivariate problems	We study approximation of compact linear multivariate operators defined over Hilbert spaces. We provide necessary and sufficient conditions on various notions of tractability with respect to the pairs (d,ε^{-1}) and $(d,\ln\,\varepsilon^{-1})$, where d denotes the d-variate problem and ε is an error threshold. The conditions are mainly given in terms of sums of ceratin functions depending on the singular values of the d-variate problems. They do not require the ordering of the singular values which is in many cases a difficult combinatorial problem. This is a joint work with Peter Kritzer
Stefan Heinrich	How difficult is it to compute the L_q norm of a function	We study the complexity of computing $S_q(f) = \|f\|_{L_q(Q)}$ that is, the L_q norm of a function. We assume that f is from the unit ball of the Sobolev space $W_p^r(Q)$, where $Q = [0,1]^d$, and $r \in \mathbf{N}_0$, $1 \le p,q \le \infty$ are such that $W_p^r(Q)$ is embedded into $L_q(Q)$. Information is standard, that is, consists of function values. Thus, we want to determine the (order of the) optimal error of approximating the (nonlinear) operator $S_q : f \to \|f\|_{L_q(Q)}$, based on algorithms using not more than n values of f. The deterministic setting was settled by G. W. Wasilkowski. We present and analyze a randomized algorithm for computing $S_q(f)$ and provide lower bounds, which allow to determine the order of the randomized n-th minimal errors. We also consider the cost in the real number model of computation. The proposed algorithms both for the deterministic and randomized setting rely on the knowledge of certain integrals. For some constellations of the parameters r and q these integrals can be computed explicitly, for others not. In the case $d = 1$ we show how to approximate these integrals for all r and q in such a way that the resulting algorithms keep the optimal error rate and are implementable at nearly optimal cost. The case $d > 1$ remains open. Finally, we mention further open problems.
Christoph Aistleitner	A cheap proof and a moment of serendipity	In this talk I will sketch the content of those two papers in Ian's Festschrift in which I am involved as a co-author. The first paper (joint work with Aicke Hinrich) gives a new simple proof of Aicke's lower bound for the inverse of the star-discrepancy. This quantity is very interesting from the viewpoint of tractability theory, and it is very unsatisfactory that its asymptotic order is still unknown. While Aicke's original proof relied on metric entropy theory and Vapnik-Chervonenkis theory, the new proof only uses some simple geometry and combinatorics. The second paper (joint work with Ida Aichinger and Gerhard Larcher) improves a result of Bourgain in the quickly developing field of metric pair correlation theory. Instead of presenting the result and proof, I will try to explain what the problem is about, and then recount the famous anecdote of "Tea time at Princeton".
Thomas Kühn	Approximation and tractability of periodic Sobolev embeddings with increasing smoothness on high-dimensional domains	the talk is devoted to approximation of embeddings of isotropic Sobolev spaces on the d-dimensional torus, where the smoothness increases with the dimension d. I will present necessary and sufficient conditions for strong polynomial, polynomial, quasi-polynomial, uniformly weak, and weak tractability.
Fred Hickernell	Automatic Algorithms for Multidimensional Integration	We review recent algorithms designed to automatically terminate when the error tolerance has been reached. There are algorithms based on IID sampling and low discrepancy sampling. The underlying function may be assumed to be deterministic or an instance of a Gaussian process. We describe the theory behind these algorithms and illustrate their performance via examples.



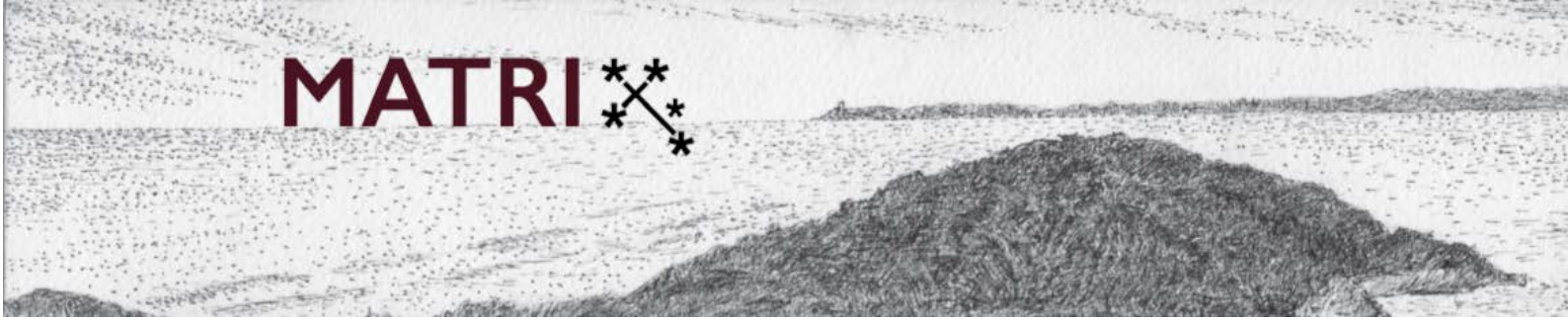
Peter Kritzer	Successive component search algorithms for good lattice points	The (fast) component-by-component construction of lattice point sets and polynomial lattice point sets is a powerful method to obtain quadrature rules for approximating integrals over the *d*-dimensional unit cube. In this talk, we present modifications of the component-by-component algorithm and of the more recent successive coordinate search algorithm, which yield savings of the construction cost for lattice rules and polynomial lattice rules in weighted function spaces. The idea is to reduce the size of the search space for coordinates which are associated with small weights and are therefore of less importance to the overall error compared to coordinates associated with large weights. We analyze tractability conditions of the resulting quasi-Monte Carlo rules, and show some numerical results. The talk is based on joint work with J. Dick (UNSW Sydney), A. Ebert (KU Leuven), G. Leobacher (KFU Graz), and F. Pillichshammer (JKU Linz).
Leszek Plaskota	Absolute Value Information	Typically, two kinds of information have been considered in Information-Based Complexity (IBC) for solving continuous problems: standard and arbitrary linear. Recently, due to Daubechies and others, new nonlinear information has been introduced in the context of phase retrieval, where it is assumed that only absolute values of linear functionals are available. We call it absolute value information (AVI). The purpose of this study is to establish the power of AVI for various IBC problems in comparison to results in the regular IBC settings. We show, in particular, that AVI is too weak to solve linear problems using standard infomation, but it is powerful enough to recover typical IBC results for linear information. However, in the latter case, the concept of algorithm error has to be slightly modified. This is a joint project with Pawel Siedlecki and Henryk Wozniakowski.
Dirk Nuyens	Randomizing the number of points of a lattice rule	We normally randomize lattice rules by using random shifting, which has the benefit of obtaining a stochastic error estimator. It is known that ``good'' randomizations can improve the convergence rate, but random shifting does not help in this sense. I will talk about a different randomization method in which the number of points of the lattice rule is taken to be random and thereby improves the convergence rates. As an extra benefit we can make this bound independent of the dimensions by assuming the usual weighted spaces. This is joint work with Peter Kritzer, Frances Y. Kuo and Mario Ullrich.
Rob Scheichl	Efficient Sampling from High-dimensional Distributions using Low-rank Tensor Surrogates	High-dimensional distributions are notoriously difficult to sample from, particularly in the context of PDE-constrained Bayesian inverse problems. In this talk, we will present general purpose samplers based on low-rank tensor surrogates in the tensor-train (TT) format, a methodology that has been exploited already for many years for scalable, high-dimensional function approximations in quantum chemistry. In the Bayesian context, the TT surrogate is built in a two-stage process. First, we build a surrogate of the entire PDE solution in the TT format, using a novel combination of alternating least squares and the TT cross algorithm. It exploits and preserves the block diagonal structure of the discretised operator in stochastic collocation schemes, requiring only independent PDE solutions at a few parameter values, thus allowing the use of existing high performance PDE solvers. In a second stage, we approximate the high-dimensional likelihood function also in TT format. Due to the particular structure of the TT surrogate, we can build an efficient inverse Rosenblatt (or cumulative) transform that only requires a sampling algorithm for one-dimensional conditionals. The overall computational cost of the sampler grows only linearly with the dimension. For sufficiently smooth prior distributions of the input random fields, the ranks required for accurate TT approximations are moderate, leading to significant computational gains. This is joint work with Karim Anaya-Izquierdo, Sergey Dolgov (both Bath) and Colin Fox (Otago).



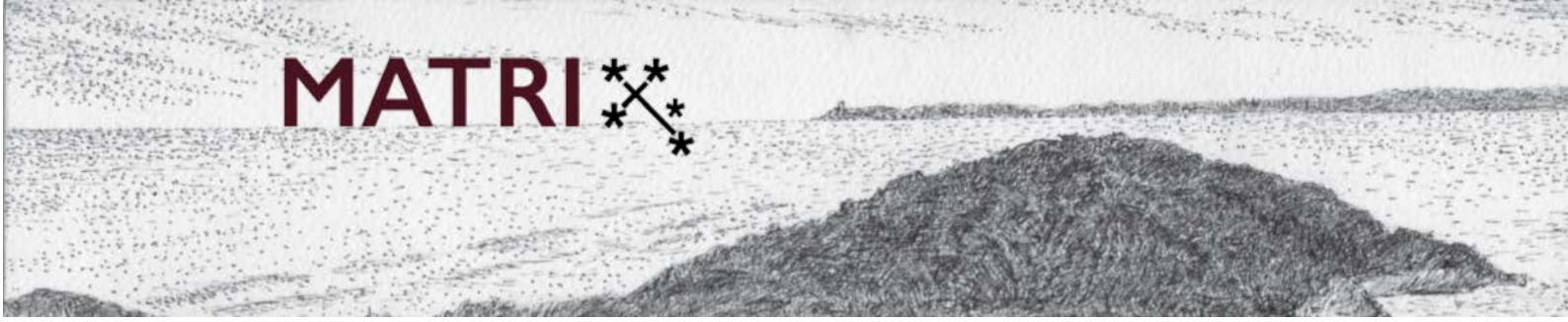
Clayton Webster	Foundations of compressed sensing for learning functions in high-dimensions	This talk will focus on compressed sensing approaches to sparse polynomial approximation of complex functions in high dimensions. Of particular interest is the parameterized PDE setting, where the target function is smooth, characterized by a rapidly decaying orthonormal expansion, whose most important terms are captured by a lower (or downward closed) set. By exploiting this fact, we will present and analyze several procedures for exactly reconstructing a set of (jointly) sparse vectors, from incomplete measurements. These include novel weighted ℓ_1 minimization, improved iterative hard thresholding, mixed convex relaxations, as well as nonconvex penalties. Theoretical recovery guarantees will also be presented based on improved bounds for the restricted isometry property, as well as unified null space properties that encompass all currently proposed nonconvex minimizations. Numerical examples are provided to support the theoretical results and demonstrate the computational efficiency of the described compressed sensing methods.
Guannan Zhang	A domain-decomposition model reduction method for linear convection-diffusion equations with random coefficients	We focus on linear steady-state convection-diffusion equations with random-field coefficients. Our particular interest to this effort are two types of partial differential equations (PDEs), i.e., diffusion equations with random diffusivities, and convection-dominated transport equations with random velocity fields. For each of them, we investigate two types of random fields, i.e., the colored noise and the discrete white noise. We developed a new domain-decomposition-based model reduction (DDMR) method, which can exploit the low-dimensional structure of local solutions from various perspectives. We divide the physical domain into a set of non-overlapping sub-domains, generate local random fields and establish the correlation structure among local fields. We generate a set of reduced bases for the PDE solution within sub-domains and on interfaces, then define reduced local stiffness matrices by multiplying each reduced basis by the corresponding blocks of the local stiffness matrix. After that, we establish sparse approximations of the entries of the reduced local stiffness matrices in low-dimensional subspaces, which finishes the offline procedure. In the online phase, when a new realization of the global random field is generated, we map the global random variables to local random variables, evaluate the sparse approximations of the reduced local stiffness matrices, assemble the reduced global Schur complement matrix and solve the coefficients of the reduced bases on interfaces, and then assemble the reduced local Schur complement matrices and solve the coefficients of the reduced bases in the interior of the sub-domains. The advantages and contributions of our method lie in the following three aspects. First, the DDMR method has the online-offline decomposition feature, i.e., the online computational cost is independent of the finite element mesh size. Second, the DDMR method can handle the PDEs of interest with non-affine high-dimensional random coefficients. The challenge caused by the non-affine coefficients is resolved by approximating the entries of the reduced stiffness matrices. The high-dimensionality is handled by the DD strategy. Third, the DDMR method can avoid building polynomial sparse approximations to local PDE solutions. This feature is useful in solving the convection-dominated PDE, whose solution has a sharp transition caused by the boundary condition. We demonstrate the performance of our method based on the diffusion equation and convection-dominated equation with colored noises and discrete white noises.
Giovanni Migliorati	Least-squares methods for approximation in high dimension	We review some recent results on the stability and accuracy of least-squares estimators, with evaluations at random or deterministic point sets.



James Nichols	Greedy measurement selection for state estimation	Parametric PDEs of the general form $$ mathcal{P}(u,a)=0 $$ are commonly used to describe many physical processes, where $mathcal{P}$ is a differential operator, a is a high-dimensional vector of parameters and u is the unknown solution belonging to some Hilbert space V. Typically one observes m linear measurements of $u(a)$ of the form $ell_i(u)=langle w_i,u rangle$, $i=1,dots,m$, where $ell_iin V'$ and w_i are the Riesz representers, and we write $W_m = text{span}{w_1,ldots,w_m}$. The goal is to recover an approximation u^* of u from the measurements. The solutions $u(a)$ lie in a manifold within V which we can approximate by a linear space V_n, where n is of moderate dimension. The structure of the PDE ensure that for any a the solution is never too far away from V_n, that is, $text{dist}(u(a),V_n)le varepsilon$. In this setting, the observed measurements and V_n can be combined to produce an approximation u^* of u up to accuracy $$ Vert u -u^*Vert leq beta^{-1}(V_n,W_m) , varepsilon $$ where $$ beta(V_n,W_m) := inf_{vin V_n} frac{Vert P_{W_m}vVert}{Vert v Vert} $$ plays the role of a stability constant. For a given V_n, one relevant objective is to guarantee that $beta(V_n,W_m)geq gamma >0$ with a number of measurements $mgeq n$ as small as possible. We present results in this direction when the measurement functionals ell_i belong to a complete dictionary.
Dongwoo Sheen	Recent development on nonconforming finite element methods and their applications	We will review recent developments on nonconforming finite element methods. We introduce a cheapest stable nonconforming finite element pair for Stokes equations. The finite element pair has lowest degrees of freedom with optimal order of convergence. We then apply the elements and other known conforming and nonconforming finite element pairs to driven cavity flows. Three types of indicators for the accuracy checking will be addressed. Finally, numerical comparison of these finite element pairs are presented based on the indicators. Other applications will be presented solving multiscale problems related with Darcy's flow.

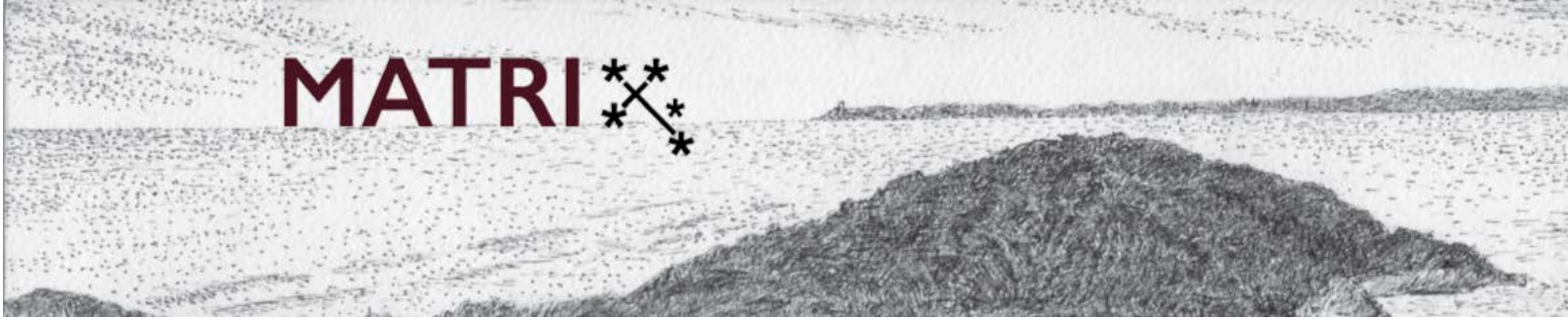


Alexander Gilbert	Applying Quasi-Monte Carlo to a stochastic eigenvalue problem	In this talk we study an elliptic eigenvalue problem, with a random coefficient that can be parametrised by infinitely-many stochastic parameters. The physical motivation is the criticality problem for a nuclear reactor: in steady state the fission reaction can be modelled by an elliptic eigenvalue problem, and the smallest eigenvalue provides a measure of how close the reaction is to equilibrium -- in terms of production/absorption of neutrons. The coefficients are allowed to be random to model the uncertainty of the composition of materials inside the reactor, e.g., the control rods, reactor structure, fuel rods etc. The randomness in the coefficient also results in randomness in the eigenvalues and corresponding eigenfunctions. As such, our quantity of interest is the expected value, with respect to the stochastic parameters, of the smallest eigenvalue, which we formulate as an integral over the infinite-dimensional parameter domain. Our approximation involves three steps: truncating the stochastic dimension, discretising the spatial domain using finite elements and approximating the now finite but still high-dimensional integral. To approximate the high-dimensional integral we use quasi-Monte Carlo (QMC) methods. These are deterministic or quasi-random quadrature rules that can be proven to be very efficient for the numerical integration of certain classes of high-dimensional functions. QMC methods have previously been applied to linear functionals of the solution of a similar elliptic source problem; however, because of the nonlinearity of eigenvalues the existing analysis of the integration error does not hold in our case. We show that the minimal eigenvalue belongs to the spaces required for QMC theory, outline the approximation algorithm and provide numerical results.
Tiangang Cui (Week 2)	Optimisation-based Sampling Approaches for Hierarchical Bayesian Inference	Markov chain Monte Carlo (MCMC) relies on efficient proposals to sample from a target distribution of interest. Recent optimization-based MCMC algorithms for Bayesian inference, e.g. randomize-then-optimize (RTO), repeatedly solve optimization problems to obtain proposal samples. We interpret RTO as an invertible map between two random functions and find that this mapping preserves the random functions along many directions. This leads to a dimension independent formulation of the RTO algorithm for sampling the posterior of large-scale Bayesian inverse problems. We applied our new methods on Hierarchical Bayesian inverse problems.
Sergei Pereverzyev	Linear Functional Strategy in Regularized Learning	The choice of the kernel is known to be a challenging and central problem of kernel based supervised learning. Recent applications and significant amount of literature have shown that using multiple kernels (the so-called Multiple Kernel Learning (MKL)) instead of a single one can enhance the interpretability of the learned function and improve performances. However, a comparison of existing MKL-algorithms shows that though there may not be large differences in terms of accuracy, there is difference between MKL-algorithms in complexity as given by the training time, for example. In this talk we present a promising approach for training the MKL-machine by the linear functional strategy, which is either faster or more accurate than previously known ones. Moreover, we also briefly discuss a possibility of applying our MKL-strategy for predicting the risk of nocturnal hypoglycemia of diabetes patients.
Yuesheng Xu	Sparse Machine Learning	We shall discuss recent development in sparse machine learning methods. In particular, we shall report recent mathematical advances of machine learning in Banach space.
Mahadevan Ganesh	An offline/online Bayesian electromagnetism algorithm	We describe an efficient algorithm for reconstruction of the electromagnetic parameters of an unbounded dielectric three-dimensional medium from noisy cross section data induced by a point source. The efficiency of our Bayesian inverse algorithm for the parameters is based on developing an offline high order forward stochastic model and also an associated deterministic dielectric media Maxwell solver. Underlying the inverse/offline approach is our high order fully discrete Galerkin algorithm for solving an equivalent surface integral equation reformulation that is stable for all frequencies. This is a joint work with Drs. Hawkins and Volkov.

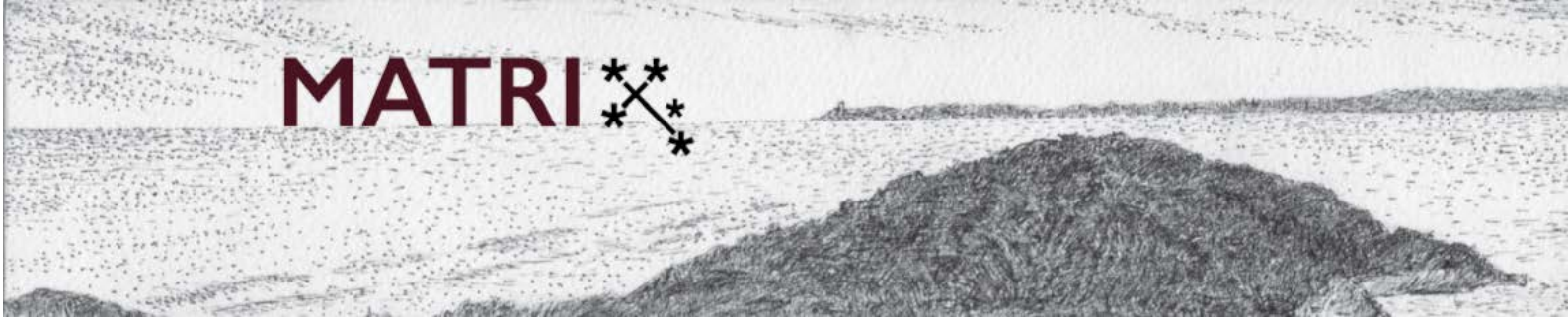


Markus Hegland	Elimination for polynomial systems of equations and applications to high dimensional approximation, quadrature and other numerical problems	Gaussian elimination is an important tool both for the development of numerical algorithms and for the theory of linear systems and approximation. I will discuss the extension of the elimination method to systems of polynomial equations. The resulting algorithms are closely related to Groebner bases and have been of some interest in algebraic geometry. Somewhat independently, low rank matrix factorisations have been used in the development of approximations to high dimensional problems. These approximations are used in uncertainty quantification, in reduced basis models and in various approximations including hierarchical methods and tensor trains. It turns out that low rank matrix factorisations are based on large polynomial systems of equations. Finally, while the solution of special polynomial systems of equations is widely used for the development of quadrature methods, more general systems of polynomials has not been widely studied in numerical analysis. Here we will provide a short discussion of some basic ideas and applications of polynomial systems of equations.
Stuart Hawkins	A reduced basis method for stochastic wave propagation problems	We consider stochastic wave propagation models in which an illuminating wave propagates through an uncertain medium. A natural approach to such problems is to apply established stochastic algorithms such as Monte Carlo (MC) or quasi-Monte Carlo (QMC) in tandem with standard deterministic wave propagation solvers. There are many such deterministic wave propagation solvers and the choice of solver is typically forced by the nature of the medium. However, unless the uncertain medium is very simple, this approach is prohibitively slow because wave propagation solvers are well known to be computationally expensive and stochastic algorithms like MC and QMC typically require thousands of evaluations of the deterministic wave propagation solver. We propose accelerating the stochastic algorithm by replacing the deterministic wave propagation solver with a reduced basis model (RBM). Our wave propagation RBM is based on the well-known T-matrix. It is well known that the standard Null Field Method for computing the T-matrix is numerically unstable for particles that deviate significantly from a sphere. We describe a completely new computational framework that is numerically stable for all scatterers. A key feature of our framework is that is can be computed for any media using its appropriate deterministic wave propagation solver.
Abhishek Bhardwaj	Numerical view of Polynomial Systems.	In this talk we explore solving polynomial systems numerically. We consider the well-known Groebner Basis method for such solutions and present our approach to making improvements.
Yuancheng Zhou	Application of Sparse grid quadrature in solving stochastic programming models	Stochastic programming is used to solve optimization problems that involve uncertainties. The objective function of a stochastic programming problem is usually an expectation of some functions of the decisions and the uncertainties. The goal is to optimize this expectation and find the best decisions that will perform well on average. If the number of the uncertainties is large, then the expectation will become a high dimensional integral. We will encounter the curse of dimensionality when we evaluate the objective function as a consequence. Thus, how to compute these expectations efficiently is the key to solve complex stochastic programming models. In this talk, sparse grid quadrature will be introduced and applied to solve some stochastic programming models.
Yoshihito Kazashi	Discrete maximal regularity of an implicit Euler–Maruyama scheme with non-uniform time discretisation for a class of stochastic partial differential equations	An implicit Euler–Maruyama method applied to a class of stochastic partial differential equations is studied. A spectral method is used for the spatial discretization and the truncation of the Wiener process. A discrete analogue of maximal L^2-regularity of the scheme and the discretised stochastic convolution is established, which has the same form as their continuous counterpart.

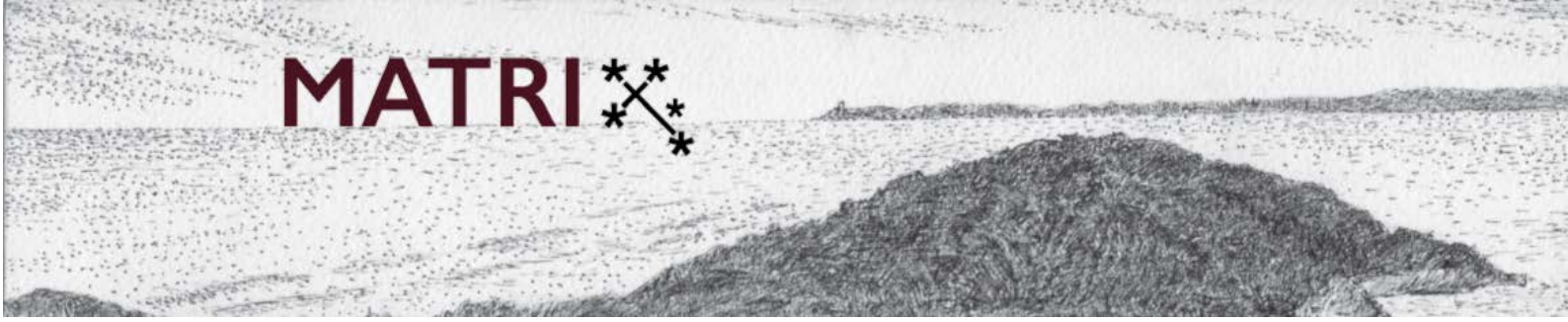
Wolfgang Wendland	Minimal energy problems with weakly and strongly singular Riesz kernels	**Abstract:** The minimal energy problem for nonnegative charges on a closed surface Γ in $\mathbb{R}^3$ goes back to C.F. Gauss in 1839.The corresponding Riesz kernel is then on Γ weakly singular. More general, in $\mathbb{R}^n, n \geq 2$, the constructive solution of minimizing the energy relative to the weakly singular Riesz kernel $\|x-y\|^{\alpha-n}$ where $1 < \alpha < n$, is considered for finitely many compact, mutually disjoint, boundaryless $(n-1)$–dimensional orientible $C^{k-1,1}$–manifolds $\Gamma_\ell, \ell = 1, \ldots, L$. For $k > (\alpha-1)/2$ the Γ_ℓ are charged with Borel measures with prescribed signs $\alpha_\ell = \pm 1$. It turns out that the corresponding Gauss problem is equivalent to a minimum problem for distributional charges belonging to the Sobolev–Slobodeckii space $H^{-\varepsilon/2}(\Gamma), \varepsilon = \alpha - 1, \Gamma = \cup_1^k \Gamma_\ell$. For $L = 1$ or 2, one finds boundary integral equations with single layer potential operators on Γ. These equations can be solved approximately with a Galerkin–Bubnov method with piecewise constant charges. Wavelet matrix compression is applied for solving the discrete system. Secondly, we study the minimal energy problem for strongly singular kernels with $-1 < \alpha < 1$ with $\Gamma \in C^\infty$. Based on the energy of harmonic double layer potentials, we are motivated to use Hadarmard's partie finie integral operators of order $\varepsilon' = 1 - \alpha$ for the definition of energy. Then the measures with finite energy belong to $H^{\varepsilon'/2}(\Gamma)$. We also relate our Sobolov space approach to the discrete one neglecting the diagonal energy weights. This is joint work with Helmut Harbrecht (Basel), Günther Of (Graz) and Natalia Zorii (Kiev).
Hrushikesh Mhaskar	Approximation of Measures	Motivated by the problem of super-resolution, we use duality to study the problem of approximation of measures. A suitable distance will be introduced, with respect to which we will establish upper and lower bounds on the degree of approximation of measures in di erent settings.
Yuan Xu	Positive Definite Functions on the Unit Sphere	A simple sufficient condition, called P\'olya criterion, is established for a function to be positive definite on the unit sphere. The key step in the proof is to show that, for $t \in (0,\pi)$ and $\|y\| =1$, the function $(t- d(\cdot,y))_+^\delta$ is positive definite if $\delta \ge d/2$.
Kerstin Hesse	Radial basis function approximation of noisy scattered data on the sphere	In geophysical applications, measured scattered data usually contains noise, and any approximation method should take this into account. In this talk we discuss the properties of a `smoothing approximation' of noisy scattered data on the sphere by a radial basis function approximant. The radial basis function approximant is the minimiser of a certain quadratic functional which depends on a smoothing parameter $lambda>0$ that balances between fitting the data and getting a smooth solution. For $lambdato 0$, we obtain the interpolation scenario. The procedure is an instance of penalised least-squares approximation and of Tikhonov regularisation. The radial basis function approximant is computed by solving a linear system with a positive definite matrix. A crucial question is how the smoothing parameter $lambda$ should be chosen depending on the noise level, and in this talk we consider one a posteriori strategy for choosing $lambda$, namely Morozov's discrepancy principle. For $lambda$ chosen with Morozov's discrepancy principle, we present order-optimal L_2-error estimates in terms of powers of the mesh norm and the noise level. A numerical test illustrates the theoretical work. This talk is about recent and ongoing joint work with Ian Sloan and Rob Womersley.



Yuguang Wang	Sparse Isotropic Regularization for Spherical Harmonic Representations of Random Fields on the Sphere	I will talk about sparse isotropic regularization for a random field on the unit sphere $\mathbb{S}^2$ in $\mathbb{R}^3$, where the field is expanded in terms of a spherical harmonic basis. A key feature is that the norm used in the regularization term, a hybrid of the ℓ_1 and ℓ_2-norms, is chosen so that the regularization preserves isotropy, in the sense that if the observed random field is strongly isotropic then so too is the regularized field. The Pareto efficient frontier is used to display the trade-off between the sparsity-inducing norm and the data discrepancy term, in order to help in the choice of a suitable regularization parameter. A numerical example using Cosmic Microwave Background (CMB) data is considered in detail. In particular, the numerical results explore the trade-off between regularization and discrepancy, and show that substantial sparsity can be achieved along with small L_2 error. This is joint work with Quoc T. Le Gia, Ian Sloan and Rob Womersley.
Johann Brauchart	Hyperuniformity on the sphere	Hyperuniformity was introduced by Torquato and Stillinger to describe idealised infinite point configurations, which exhibit properties between order and disorder. We are interested in studying an analogous property of sequences of point sets in compact spaces. For convenience we study the d-dimensional sphere. This talk reports on recent progress of joint work with P. Grabner (Graz University of Technology), W. Kusner (Vanderbilt University), and Jonas Ziefle (University of Tübingen)
Rob Womersley	Computation of spherical designs in higher dimensions	This talk considers the characterization and computation of spherical designs for the real unit sphere $\mathbb{S}^d$ in $\mathbb{R}^{d+1}$ and the complex unit sphere $\Omega(d)$ in $\mathbb{C}^d$. Although the most prominent case in applications is $\mathbb{S}^2$, this talk will focus on higher dimensions, $d \geq 3$ in the real case. Results of Yudin imply that a real sphercale t-design on $\mathbb{S}^d$ with the optimal order $N = O(t^d)$ for the number of points N has a covering radius that is also of the optimal order $O(N^{-1/d})$. Thus the interest is in efficient (low number of points N), spherical designs with both good covering and separation, and the relation to different notions of complex spherical designs.
Houying Zhu	Variable selection using MCQMC algorithm	Variable selection problem arises in many different areas, loosely speaking, it is aiming to find the best subset of explanatory variable ${X_1, …X_p}$, which is statistically significant to the response variable Y where response and explanatory variable may be related via logistic regression model. It is commonly raised in many different situations in medicine and biology. However, simply applying selection criterion such as AIC or BIC for an exhaustive search is computationally infeasible, even for p is moderately large. To overcome this problem, by defining a proper distribution on the set of candidate models via model section criteria, we reformulate the original problem as a sampling problem, then MCMC/MCQMC can be employed to tackle this problem. Both simulation and real data application have demonstrated the efficiency of the proposed method (This is a joint work with A/Prof. Guoqi Qian).
Michael Griebel	Manifold Learning by Sparse Grid Methods	High-dimensional problems and data often live in a lower-dimensional subspace or manifold with relatively small intrinsic dimension. In such cases it is possible to break the curse of dimension, i.e. to circumvent the exponential dependency on the high dimension in the complexity of associated algorithms, by transferring the problem approximatively into a representation which uses the intrinsic coordinates of the lower-dimensional subspace. We then may design algorithms whose complexity only depend (exponentially) on the dimension of this subspace. Unfortunately, neither the lower-dimensional subspace/manifold nor its (non-linear) coordinate system is usually known a-priori. We discuss how such lower-dimensional manifolds can be detected by sparse grid methods. This is joint work with Bastian Bohn (Bonn).



Hans de Sterck	Nonlinearly Preconditioned LBFGS and Nesterov Optimization Methods for Tensor Decompositions	Tensors are a natural way to represent multidimensional data. Low-rank tensor decompositions are used extensively in a range of fields, including signal processing, machine learning, chemometrics and statistics. Algorithms of alternating least squares (ALS) type are widely used for canonical polyadic (CP) and Tucker tensor decompositions, but they can converge slowly for difficult problems. In this talk, we derive nonlinear acceleration methods for ALS based on the limited memory BFGS (LBFGS) and Nesterov methods. Our approach starts from linear preconditioning ideas that use linear transformations encoded by matrix multiplications, and extends these ideas to the case of genuinely nonlinear preconditioning, where the preconditioning operation involves fully nonlinear transformations (as in ALS). Numerical results show that the nonlinearly preconditioned methods, when applied to large and noisy tensor problems, offer substantial improvements in terms of time-to-solution and robustness over state-of-the-art methods, including previously described acceleration methods for ALS based on nonlinear conjugate gradients (NCG) and nonlinear GMRES (a.k.a. Anderson acceleration). Our numerical tests also indicate that LBFGS acceleration is more efficient than Nesterov acceleration.



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