Abstracts

Monday, October 08th, 2018	
11:00 – 12:00	**Discrete conformal geometry of polyhedral surfaces** Feng Luo, Rutgers University *Abstract* We discuss some of the recent work on discrete conformal geometry of polyhedral surfaces. The following topics will be addressed: the relationship among discrete conformal geometry, convex surfaces in hyperbolic 3-space, and the Koebe circle domain conjecture, discrete uniformization for non-compact simply connected polyhedral surfaces, and the convergence of the discrete uniformization metrics to the Ponicare metric. This is a joint work with D. Gu, J. Sun, and T. Wu.
13:30 – 14:15 **SFB-Talk**	**Tri-partition of a simplicial complex** Herbert Edelsbrunner, IST Austria, Joint work with Katharina Oelsboeck *Abstract* We prove that for every simplicial complex, K, and every dimension, p, there is a partition of the p-simplices into a maximal p-tree, a maximal p-cotree, and the remaining p-simplices defining the p-th homology of K. Given a monotonic order of the simplices, this tri-partition is unique and can be computed by matrix reduction. Collecting the sets over all monotonic orders, we get matroids over the set of p-simplices. As an application, we consider the manipulation of the hole structure in geometric shapes, using the tri-partition to facilitate the opening and closing of holes in subcomplexes of K. In concrete applications, we let K be the Delaunay triangulation of a finite set, and we enhance the persistence diagram of the Euclidean distance function with the tri-partition to guide the opening and closing of holes in its alpha subcomplexes.
14:15 – 15:00 **SFB-Talk**	**Numerical Tracking of Ellipsoids in Stochastic Dynamics** Christian Kühn, TU München *Abstract* In this talk, I shall explain a method how to analyze certain aspects of stochastic dynamical systems from a purely deterministic, discrete, and geometric perspective. In particular, we study fluctuations around steady states in stochastic differential equations using ellipsoids calculated via Lyapunov matrix equations. The method will be embedded in a numerical

continuation framework to effectively study parametrized problems.
The main references for the presented work are:

- "Deterministic continuation of stochastic metastable equilibria via Lyapunov equations and ellipsoids", C. Kuehn, SIAM Journal on Scientific Computing, Vol. 34, No. 3, pp. A1635-A1658, 2012.
- "Numerical continuation and SPDE stability for the 2D cubic-quintic Allen-Cahn equation", C. Kuehn, SIAM/ASA Journal on Uncertainty Quantification, Vol. 3, No. 1, pp. 762-789, 2015.
- "Continuation of probability density functions using a generalized Lyapunov approach", S. Baars, J.P. Viebahn, T.E. Mulder, C. Kuehn, F.W. Wubs and H.A. Dijkstra, Journal of Computational Physics, Vol. 336, No. 1, pp. 627–643, 2017.
- "Combined error estimates for local fluctuations of SPDEs", C. Kuehn and P. Kürschner, arXiv.

Tuesday, October 09th, 2018

09:00 – 10:00

Noether's Theorem, one hundred years later
Elizabeth Mansfield, University of Kent

Abstract
It is now 100 years since Emmy Noether published her paper, “Invariante Variationsprobleme” containing the two theorems for which she is so famous amongst physicists. The first theorem, often referred to simply as “Noether’s theorem”, is used to connect symmetries with conserved quantities. The second is used to obtain dependencies amongst the Euler Lagrange equations.
In this talk I will illustrate progress, first in the understanding of the mathematical structure of Noether's laws, in terms of invariants and an equivariant moving frame, and second their adaptation to various discrete versions. In this last, the main theme has been to embed the laws, a priori, into numerical schemes, so that we can claim that the scheme truly incorporates the physical symmetries of the underlying model.
I will indicate how we may get around the famous 'no go' theorem of Ge and Marsden and achieve the incorporation of symmetries in a variational method. Numerical schemes include finite difference methods, where the results are startlingly similar to the those of the smooth case, and to finite element methods, where we must take a weak version of the law, in the functional analytic sense.
The talk incorporates joint work with Peter Hydon, Tristan Pryer, Gloria Mari Beffa, Ana Rojo-Echeburua and Linyu Peng.

10:30 – 11:30	**Elliptic bipartite dimers on isoradial graphs** Cédric Boutillier, Sorbonne University *Abstract* Isoradial graphs are infinite planar graphs embedded in the plane in such a way that all faces are inscribed in a circle of radius 1. We define a weight function on edges of any bipartite isoradial graph from the geometry of the embedding through theta functions. Without any assumption on periodicity, we obtain a family of Gibbs measures with a single gaseous measure, parameterized by a two-dimensional magnetic field. These measures are determinantal processes with a kernel whose entries for any two vertices are local, i.e. depend only on the geometry of the graph along a path between these vertices. When the graph and the weight function is periodic, the spectral curve is a Harnack curve of genus 1, and any Harnack curve of genus 1 can be realized this way. This construction degenerates to Kenyon's critical dimer weights when the elliptic parameter tends to 0, and generalizes constructions of inverse Kasteleyn operators in connection with the Z-invariant elliptic Ising model or massive Laplacian. This is joint work with David Cimasoni and Béatrice de Tilière.
13:30 – 14:15 **SFB-Talk**	**Recent advances on variational theory of integrable systems** Yuri Suris, TU Berlin *Abstract* We will discuss the notion of a pluri-Lagrangian structure, which should be understood as an analog of integrability for variational systems. This is a development along the line of research of discrete integrable Lagrangian systems initiated about a decade ago, however having its more remote roots in the theory of pluriharmonic functions, in the Z-invariant models of statistical mechanics and their quasiclassical limit, as well as in the theory of variational symmetries going back to E. Noether. We will discuss main features of pluri-Lagrangian systems in dimensions 1 and 2, both continuous and discrete, along with results on the continuum limit and with relations of this novel structure to more standard notions of integrability. We will also consider some applications of this structure, including the classical billiards in quadrics and the problem of commutativity of multi-valued maps (correspondences).

14:15 – 15:00 **SFB-Talk**	**Periodic Tangled Filaments** Myfanwy E. Evans, TU Berlin *Abstract* This talk will give a constructive approach to exploring tangled filaments in a periodic box, where hyperbolic line packings decorate triply-periodic minimal surfaces. A particular arrangement of tangled filaments will be explored in the context of keratin filaments in human skin cells, as well as the broader idea of geometric form as a consequence of the restoring force of a liquid. Finally, I will connect the idea of filament tangling with framework material design.
Wednesday, October 10th, 2018	
09:00 – 10:00	**Energies for shape comparison and alignment** Joel Hass, University of California, Davies *Abstract* Shape is a surface, with either a Riemannian or discrete metric. I will discuss energies that can be used for comparing shapes and for aligning them. One energy is based on conformal maps, and one on hyperbolic geometry. I will also discuss applications to biological data sets.
10:30 – 11:30	**Dynamics on lattices** Hermen Jan Hupkes, University of Leiden *Abstract* We study dynamical systems posed on lattices, with a special focus on the behaviour of basic objects such as travelling corners, expanding spheres and travelling waves. Such systems arise naturally in many applications where the underlying spatial domain has a discrete structure. Think for example of the propagation of electrical signals through nerve fibres, where the the myeline coating has gaps at regular intervals. Or the study of magnetic spins arranged on crystal lattices. Throughout the talk we will explore the impact that the spatial topology of the lattice has on the dynamical behaviour of solutions. We will discuss lattice impurities, the consequences of anistropy and make connections with the field of crystallography.

Thursday, October 11th, 2018

09:00 – 10:00

Embeddings of Simplicial Complexes: Some New Algorithmic Undecidability Results

Uli Wagner, IST Austria

Abstract

Given a finite simplicial complex K of dimension at most k, does K admit a (piecewise-linear) embedding into d-dimensional Euclidean space? More generally, given a subcomplex A of K and an embedding f of A, can f be extended to an embedding of K? These are classical questions in geometric topology. Here, we are interested in the computational complexity of these decision problems, which we will refer to as the embeddability problem and the relative embeddability problem, respectively.

In the so-called metastable range d≤3(k+1)/2, a classical theorem of Haefliger and Weber guarantees that both questions are equivalent to an (equivariant) homotopy-theoretic extension problem, which was shown to be polynomially-time solvable (for fixed k and d) by Čadek, Krčal, and Vokřınek, building on a series of papers on computational homotopy theory. Outside the metastable range, in joint work with Matoušek and Tancer, we showed that the embeddability problem is algorithmically undecidable if the codimension d-k is at most 1, and that the general case is at least NP-hard.

Here, we present an approach for obtaining new undecidability results outside the metastable range, in codimension 3 and higher. As an example result, we show that the relative embeddability problem is undecidable if d=8 and k=5.

Joint work with Marek Filakovský and Stephan Zhechev

10:30 – 11:30

Shape from Metric

Albert Chern, TU Berlin

Abstract

We study the isometric immersion problem: given a triangle mesh with only lengths of edges known, map the mesh to 3D isometrically as an immersed surface. To address this challenge we develop a discrete theory for surface immersions into 3D. In particular the theory correctly represents the topology of the space of immersions, i.e., the regular homotopy classes. Our approach relies on unit quaternions to represent triangle orientations and to encode, in the spin connection, the regular homotopy class. In unison with this theory we develop a computational apparatus based on a variational principle. Minimizing a non-linear Dirichlet energy optimally finds extrinsic geometry for the given intrinsic geometry and ensure low metric approximation error. We demonstrate our algorithm with

	a number of applications from mathematical visualization and art directed isometric shape deformation, which mimics the behavior of thin materials with high membrane stiffness.
13:30 – 14:15 **SFB-Talk**	**Conformally equivalent triangular lattices: C^\infty convergence, conformal symmetry and a generalization** Ulricke Bücking, TU Berlin *Abstract* Two triangle meshes are discretely conformally equivalent if for any pair of incident triangles the absolute values of the corresponding cross-ratios of the four vertices agree. We consider two conformally equivalent planar triangle meshes as preimage and image of a discrete conformal map and restrict to the case where the preimage is part of a triangular lattice T with strictly acute angles. We show that a smooth conformal map f can be approximated on a compact subset by such discrete conformal maps f^\epsilon, defined on scaled lattices \epsilon T. Moreover, the convergence is in C^\infty and the cross-ratios of pairs of incident triangles are related to the Schwarzian derivative of f. Focussing on these cross-ratios and their properties, we study the class of conformally symmetric triangular lattices. Finally, we motivate a generalized notion of discrete conformal maps based on cross-ratios.
14:15 – 15:00 **SFB-Talk**	**The maximal fluctuation estimate of Wulff shapes on lattices** Marco Cicalese, TU München *Abstract* We briefly review the quantitative isoperimetric inequality (QII). Then we discuss a possible application of quantitative estimates to study rates of convergence of asymptotic minimisers of sequences of energies. As a result, we find an elementary proof, via QII, of the sharp asymptotic estimate for the maximal fluctuation of Wulff shapes on several lattices.

Friday, October 12th, 2018	
09:00 – 10:00	**Commuting Hamiltonian Flows on Space Curves** Franz Pedit, University of Massachusetts Amherst *Abstract* In this lecture we will discuss the structure of the infinite dimensional manifold of space curves as a phase space of an infinite dimensional completely integrable system. This manifold admits an infinite hierarchy of energy functionals, for instance, length, total torsion, elastic energy, projected area etc., whose Hamiltonian flows are avatars of the non-linear Schrödinger hierarchy. Consistently working within the geometric setting of space curves, rather than with their derived invariants such as curvature, will clarify the role of the various ingredients of infinite dimensional integrable systems: loop algebras and groups, zero curvature equations, Lax pairs, spectral curves, stationary solutions, and Darboux transformations. In addition to new characterizations of elastic curves via isoperimetric conditions, our geometric setup can conceivably be extended to surfaces in 4-space.
10:30 – 11:30	**Weak-average case computational complexity, with applications in geometry and numerical algorithms** Martin Lotz, University of Warwick *Abstract* In many areas of computational mathematics there is a considerable gap between provable performance guarantees for algorithms and practical experience. Attempts to address this problem, for example using average-case or smoothed analysis, suffer from often unreasonable assumptions and often still don't manage to close the gap. We present an approach that gives a more realistic picture of the computational complexity landscape, based on the simple idea that excluding a "numerically invisible" set from the input space of a problem can lead to exponential (or more) improvements in performance bounds. We illustrate this approach with some simple examples from numerical analysis and optimization, and then some more involved examples such as singular polynomial eigenvalue problems and computational topology. Based on joint work with D.Amelunxen (Hong Kong) and V.Noferini (Essex)