Welcome to the

Special Semester on New Trends in Calculus of Variations

Linz, October 13 – December 12, 2014

http://www.ricam.oeaw.ac.at/specsem/specsem2014

Organizer

Maïtine Bergounioux, Universite d'Orleans, France

Local Organizer

Karl Kunisch, University of Graz & RICAM, Austria
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Workshops

Workshop 1: Shape and topological optimization
October 13-17, 2014

Workshop 2: Variational methods in imaging
October 27-31, 2014

Workshop 3: Geometric control and related fields
November 17-21, 2014

Workshop 4: Optimal Transport in the Applied Sciences
December 08-12, 2014

Schools

School 1: Imaging
October 22-24, 2014

School 2: Optimal Transport in the Applied Sciences
December 02-05, 2014

Workshop 1: Shape and topological optimization
October 13-17, 2014

Organizers

Édouard Oudet, Université Joseph Fourier Grenoble, France
Martin Rumpf, Universität Bonn, Germany

Main topics

The optimization of geometry and topology of shapes with applications in engineering and geometry processing requires the combination of a variety of mathematical tools among them different implicit shape representations, relaxation theory, homogenization, duality techniques, and optimal transportation methods. The workshop will bring together experts on geometry, regularity theory, structural mechanics, numerical analysis, and optimization to discuss recent trends, identify synergies between different disciplines, and explore new directions.

List of speakers

Gregoire Allaire (Paris)
Andrés León Baldelli (Oxford)
Soeren Bartels (Freiburg)
Eric Bonnetier (Grenoble)
Elie Bretin (Lyon)
Dorin Bucur (Chambery, France)
Blanche Buet (Lyon)
Giuseppe Buttazzo (Pisa)
Charles Dapogny (Rutgers)
Ilaria Fragala (Milan)
Pedro Freitas (Lisbon)
Harald Garcke (Regensburg)
Helmut Harbrecht (Basel)
Antoine Henrot (Nancy)
Michael Hintermüller (Berlin)
Francois Jouve (Paris)
Victor Kovtunenko (Graz)
Simon Masnou (Lyon)
Georgios Michailidis (Paris)
Yannick Privat (Paris)
Michael Stingl (Erlangen)
Anca-Maria Toader (Lisboa)
Bozhidar Velichkov (Pisa)
David Vicente (Orléans)
Benedikt Wirth (Münster)

Abstracts

"*A LINEARIZED APPROACH TO WORST-CASE DESIGN IN SHAPE OPTIMIZATION*"

Grégoire ALLAIRE CMAP, Ecole Polytechnique

Abstract

The purpose of this work is to propose a deterministic method for optimizing a structure with respect to its worst possible behavior when a 'small' uncertainty exists over some of its features. The main idea of the method is to linearize the considered cost function with respect to the uncertain parameters, then to consider the supremum function of the obtained linear approximation, which can be rewritten as a more classical function of the design, owing to standard adjoint techniques from optimal control theory. The resulting "linearized worst-case" objective function turns out to be the sum of the initial cost function and of a norm of an adjoint state function, which is dual with respect to the considered norm over perturbations. This formal approach is very general, and can be justified in some special cases. In particular, it allows to address several problems of considerable importance in both parametric and shape optimization of elastic structures, in a unified framework. This is a joint work with Charles Dapogny (LJK, CNRS).

"*Quasi-periodic fracture patterns in thin films under homogeneous loads*"

Andrés A. León Baldelli Mathematical Institute, Oxford University, Oxford, UK

Abstract

Structuration of complex crack patterns, observed in three- and two-dimensional systems under tensile loads, can be successfully tackled with the Variational Approach to fracture. Unlike in other approaches, mechanisms of crack path selection follow an energetic argument of unilateral stability. Based on a first order, linear, two-dimensional, variational model of a brittle thin film issued from asymptotic analysis, I will show the numerical impolementation of the fracture problem and a large-scale numerical investigation of the emergence of morphologically robust complex patterns of quasi-periodic transverse cracks, in competition with mechanisms of interfacial debonding. In such fragmentation regime, energy minimizers feature the hexagonal tessellation of the pristine material and peripheral interfacial debonding. Furthermore, evolution of crack patterns along monotonic load paths is constrained by the physical irreversibility constraint.

This is a joint work with B. Bourdin, Department of Mathematics and Center for Computation & Technology, Louisiana State University, Baton Rouge, LA, USA, and C. Maurini, Sorbonne University, UPMC Univ Paris 6, CNRS, UMR 7190 Institut Jean Le Rond d'Alembert, Paris, France.

"*Numerical solution of bilayer bending problems*"

Sören Bartels Department of Applied Mathematics, University of Freiburg, Germany

Abstract

Thin elastic bilayer structures arise in various modern applications, e.g., in the fabrication of nanotubes or microgrippers. The mechanical behavior is characterized by large isometric deformations with large curvature in one direction. The mathematical modeling leads to a nonlinear fourth order problem with nonlinear pointwise constraint. The reliable and efficient numerical treatment is therefore challenging. We prove the convergence of a finite element discretization within the framework of Γ-convergence and discuss the convergence of an iterative solution method. The work is based on results by Friesecke, James, and Müller (2002) as well as Schmidt (2007,) and extends methods for the approximation of large bending problems. The talk represents joint research with Andrea Bonito (Unversity of Texas, A& M) and Ricardo H. Nochetto (University of Maryland, College Park).

"*On phase field approximations of Willmore Flow*"

Bretin Elie ICJ, INSA de Lyon, Batiment Leonard de Vinci, France

Abstract

This presentation introduces two different phase field models for the approximation of Willmore flow. For each of the models, I will analyze its sharp interface limit and I will present a series of numerical simulations to illustrate their behavior in both smooth and singular situations. Finally, I will explain how to take into account efficiently some additional constraints on the area and on the volume of the evolving interfaces. Most of this work has been done in collaboration with Edouard Oudet and Simon Masnou.

"*Evolution laws for some models of materials combining plasticity and fracture*"

Eric Bonnetier Laboratoire Jean Kuntzmann, Université de Grenoble-Alpes, Grenoble France

Abstract

We study models of materials that can combine several mechanisms of energy dissipation: plasticity, visco-plasticity or visco-elasticity and fracture. The latter is in fact regularized using the Ambrosio-Tortorelli functional in the spirit of the work of B. Bourdin, G. Francfort and J.J. Marigo: the shape of cracks is approximated by a phase field. Fixing the associated regularization parameter, we define time evolutions as limits of sequences of solutions to semi-discretized problems when the time step tends to 0. We show existence of time evolutions in cases where we can control the product of the local elastic energy density with the phase field. We report some numerical simulations that show that the dissipation mechanisms may be non exclusive. This is joint work with L. Jakabčin and S. Labbé.

"*Shape optimization with Robin boundary conditions*"

Dorin Bucur Laboratoire de Mathmatiques (LAMA) UMR 5127, Universit de Savoie, France

Abstract

In this talk I will discuss shape optimization problems with Robin boundary conditions on the free part. For general shape functionals, the existence of a solution may not occur, but for a suitable class of energy type functionals one can prove the existence of a solution and some partial regularity results. The main tools are of free discontinuity type. As main example, one could consider the minimization of the first Robin eigenvalue of the Laplacian, among arbitrary open sets of prescribed measure, contained in a given design region.

"*Discrete vanifolds and regularization of the generalized curvature*"

Blanche Buet Institut Camille Jordan, Université Lyon 1, France

Abstract

We investigate a volumetric surface discretization model that aims at being both accurate and able to handle the presence of singularities (singularities like in soap films and bubbles for instance). We believe that it could be a suitable tool to handle in a general setting the minimization of functionals defined on surfaces as the area functional or the Willmore functional. The idea to build this discrete object is simple: given a surface and some mesh of the space, each cell is associated with a non-negative number (the area in the cell) and a plane (a mean tangent plane). This is a natural way to discretize surfaces in the spirit of varifolds and it has the advantage to extend easily to any finite dimension or codimension. Varifolds have proved to be useful when dealing with geometric variational problems in the continuous setting since they were introduced by F. Almgren as he was interested in finding critical points of the area functional in a broader class than parametrized surfaces. A sub-class of varifolds, called integral (rectifiable) varifolds provide a set of generalized surfaces with compactness properties and a consistent notion of generalized curvature (called first variation). The point is that not only the discretization we propose can be endowed with a structure of varifold but also a great part of objects used for surface representation and discretization (triangulation, cloud points, level sets etc.) so that we can use varifolds tools to study in some unified setting different way of discretizing surfaces.

An important point to overcome is that these structures are generally not rectifiable (i.e. not regular enough) so that we address the following question: how to ensure that the limit of a sequence of such discrete surfaces is regular? or in a more technical way, what conditions on a sequence of varifolds (not supposed rectifiable nor with bounded variation) ensure that the limit varifold has bounded first variation? The first variation is not well-adapted to discrete structures that is why we define a regularized form of the first variation, allowing us to exhibit an energetic condition ensuring that a limit of a sequence of varifolds has bounded first variation. We use this regularized form to build approximate Willmore energies Γ–converging in the class of varifolds to the Willmore energy. This regularized first variation also provides a notion of approximate curvature, allowing to recover both regular and singular part of the curvature, which we numerically test. It is a joint work with my advisors Gian Paolo Leonardi and Simon Masnou.

"*Dirichlet-Neumann shape optimization problems*"

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Abstract

We consider spectral optimization problems of the form

$$\min\Big\{\lambda_1(\Omega;D):\ \Omega\subset D,\ |\Omega|=1\Big\},$$

where D is a given subset of the Euclidean space $\mathbb{R}^d$. Here $\lambda_1(\Omega;D)$ is the first eigenvalue of the Laplace operator $-\Delta$ with Dirichlet conditions on $\partial\Omega\cap D$ and Neumann or Robin conditions on $\partial\Omega\cap\partial D$. The equivalent variational formulation

$$\lambda_1(\Omega;D)=\min\Big\{\int_\Omega|\nabla u|^2\,dx+k\int_{\partial D}u^2\,d\mathcal{H}^{d-1}\ :\ u\in H^1(D),\ u=0\text{ on }\partial\Omega\cap D,\ \|u\|_{L^2(\Omega)}=1\Big\}$$

reminds the classical drop problems, where the first eigenvalue replaces the total variation functional. We prove an existence result for general shape cost functionals and we show some qualitative properties of the optimal domains.

"*A level-set based mesh evolution method for shape optimization*"
Charles Dapogny Department of Mathematics, Rutgers University, New Brunswick (NJ), USA

Abstract

The purpose of this joint work with Grégoire Allaire and Pascal Frey is to propose an original numerical method for shape and topology optimization in two and three space dimensions, which allows to account for arbitrarily large deformations of the shape from one iteration to the next while benefiting from the accuracy of an explicitly discretized shape at each iteration of the evolution process.

The key idea is to combine two descriptions of a shape - namely a meshed representation and an implicit representation (using the framework of the level set method) -, switching consistently from one to the other depending on their relevance with respect to the operation of interest:

- Equipping a shape Ω with a simplicial mesh $\mathcal{T}$ (i.e. composed of triangles in $2d$, of tetrahedra in $3d$) is an efficient way to perform accurate mechanical analysis on it (e.g. to calculate the Von Misses stress in the context of linear elastic structures) by using the Finite Element method;
- The level set method is one method of choice for tracking the motion of an evolving shape $\Omega(t)$ with respect to a given velocity field V; it mainly consists in describing $\Omega(t)$ via a scalar function $\phi(t,\cdot)$ defined on the whole ambient space $\mathbb{R}^d$ (a large computational domain D in numerical practice), in which case the motion of the shape can be rephrased as a PDE for ϕ.

The main ingredients of the proposed mesh evolution method are the following two operators, which enable comings and goings between these two complementary descriptions of shapes:

- On the one hand, a numerical algorithm for calculating the signed distance function d_Ω to a domain Ω (e.g. supplied by the datum of a mesh) at the vertices of a (simplicial) mesh $\mathcal{T}$ of a computational domain D.
- Conversely, a meshing algorithm for implicit geometries, that is, a numerical method for meshing the negative subdomain of a scalar function $\phi: D\to\mathbb{R}$ defined at the vertices of a (simplicial) mesh of D.

"*Geometric issues in PDE problems at infinity*"
Ilaria Fragalà Politecninco di Milano

Abstract

This talk will be focused on some topics regarding the interplay between geometry and PDEs.

We shall start from two PDE problems which to some extent can be seen as the limit, for $p\to+\infty$, of Serrin's overdetermined problem for the p-Laplacian. Inspired and motivated by these problems, we shall move to geometry by giving some new results for shapes in the Euclidean space, which may have an autonomous interest. Finally we shall go back to PDEs to see what the geometric results entail.

Based on some recent joint works with Graziano Crasta (Università di Roma "La Sapienza").

"*Sharp inequalities for eigenvalues of the Laplace operator with Robin boundary conditions*"
Pedro Freitas Universidade de Lisboa

Abstract

We give a counterexample to the long standing conjecture that the ball maximises the first eigenvalue of the Robin eigenvalue problem with negative parameter among domains with the same volume. Furthermore, we show that the conjecture holds in two dimensions, provided that the boundary parameter is small. These results are complemented with a numerical study, including an exploration of the behaviour of higher eigenvalues.

This is joint work with David Krejčiřík and P.R.S. Antunes.

"*Phase Field Approaches for Shape and Topology Optimization* "

Harald Garcke Universität Regensburg, Fakultät für Mathematik, Germany

Abstract

Shape and topology optimization problems for structural and fluid optimization problems are solved with a phase field method. In this approach a perimeter regularization will be approximated by a Cahn-Hiliard type energy. In the talk I will derive first order necessary conditions and discuss the sharp interface limit of the phase field method. Finally, I will present numerical computations which demonstrate that the approach can be applied for complex shape and topology optimization problems.

"*Comparison of formulations and strategies for thickness control in shape and topology optimization via a level-set method* "

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Abstract

(joint work with Prof. ALLAIRE Grégoire and Prof. JOUVE François)

Shape and topology optimization methods usually result in optimized structures that violate industrial fabrication constraints related to a notion of thickness. For example, in casting, too thick, thin, or closely spaced features should be avoided. Post-treating the optimized shape is usually a non-trivial task and can lead to a complete loss of its optimal characteristics. Therefore, it seems preferable to integrate thickness constraints in the optimization algorithm.

A first difficulty towards this direction is the formulation of thickness constraints for continuous structures. Different approaches have been presented in the literature, which present significant differences between them. Moreover, different strategies for their application can be followed that can result in very different optimized shapes.

We compare several formulations for imposing a maximum or minimum feature size, in the framework of shape and topology optimization using the level-set method. We focus both on theoretical and numerical problems in their application and show numerical results.

"*On parametric shape optimization*"

Helmut Harbrecht Mathematisches Institut, Universität Basel

Abstract

Shape optimization is indispensable for designing and constructing industrial components. Many problems that arise in application, particularly in structural mechanics and in the optimal control of distributed parameter systems, can be formulated as the minimization of functionals defined over a class of admissible domains.

The present talk aims at surveying on parametric shape optimization with elliptic or parabolic state equation. Especially, the following items will be addressed:

- first and second order optimality conditions
- the discretization of shapes
- existence and convergence of approximate shapes
- efficient numerical techniques to compute the state equation.

"*Elastic energy, total mean curvature and isoperimetric inequalities*"

Antoine Henrot Institut Élie Cartan - Université de Lorraine

Abstract

Following L. Euler, we define the elastic energy of a plane regular compact set $K \subset \mathbb{R}^2$ as $E(K) = \frac{1}{2}\int_{\partial K} C^2 ds$ where C is the curvature of the boundary. We will denote by $A(K)$ the area of K. In this talk, we investigate the problem $\min\{E(K), A(K) = A_0$ and prove the new isoperimetric inequality $A(K)E(K)^2 \geq \pi^3$ for simply connected domains (with equality only for the disk). We also look for similar inequalities in three dimension. In particular we look at the minimization of the total mean curvature $\int_\Sigma H$ where H is the mean curvature of the surface Σ. This is joint works with Dorin Bucur (in 2-D), Jérémy Dalphin, Simon Masnou and Takéo Takahashi (in 3-D).

"*Shape and Topological Sensitivity Based Methods in Tomographic Reconstruction and Image Segmentation*"

Michael Hintermüller Humboldt-Universität zu Berlin, Institute for Mathematics, Germany

Abstract

For various tomographic reconstruction tasks, including electrical impedance, fluourescent optical diffusion or magentic induction tomography, respectively, topological sensitivity calculus is developed in order to detect hidden inclusions in the region of interest. It is further demonstrated that higher order expansions are required to obtain reliable topological indeitification. In a second part of the talk, topological sensitivities are used for image segmentation based on the Mumford-Shah functional. Besides the segmentation, the handling of image modulations due to coil sensitivities in MRI is discussed.

"*Recent Advances in Shape and Topology Optimization via the Level Set Method in an Industrial Context*"

Franois Jouve Laboratoire J.L.Lions, University Paris Diderot (Paris 7), Paris, France

Abstract

Joint work with Grgoire Allaire and Georgios Michailidis (CMAP, Ecole Polytechnique, Palaiseau, France), and supported by the Rodin consortium.

Shape and topology optimization via the level set method has started attracting the interest of an increasing number of researchers and industrial designers over the past years. A large number of academic problems, using various objective functions and constraints, have been successfully treated with this class of methods, showing its efficiency and flexibility.

But real industrial applications may involve more complex and mixed constraints than classical optimal design problems. Moreover, they are sometimes not easy to formulate from a mathematical point of view, and even more difficult to handle numerically. Examples of such real life problems will be shown at the conference.

"*Object identification based on optimality conditions. Helmholtz problem*"

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Abstract

This is joint work with Karl Kunisch (University of Graz).

The problem of identification of a geometric object and reconstruction of its geometric and physical parameters from given measurements has numerous applications in the engineering and biomedical sciences in the context of nondestructive testing. From a mathematical point of view, object identification is an inverse problem, which belongs to the field of shape and topology optimization. Methods of topological analysis are inherently connected with singular perturbations. In fact, for the task of identification, a trial geometric object put in a test domain is examined by reducing the trial object from a finite to an infinitesimal one. Classic methods, however, are frequently restricted to simple shapes of the test object given in parameterized form and to prescribed boundary conditions. Commonly, either Dirichlet (the sound soft) or Neumann (the sound hard) conditions are assumed a-priori. For identifying arbitrary geometric and physical variables, we suggest a Robin type (the surface impedance) condition with unknown parameter, which plays a crucial role. Within iterative approaches, a geometric test object is reconstructed iteratively in the descent direction of an objective function. However, iterative methods have large computational costs. Within non-iterative approaches, a test object is to be reconstructed directly from a far field asymptotic pattern. There are well known sampling and probe techniques. Nevertheless, the main difficulty concerns numerical instability and low resolution of imaging in the discrete counterpart. To improve stability and resolution properties of object imaging we suggest a novel direct approach based on optimality conditions and level sets. We utilize the necessary optimality conditions for finding extrema of an objective function with respect to trial geometric variables. Henceforth we can reconstruct the test object directly from the extremal values which associate an imaging function with respect to input data and measured output data. For geometric realization of the imaging function deduced from proper measurements, we relate the respective (multiple) images to level set functions. Hence, the test object can be imaged precisely from its zero sets. As result we obtain a robust and highly accurate numerical method for object identification. The optimality conditions based concept has a broad scope. Here we specify in detail the model Helmholtz problem. From optimality conditions of the respective objective functional the imaging function is derived which is suitable for high precision identification of the center an arbitrary geometric object under unknown boundary conditions. For its numerical implementation we suggest an original Petrov-Galerkin based enrichment method within generalized FEM. This improves significantly the accuracy of discretization in comparison with the standard solvers of the Helmholtz equation.

The research is supported by the Austrian Science Fund (FWF) in the framework of the SFB F32 "Mathematical Optimization and Applications in Biomedical Sciences" and the research projects P26147-N26.

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[2] V.A. Kovtunenko, State-constrained optimization for identification of small inclusions, Proc. Appl. Math. Mech. 11 (2011), 721-722.

"*A new phase field model for the approximation of interfacial energies of multiphase systems*"

Simon Masnou Institut Camille Jordan, University Lyon 1, France

Abstract

We address the problem of approximating the interfacial energies of multiphase systems which can be found in material sciences or image processing. We propose a new multiphase field approximation model which has several advantages when the surfaces tensions satisfy a suitable embedding property (namely the ℓ^1-embeddability):

1. the Γ–convergence to the multiphase perimeter can be proven;
2. the model can be explicitly derived from the surface tensions;
3. it is convenient for the robust numerical approximation of the associated gradient flow, and we study several applications.

It is a joint work with Elie Bretin (Institut Camille Jordan, INSA Lyon, France)

"*Optimal shape and location of actuators or sensors in PDE models*"

Yannick Privat CNRS & Universit Pierre et Marie Curie (Paris 6) Laboratoire Jacques-Louis Lions

Abstract

We investigate the problem of optimizing the shape and location of actuators or sensors for evolution systems driven by a partial differential equation, like for instance a wave equation, a Schrdinger equation, or a parabolic system, on an arbitrary domain Omega, in arbitrary dimension, with boundary conditions if there is a boundary, which can be of Dirichlet, Neumann, mixed or Robin. This kind of problem is frequently encountered in applications where one aims, for instance, at maximizing the quality of reconstruction of the solution, using only a partial observation. From the mathematical point of view, using probabilistic considerations we model this problem as the problem of maximizing what we call a randomized observability constant, over all possible subdomains of Omega having a prescribed measure. The spectral analysis of this problem reveals intimate connections with the theory of quantum chaos. More precisely, if the domain Omega satisfies some quantum ergodic assumptions then we provide a solution to this problem. These works are in collaboration with Emmanuel Trlat (Univ. Paris 6) and Enrique Zuazua (BCAM Bilbao, Spain).

"*The Adjoint Method in Optimization of Eigenvalues and Eigenmodes*"

Anca-Maria Toader CMAF, Av. Prof. Gama Pinto, 2, 1649-003 Lisboa, and Faculdade de Cincias da Universidade de Lisboa

Abstract

The Adjoint Method goes back to the works of Pontryagin in the framework of Ordinary Differential Equations. In the eighties, J. Cea employed the Adjoint Method in a practical way, from the perspective of Lagrange multipliers. Since then, applications of the Adjoint Method were successfully used in Shape Optimization, Topology Optimization and very recently to optimize eigenvalues and eigenmodes (eigenvectors). The main contribution of this study is to show how the Adjoint Method is applied to the optimization of eigenvalues and eigenmodes. The general case of an arbitrary cost function will be detailed. In this framework, the direct problem does not involve a bilinear form and a linear form as usual in other applications. However, it is possible to follow the spirit of the method and deduce N adjoint problems and obtain N adjoint states, where N is the number of eigenmodes taken into account for optimization. An optimization algorithm based on the derivative of the cost function is developed. This derivative depends on the derivatives of the eigenmodes and the Adjoint Method allows one to express it in terms of the the adjoint states and of the solutions of the direct eigenvalue problem. This method was applied in [1] for material identification purposes in the framework of free material design. In [2] this study is applied to optimization of microstructures, modeled by Bloch wave techniques.

References [1] S. Oliveira, A.-M. Toader, P. Vieira, Damage identification in a concrete dam by fitting measured modal parameters. Nonlinear Analysis: Real World Applications, 13, Issue 6, 2888-2899, 2012. [2] C. Barbarosie, A.-M. Toader, The Adjoint Method in the framework of Bloch Waves (in preparation).

"*A New Algorithm for the Optimal Design of Anisotropic Materials*"

Michael Stingl Department of Mathematics, Friedrich-Alexander-Universität Erlangen-Nürnberg

Abstract

A new algorithm for the solution of optimal design problems with control in parametrized coefficients is discussed. The algorithm is based on the sequential convex programming idea, however, in each major iteration a model is established on the basis of the parametrized material tensor. The potentially nonlinear parametrization is then treated on the level of the sub-problem, where, due to block separability of the model, global optimization techniques can be applied. Theoretical properties of the algorithm are discussed. The effectiveness of the algorithm in terms of computation time as well as quality of the solution with respect to global lower bounds is demonstrated by a series of numerical examples. Examples range from free material optimization problems via parametric and discrete material optimization problems (e.g. optimal orientation problems) to two-scale material design.

"*Lipschitz continuity of eigenfunctions on optimal sets*"

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Abstract

This talk is based on a recent joint work with Dorin Bucur, Dario Mazzoleni and Aldo Pratelli, in which we study the optimal sets $\Omega^* \subset \mathbb{R}^d$, of unit measure, for very general spectral functionals $F\big(\lambda_1(\Omega), \dots, \lambda_p(\Omega)\big)$,

$$\min\big\{F\big(\lambda_1(\Omega), \dots, \lambda_p(\Omega)\big) \ : \ \Omega \subset \mathbb{R}^d,\ |\Omega| = 1\big\},$$

the main result being the global Lipschitz regularity of the eigenfunctions $u_1, \dots, u_p \in H_0^1(\Omega^*)$ of the Dirichlet Laplacian on the optimal set Ω^*.

In this talk we will concentrate our attention to the special case

$$F\big(\lambda_1(\Omega), \dots, \lambda_p(\Omega)\big) = \lambda_k(\Omega),$$

and we will obtain the precise bound on the global Lipschitz constant of the kth eigenfunction u_k on the optimal domain Ω_k, extended by zero on its complementary

$$-\Delta u_k = \lambda_k(\Omega_k) u_k \quad \text{in} \quad \Omega_k, \qquad u_k = 0 \quad \text{on} \quad \mathbb{R}^d \setminus \Omega.$$

The main technical difficulty in this case comes from the estimate of the gradient $|\nabla u_k|$ on the boundary $|\partial \Omega_k|$.

"*Anisotropic Energy for detection of thin tubes and its* Γ*-convergence approximation*"

David Vicente University of Orlans, France

Abstract

Detecting thin objects in 3D volumes, for instance vascular networks in medical imaging, has been of interest for some time. Particularly, tubular objects are everywhere elongated in one principal direction which varies spatially and are thin in the other two perpendicular directions. In this talk, we introduce an energy functional which depends on a pair $(f, \mathbf{g})$ where f is a function and $\mathbf{g}$ is a riemannian metric which captures the local geometry of the image g. The metric is in a domain suitable for tubular geometry. Formally, the energy takes the form

$$\int_\Omega (f-g)^2 \mathrm{d}x + \alpha \int_{S_f} \mathbf{g}(x, \boldsymbol{\nu}_f)^{\frac{1}{2}} \mathrm{d}\mathcal{H}^{n-1} + \beta \|\mathbf{g}\|_{W^{1,r}(\Omega)} + \gamma \int_{\Omega \setminus S_f} |\nabla f|^2 \mathrm{d}x.$$

This functional is derived from the energy introduced by Mumford and Shah, excepted for the second and the third terms which may be interpreted as the anisotropic surface with respect to the dual metric plus a regularization term for the metric. Its appropriate domain for f is the set of special functions with bounded variation SBV. We prove an existence result for the minimizing problem. Then, we perform an approximation in the sense of Γ-convergence and prove it. Finally, we show numerical results.

"*Optimal fine-scale structures in composite materials*"

Benedikt Wirth Institute for Computational and Applied Mathematics, Einsteinstraße 62, 48149 Münster, Germany

Abstract

A very classical problem consists in optimizing the structure of a composite material, for instance to achieve high rigidity against a prescribed mechanical loading. In the simplest case, the material is a composite of void and the elastic base material. The problem then reduces to finding the optimal topology and geometry of the structure. One typically aims to minimize a weighted sum of material volume, structure perimeter, and structure compliance (a measure of the inverse structure stiffness). This task is not only of interest for optimal material designs, but also represents a prototype problem to better understand biological structures. The high nonconvexity of the problem makes it impossible to find the globally optimal design; if in addition the weight of the perimeter is chosen small, very fine material structures are optimal that cannot even be resolved numerically. However, one can prove an energy scaling law that describes how the minimum of the objective functional scales with the model parameters. Part of such a proof involves the construction of a near-optimal design, which typically exhibits fine multi-scale structure in the form of branching and which gives an idea of how optimal geometries look like. (Joint with Robert Kohn)

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Garcke	Harald	University Regensburg	harald.garcke@ur.de
Geihe	Benedict	Bonn University	benedict.geihe@ins.uni-bonn.de
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Harbrecht	Helmut	University of Basel	helmut.harbrecht@unibas.ch
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Jouve	François	Université Paris Diderot	jouve@ljll.univ-paris-diderot.fr
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Kovtunenko	Victor	University of Graz	victor.kovtunenko@uni-graz.at
Kunisch	Karl	KFU graz	karl.kunisch@uni-graz.at
León Baldelli	Andrés A	University of Oxford	a.leon.baldelli@gmail.com
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Masnou	Simon	University of Lyon 1	masnou@math.univ-lyon1.fr
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Misur	Marin	University of Zagreb	pfobos@gmail.com
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Nardi	Giacomo	Ecole Normale Superieure de Cachan	nardi@ceremade.dauphine.fr
Oudet	Edouard	Université Joseph Fourier	edouard.oudet@imag.fr
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Privat	Yannick	CNRS & Univ. Pierre et Marie Curie (Paris 6)	yannick.privat@upmc.fr
Provenzano	Luigi	Università degli Studi di Padova	proz@math.unipd.it
Ring	Wolfgang	University of Graz	wolfgang.ring@uni-graz.at
Rodrigues	Sergio	RICAM, OeAW	sergio.rodrigues@ricam.oeaw.ac.at
Ruffini	Berardo	Institut Fourier, Grenoble	berardo.ruffini@sns.it
Rumpf	Martin	University of Bonn	martin.rumpf@uni-bonn.de

Scherzer	Otmar	Ricam	otmar.scherzer@univie.ac.at
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ÖAW
Austrian Academy of Sciences

RICAM
JOHANN · RADON · INSTITUTE
FOR COMPUTATIONAL AND APPLIED MATHEMATICS

General Information

Some useful pieces of information.
Please READ CAREFULLY.
Thank you!

ACCOMMODATION

for our invited speakers and for those who receive financial support we have booked rooms at:

University Guesthouse: "Hotel Sommerhaus"
Address: Julius-Raab-Straße 10, 4040 Linz
http://www.sommerhaus-hotel.at/en/
Check-in desk: open from 0-24 h; English speaking

Breakfast included, Shower/toilet in every room, 10 minutes walk to university, indoor swimming pool, internet connection in every room, fitness room, music room...

If support on accommodation has been agreed upon by the organizers, accommodation will directly be paid by RICAM (those with double rooms shared with a non participating person, will be asked to pay for the difference themselves when they move out).

For the regular participants: please take care for your own bookings. You can find recommendations of Hotels on our website!

REIMBURSEMENT

to all who have been granted support:
Keep ALL the ORIGINAL RECEIPTS (boarding passes, passenger receipts, train tickets, taxi receipts, tram/bus tickets ... **everything**) otherwise we will NOT be able to transfer money to your accounts!!!
There is NO CASH involved in the reimbursements.
In Linz you will receive a form where you can write down all your expanses and hand it in.

YOU CAN REACH RICAM VIA

Linz Airport to university and hotel:
Shuttle bus (see link below) to main train station and then take tram
http://www.flughafen-linz.at/www/cm/en/passengers/approach/bus.html
or taxi (approx. 40 Euro).

Linz main train station (“Linz Hauptbahnhof”, Hauptbhf.) to university and hotel:
Purchase with cash **a MIDI** (1 hour, € 2) **or MAXI** (24 hours, € 4) **ticket** from a ticket machine or from a tobacco store ("Trafik"). Take tram 1 or 2 (stops directly at the underground of the train station) into the direction of “JKU Universität” and get off at the stop **"JKU Universität"** (last stop).

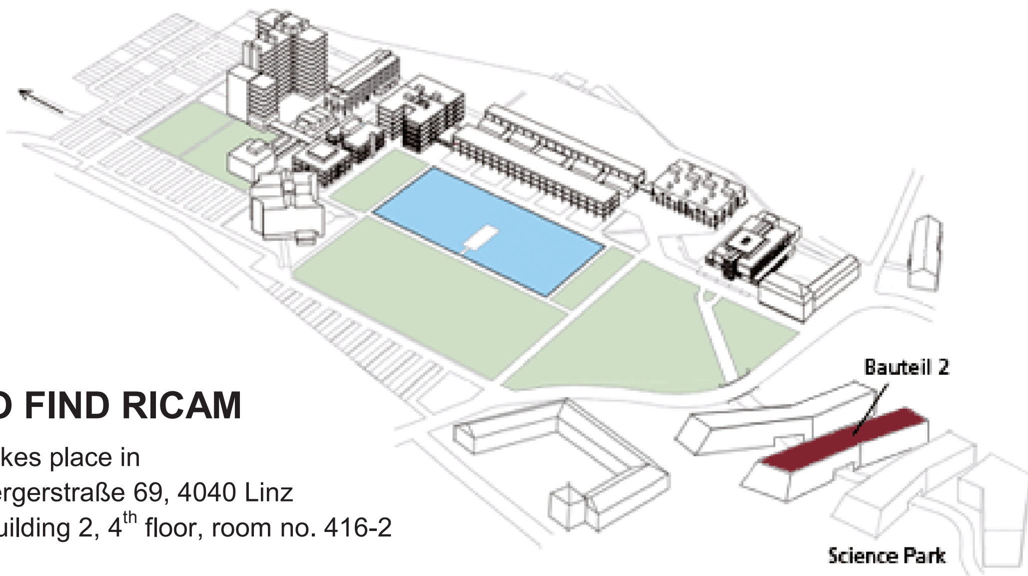
Vienna Airport ("Schwechat") to Vienna train station ("Wien-Westbahnhof"):
There is a shuttle bus every 30 minutes directly to the Viennese train station.
Time table Bus: http://www.viennaairport.com/jart/prj3/va/uploads/data-uploads/Passagier/Parken/VIE_Postbus_1187_de_en.pdf
If you take the Train, use “Schnellbahn - S7” in direction “Wien Floridsdorf” via “Wien Mitte - Landstraße” (U3, Underground) to “Wien-Westbahnhof”
Time table Train: http://www.viennaairport.com/en/passengers/arrival__parking/s-bahn__suburban_railway or check http://www.oebb.at/en

Vienna Central Station (Westbahnhof) - Train from Vienna to Linz:
https://westbahn.at (cheaper tickets!)
www.oebb.at/en

PUBLIC TRANSPORT MAP „LINZ LINIEN“

https://www.linzag.at

UNIVERSITY CAMPUS



WHERE TO FIND RICAM

the workshop takes place in
RICAM, Altenbergerstraße 69, 4040 Linz
Science Park Building 2, 4th floor, room no. 416-2

Special Semester Office:
Verena GRAFINGER
Science Park 2, 4th floor, room no. 456
fax machine, copy machine, office supplies ...

Opened: Monday – Friday 9:00 a.m. – 12:00 a.m.
Monday and Wednesday until 2:30 p.m.

WORKSHOP SCHEDULE

Registration: Monday 8:15 – 8:45, Science Park2, 4th floor
We will be there to help if questions arise and to hand out your personal folders and name badges.

Opening: from 8:45 (depends on workshop(school) in seminar room 416-2

Let us most politely ask you to try to be on time for the opening.

COFFEE BREAKS & EVENING SNACKS

Coffee breaks - as mentioned on the workshop timetable - take place in room no. 416-1 (small seminar room, next to the big one).
In the evenings there is the possibility to have access to this seminar room to come together.
Small snacks and drinks are available.

INTERNET

w-Lan connection possible all over the campus and in all RICAM offices
w-Lan-name: ricam
Password: agodaricamo

COMPUTER ROOM

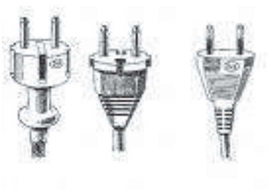
If needed room no. 413.
Username and password on the screen.

TECHNICAL SUPPORT

If you need any help concerning w-lan, laptops, etc. please contact:
Florian TISCHLER or Wolfgang FORSTHUBER
Room no. 458

PLUGS IN AUSTRIA

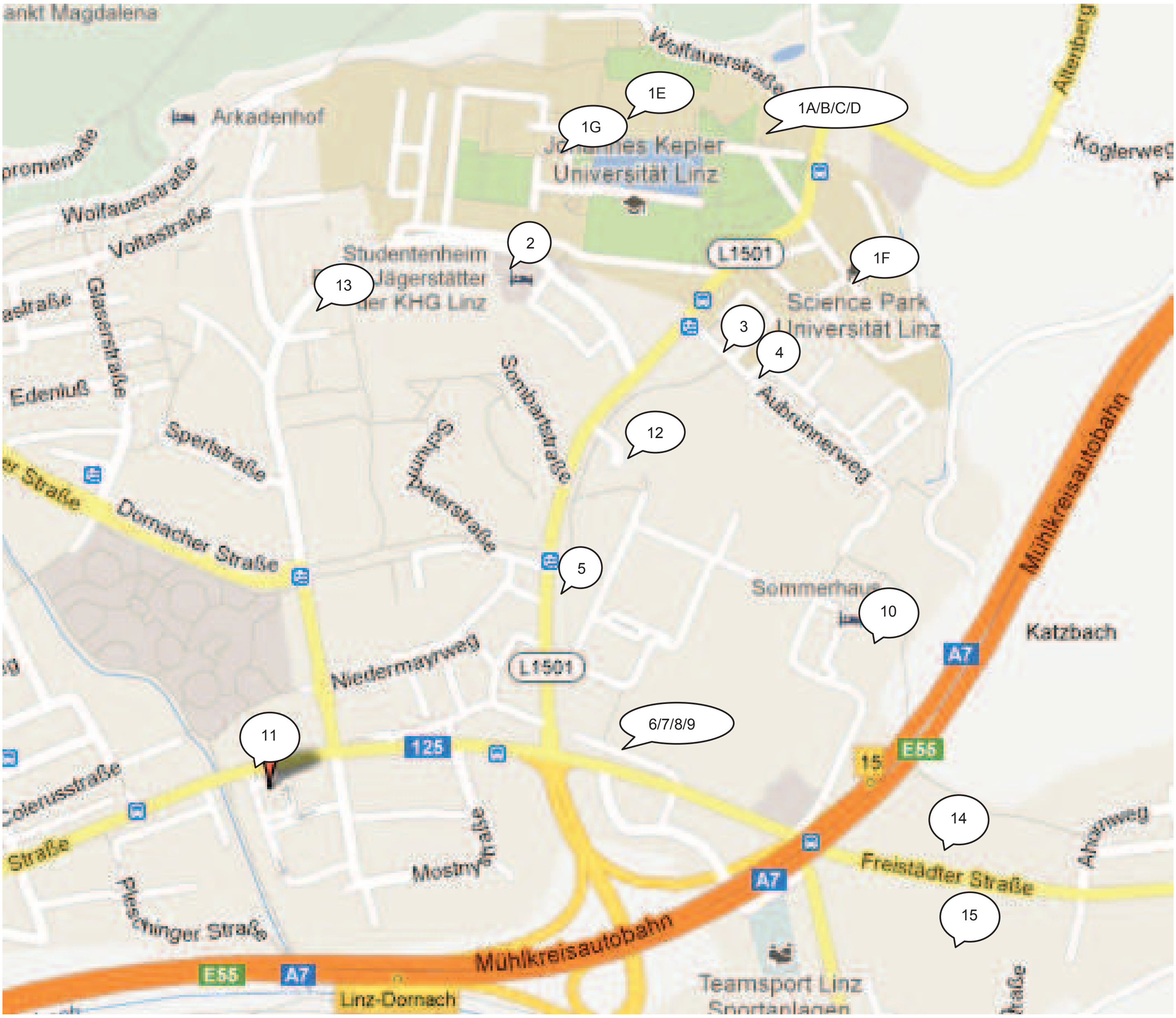
please, see photo



RESTAURANTS & FOOD

1	At University campus *Check your dish:* http://www.jku.at/content/e213/e175/e6780	**A) Mensa** **B) Choice** (in Mensa) **C) Kepler's** Restaurant **D) Café** (in Mensa) **E) Ch@t** (Cafe Keplergebäude) **F) Science Cafe** (Science Park3) **G) Cafe SASSI** (Bankengebäude)	Mo-Fri 11:15 – 13:30 Mo-Thu 10:30 – 14:30; Fri 10:30 – 13:30 Mo-Thu 11:30 – 14:00; Fri 11:30 – 13:30 Mo-Thu 08:00 – 14:30; Fr 08:00 – 13:30 Mon-Thu 08:00 – 19:00; Fri 08:00 – 14:00 Mon-Thu 08:00 – 16:00; Fri 08:00 – 14:00 Mon-Fri 08:00 – 20:00; Sa 09:00 – 14:00
2	KHG Mensa	Mengerstraße 23 Tel: 0732 244011	Mon-Fri 11:00 - 13:00
3	„Bella Casa“ - Pizzeria	Aubrunnerweg 1a Tel: 0732 245646	Open daily 11:00-15:00 and 17:00 - 24:00
4	„Jadegarten“ – Chinese Restaurant	Aubrunnerweg 11 Tel: 0732 750160	Open daily 11:00 – 23:00
5	Burgers	Altenbergerstraße 6-8 Tel: 050 66 66 66	Mo-Thu 10:30 – 22:00 Fri-Sat 10:30 – 23:00 Sun 10:30 – 22:00
6	Pizza Mann	Freistädter Straße 313 Tel: 05 10 10 10 www.pizzamann.at	Open daily 11:00 – 03:00 (Online order)
7	Subway	Freistädter Straße 313 Tel.: 05 995 9910 http://linz.suborder.at	Open daily 08:30 – 24:00 (Online order)
8	Burger Checker	Freistädter Straße 313 Tel.: 0660 1101 200	Mon – Sun 11:00 – 14:00 and 17:00 – 20:30
9	„Goldener Hof” – Chinese Restaurant	Freistädter Straße 315 Tel: 0732 24 40 42	Open daily 11:30 – 14:30 and 17:30 – 23:00
10	„RaabMensa.Lounge.Restaurant.Bar” – Hotel Sommerhaus	Julius Raab-Straße 10 Tel: 0732 24570	Lounge, Bar: Mon – Thu 06:30 – 23:30 Fri 06:30 – 14:00 Sat – Sun 06:30 – 11:00 Hot food daily: 11:30 – 14:30 17:00 – 21:30
11	Mc Donalds & Mc Cafe	Freistädter Straße 298	Mon – Thur 07:00 – 01:00 Fri – Sat 07:00 – 02:00 Sun 07:00 – 01:00
12	Supermarket „Winkler Markt“	Altenbergerstraße 40 **Sunday closed!**	Mon – Thur 07:30 – 18:30 Fri 07:30 – 19:00 Sat 07:30 – 17:00
13	Supermarket “Penny”	Johann-Wilhelm-Klein-Strasse 58 **Sunday closed!**	Mon – Fri 7:30 – 19:00 Sat 7:30 – 18:00

14	Supermarket „Hofer“	Freistädter Straße 401 **Sunday closed!**	Mon-Fri Sat	08:00 – 20:00 08:00 – 18:00
15	Supermarket „Billa“	Freistädter Straße 400 **Sunday closed!**	Mon-Fri Sat	07:40 – 20:00 07:40 – 18:00



PHYSICIANS, HOSPITALS AND PHARMACIES

The following physicians have offices in the area of Hotel Sommerhaus and the university:

Dr. Winfried Mraczansky
Altenbergerstraße 43
4040 Linz
Phone +43 (0) 732 245655

Mon 8–11:30 and 16–17:30
Tue 8–11:30, Thu 8–11:30
Wed 8–11:30 and 16–17:30
Fri 8–11

Dr. Kurt Kellermair
Freistädter Straße 41
4040 Linz
Phone +43 (0) 732 730595

Mon 8–12 and 17–19
Tue 9–12, Wed 8–11
Thu 8–11 and 16–19
Fri 8–11

Dr. Gottfried Maria Jetschgo
Pulvermühlstraße 23
4040 Linz
Phone +43 (0) 732 254121

Mon 8–12
Tue-Fri 8–11
Tue 16-18
Thu 16-18

Should you need medication the doctor will give you a prescription which you can take to any pharmacy to pick up the medicine. Usually, you will have to pay for a small part of the medication yourself. Pharmacies are also the only places which sell over-the-counter drugs like pain relievers etc. The **pharmacy** nearest to the campus is located **in the Winkler-Markt building (nr.12)**. After hours, a sign in any pharmacy's window will always tell you the nearest pharmacy on duty. The general hospital in Linz is Allgemeines Krankenhaus (AKH Linz), Krankenhausstraße 9. It provides an emergency room. In addition, Linz has a number of specialized hospitals, some of which also have emergency rooms. In case of a medical emergency, call 144.

EMERGENCIES

In case of emergencies, here are a few useful phone numbers to remember:

Fire Department **122**
Police **133**
Medical Emergencies **144**
Emergency calls at the University campus **8144** (for urgent cases), otherwise **9100**
Europe-wide general emergency call **112**
Car Breakdown **120** or **123**
Mountain Rescue **140**
Information about physicians on duty after hours **141**
Intoxication hotline **01/4064343**

Note that the europe-wide general emergency number **112** can be called in particular from any cell phone even without a valid subscription or prepaid SIM card inserted.

VACCINATION

NO vaccinations necessary!

WEATHER FORECAST FOR AUSTRIA

http://www.wetter.at/wetter/oesterreich/oberoesterreich/linz

We wish you all a very pleasant time in Linz!

Social Event: Höhenrausch

Wednesday, October 15

Start of the Guided Tour: 16:00

We will **meet at 15:45** a t the entrance of MOVIEMENTO (Cinema) in

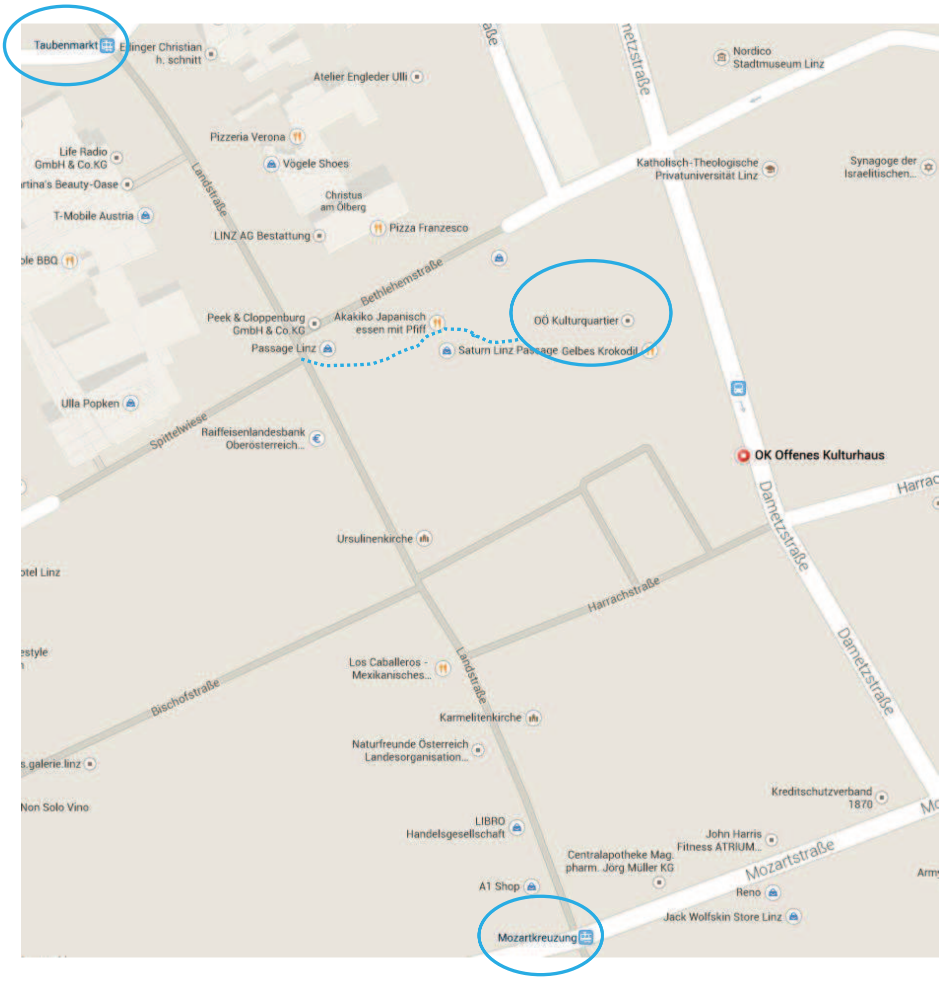
OÖ Kulturquartier
OK Platz 1
4020 Linz

Tram Stop (1, 2): *Taubenmarkt* or *Mozartkreuzung (travel time: about 20 min. in the tram from University)*

Entrance via PASSAGE Shopping center (just follow the signs on the floor) or via U:/hof (Ursulinenhof)

http://hoehenrausch.at/en

If you don´t want to participate, please let the secretary (Verena Grafinger) know as soon as possible.



Timetable

Workshop 1: Shape and topological optimization

October 13 - 17, 2014

	Monday Oct. 13	Tuesday Oct. 14	Wednesday Oct. 15	Thursday Oct. 16	Friday Oct. 17
08:15 - 08:45	**REGISTRATION**				
08:45 - 09:00	**Opening**				
09:00 - 09:45	Guiseppe Buttazzo	Gregoire Allaire	Dorin Bucur	Ilaria Fragalà	Francois Jouve
10:00 - 10:45	Pedro Freitas	Anca-Maria Toader	Michael Stingl	Helmut Harbrecht	Eric Bonnetier
10:45 - 11:15	***Coffee Break***	***Coffee Break***	***Coffee Break***	***Coffee Break***	***Coffee Break***
11:15 - 12:00	Elie Bretin	Benedikt Wirth	Soeren Bartels	Michael Hintermüller	Antoine Henrot
12:00 - 13:30	***Lunch Break***	***Lunch Break***	***Lunch Break***	***Lunch Break***	**Closing**
13:30 - 15:30	**Discussion Time**	**Discussion Time**	**13:30 – 15:00 Fast forward Session**	**Discussion Time**	
15:30 - 16:00	15:30 - 16:15 Simon Masnou	Yannick Privat	**15:00 Start Excursion 16:00 Guided Tour "Höhenrausch"**	Bozhidar Velichkov	
16:10 - 16:50	16:30 - 17:15 Harald Garcke	Blanche Buet		Michailidis Georgios	
16:50 - 17:10	17:30 – 18:00 Andres Leon Baldelli	***Coffee Break***		***Coffee Break***	
17:10 - 17:40		Charles Dapogny		David Vicente	
17:50 - 18:20		Andres Leon Baldelli		Victor Kovtunenko	
19:30		***Conference Dinners at Keplers (JKU Mensa)***			