

Differential Geometry Workshop 2026

University of Rostock, Germany
Institute of Mathematics

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Book of Abstracts

Organizers:

Volker Branding, Institute of Mathematics

Jan Heck, Institute of Mathematics



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Preface

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- Stefan Andronic (Alexandru Ioan Cuza University of Iasi)
- Luis Alias (Universidad de Murcia)
- Giulio Colombo (Università degli Studi di Milano)
- Antoine Detaille (ETH Zürich)
- Alejandro Peñuela Diaz (University of Rostock)
- Andreas Gastel (University of Duisburg-Essen)
- Penelope Gehring (Stockholm University)
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- Simona Nistor (Alexandru Ioan Cuza University of Iasi)
- Cezar Oniciuc (Alexandru Ioan Cuza University of Iasi)
- Alberto Richtsfeld (Stockholm University)
- Oskar Riedler (University of Potsdam)
- Antonio Sanna (University of Cagliari)
- Theodoros Vlachos (University of Ioannina)
- Hazal Yürük (Istanbul Technical University)

Main scientific topics

- Harmonic maps,
- Biharmonic maps and
- Related topics

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Calabi-Bernstein results for spacelike hypersurfaces in Lorentzian product spaces

A maximal hypersurface in a Lorentzian manifold is a spacelike hypersurface with zero mean curvature. Here by spacelike we mean that the induced metric from the ambient Lorentzian metric is a Riemannian metric on the hypersurface. Besides their mathematical interest, maximal hypersurfaces and, more generally, spacelike hypersurfaces with constant mean curvature (CMC) are also important in General Relativity. One of the most important global results about maximal hypersurfaces is the Calabi-Bernstein theorem in the Lorentz-Minkowski space, which, in parametric version, states that the only complete maximal hypersurfaces are the spacelike hyperplanes. This result can also be seen in a non-parametric form, establishing that the only entire solutions to the so called maximal surface equation on the Euclidean space are affine functions.

In this lecture, we will first review on the Calabi-Bernstein theorem and other related results for spacelike hypersurfaces in the Lorentz-Minkowski space, trying to make the topic comprehensible for a general audience. We will later introduce new Calabi-Bernstein theorems in more general ambient spaces. Specifically, we will show new Calabi-Bernstein results for spacelike hypersurfaces in $(n+1)$ -dimensional Lorentzian product spaces of the form $M \times \mathbb{R}$, where the Riemannian factor is a complete, noncompact n -dimensional manifold M with nonnegative Ricci curvature.

Observe that when M is the Euclidean space, this construction reduces to the classical Lorentz-Minkowski spacetime. In this setting, we will prove, for instance, that the only complete, noncompact spacelike hypersurfaces with constant mean curvature H for which the Gauss map N converges to the vertical direction at infinity are the totally geodesic slices $t = \text{constant}$. In particular, $H = 0$. In other words, the only entire spacelike graphs of constant mean curvature, given by $t = u(x)$ for which $|Du|$ converges to zero at infinity are the slices $u(x) = \text{constant}$.

Our results are part of our joint work with Antonio Caminha and F. Yure Jansel, from Universidade Federal do Ceará at Fortaleza (Brazil).

Stefan Andronic

Alexandru Ioan Cuza University of Iasi

On rigidity results for compact biconservative hypersurfaces

In the first part of the talk, we present some basic properties of biconservative submanifolds and hypersurfaces. In the second part, we present known rigidity results for biconservative hypersurfaces in space forms and provide shorter and simpler proofs of these results. At the end, we present some generalizations of these rigidity results involving estimates of the squared norm of the shape operator.

Giulio Colombo

Università degli studi di Milano

q-convex hypersurfaces in Riemannian manifolds

An oriented hypersurface immersed in a Riemannian manifold is q -convex (for a given positive integer q) if the sum of the q smallest eigenvalues of its shape operator is non-negative at each point. We present some estimates on Betti numbers of q -convex hypersurfaces in Riemannian manifolds with curvature operator bounded from below. The estimates are obtained via the Bochner technique, by suitably exploiting the q -convexity assumption when dealing with the curvature term in the Bochner-Weitzenböck identity for the Hodge Laplacian. This is based on a joint work with Christos-Raent Onti (University of Cyprus).

Antoine Demaille

ETH Zürich

Existence of infinitely many minimizing n -harmonic maps in homotopy classes via critical exponents

In 1998, T. Rivière showed the existence of infinitely many homotopy classes of $\pi_3(S^2)$ admitting a minimizing 3-harmonic map as a representative. The key ingredient of the proof is the rate of growth of the minimal energy required to generate a map with given Hopf degree, along with an energy identity for the problem of minimizing the 3-Dirichlet energy.

In this talk, we show that this is a special case of a more general principle, also valid in the fractional regularity setting: If $0 < s \leq 1$ and $1 \leq p < +\infty$ are such that $sp = d \in \mathbb{N}_*$, and if $\mathcal{N}$ is a compact Riemannian manifold, we explain how to exploit the information on the rate of growth of the minimal energy needed to realize a map with given “degree” in $\pi_d(\mathcal{N})$ to deduce the existence of infinitely many homotopy classes in $\pi_d(\mathcal{N})$ admitting a minimizing (s, p) -harmonic map as a representative.

We also provide several families of examples to which this general principle can be applied, including spheres and projective planes.

This is joint work with Adam Grzela and Katarzyna Mazowiecka.

Alejandro Peñuela Díaz

University of Rostock

Curvature Inequalities and Rigidity for CMC and STCMC Surfaces

I will discuss sharp curvature inequalities and rigidity results for constant mean curvature type surfaces in both Riemannian and Lorentzian geometry. In the Riemannian setting, I will describe an extension of the Christodoulou–Yau inequality under a weaker stability condition, yielding rigidity in the equality case without symmetry assumptions. I will also briefly mention analogues in the hyperbolic and spherical settings. In the Lorentzian setting, I will introduce a notion of stability for spacetime constant mean curvature surfaces and present the corresponding sharp inequality and rigidity result under the dominant energy condition. This talk is based on the preprint arXiv:2603.16707.

Andreas Gastel

University of Duisburg-Essen

Harmonic maps "with coefficients"

Applications of harmonic map theory sometimes require studying energies in which the Dirichlet energy is replaced by some elliptic integral. We identify a class of functionals for which there is still some monotonicity formula. We discuss its relevance for applications and try first steps towards a regularity theory.

(joint work with Vanessa Hüsken, Magdeburg)

Penelope Gehring
Stockholm University

Nonlocal boundary conditions for symmetric hyperbolic systems on spacetimes with timelike boundary

The Atiyah–Patodi–Singer index theorem for Dirac operators on compact Riemannian manifolds with boundary is a cornerstone result that has stimulated extensive research on nonlocal boundary conditions for first-order elliptic operators. In contrast, the study of nonlocal boundary conditions in the Lorentzian setting – and hence for hyperbolic operators – is a more recent development.

In this talk, we focus on spacetimes with timelike boundary and an important class of first order operators, the symmetric hyperbolic systems. In this setting, we examine how nonlocal boundary conditions can be imposed on the timelike boundary in order to obtain solutions to the associated initial boundary value problem. Furthermore, we will see how the nonlocal behavior of the boundary conditions influence the propagation speed of the solutions. This is joint work with Christian Bär.

Adam Grzela
University of Warsaw

Quantitative estimates for the Hopf lift in fractional Sobolev spaces

The classical lifting problem asks: given a "good map" $\Pi : E \rightarrow N$ (such as a Riemannian covering, fiber bundle, etc.) and a map $u : M \rightarrow N$, can one construct a so-called lift — that is, a map $U : M \rightarrow E$ such that $u = \Pi \circ U$ — or show an obstruction to doing so? In the continuous setting, this is a purely topological problem, but new questions arise when considering Sobolev mappings. In particular, given u in a fixed Sobolev class, one would like to establish Sobolev regularity for the lift, preferably with direct estimates in terms of the original mapping.

We investigate a particular case of this problem, namely the existence of liftings in the Hopf bundle $H : \mathbb{S}^3 \rightarrow \mathbb{S}^2$ for fractional Sobolev regularity with critical exponent.

Based on joint work with Katarzyna Mazowiecka, Armin Schikorra and Jean Van Schaftingen

Sigmundur Gudmundsson

Lund University

Harmonic morphisms and minimal conformal foliations on Lie groups

Harmonic morphisms are maps between Riemannian manifolds pulling back harmonic functions on N to harmonic functions on M . They have been characterised as being the harmonic maps which are horizontally conformal. Under certain natural conditions they induce a conformal foliation on M with minimal leaves.

In this talk we will give a short introduction to the general theory. Then we will describe what is known in the important cases when M is a Lie group foliated in this way by the left translations of a semisimple subgroup of M .

Laurent Hauswirth
Université Gustave Eiffel

Minimal surfaces bounded by asymptotic line

I will describe analytic, algebraic and architectural aspect of the problem to study minimal surface whose boundary is an asymptotic line of constant curvature.

Adam Lindström
University of Vienna

Spherically symmetric coupled Dirac-Yang-Mills pairs

The Dirac-Yang-Mills functional constitutes a part of the action functional of the standard model of particle physics modelling the interaction of a bosonic field with a massless fermionic matter field. Mathematically, it is as a variational problem involving fibre bundles over a base Riemannian spin manifold. Solutions consist of a Dirac-Yang-Mills (DYM) pairs (ω, Ψ) where ω is a connection on a principal bundle P and Ψ a harmonic spinor twisted by an associated Bundle to P . Such a DYM pair is said to be coupled if ω is not a Yang-Mills connection (i.e. the curvature is not co-closed).

In the talk we will make a spherically symmetric ansatz to reduce the DYM system on a spherically symmetric 3-manifold to a system of ODE's, for which we find explicit solutions. A simple argument shows that all solutions in this setting are necessarily coupled and we thus construct the first known coupled DYM pairs on a closed manifold. If time permits we will also see how to lift these solutions to yield coupled solutions on closed product manifolds of any dimension ≥ 3 .

Dorian Martino

ETH Zürich

Weak immersions with second fundamental form in a critical Sobolev space

Over the past decade, the generalization of the Willmore energy to even dimensional submanifolds of the Euclidean space has been subject to numerous works, due to their relation to renormalized volume of minimal submanifolds in Poincaré-Einstein manifolds and their applications to AdS/CFT correspondence.

I will present an analytical framework, recently developed in a collaboration with Tristan Rivière, in order to address variational problems concerning these generalized Willmore energies.

Katarzyna Mazowiecka

University of Warsaw

Regularity of minimizing p -harmonic maps into spheres

Regularity of minimizing p -harmonic maps, i.e., minimizers of the Dirichlet p -energy among maps between two given manifolds, is known to depend on the topology of the target manifold. In particular, the case of maps into spheres has been studied extensively, yet some of the most basic questions concerning maps from $\mathbb{B}^3$ into $\mathbb{S}^3$ remain open. For many years, minimizing maps in this context were known to be regular when $p = 2$ or $p \geq 3$, leaving a gap in between. I will discuss how the relevant tools have developed over time (from 1984 until now) and how they eventually led to closing the gap.

This is joint work with Andreas Gastel, Katarzyna Mazowiecka and Patryk Tokarczuk.

Driving a Wedge in a Willmore Half-Sphere

We minimize the Willmore energy among half-spheres that satisfy the Dirichlet boundary conditions of the round half-sphere as well as an obstacle-constraint. Standard questions for such obstacle problems include existence and optimal regularity of minimizers as well as the size of the coincidence set, i. e., the set where the obstacle is touched.

Standard existence theory is obstructed by Möbius invariance of the Willmore energy. However, generalizing some Kuwert-Li-type compactness results to surfaces with boundary resolves this issue.

After discussing existence, we focus on conic obstacles (with some mild restrictions on their opening angle). Our main observation is that the obstacle is touched (i) nowhere if the cone lies below the round half-sphere and (ii) only once at the tip of the cone if not. While the non-coincidence case (i) is expected, it once again reveals the higher-order nature of the energy and the absence of a maximum principle.

More interesting is case (ii), i. e., touching at one point. In this case minimizers must satisfy the Willmore equation with a Dirac measure on the right hand side, as I will discuss. The optimal regularity of solutions to this PDE is $W^{3,p}$ for any $p < 2$ (and not $W^{3,2}$). This regularity result was found in a previous work by Röger-Rupp. Our contribution shows that such irregular solutions can indeed yield energy-minimal configurations (and not just stationary points).

By computing symmetric minimizers explicitly, we discover an intriguing connection between this regularity loss and the Möbius inversion of the catenoid.

Thomas Munn
Lund University

(λ, μ) -Eigenfunctions on Compact Lie groups

A complex valued function $f : (M, g) \rightarrow \mathbb{C}$ is said to be a (λ, μ) -eigenfunction if it is eigen with respect to both the Laplace-Beltrami operator and the conformality operator $\kappa(f, f) = g(\nabla f, \nabla f)$. Recent developments have shown that (λ, μ) - eigenfunctions can be used in the construction of harmonic morphisms, proper r -harmonic maps, and minimal submanifold of codimension two. There has also been interest in classifying eigenfunctions.

In this talk we consider the case when (M, g) is a compact Lie group equipped with a bi-invariant metric, as the Laplace-Beltrami operator's spectral theory is described by the Peter-Weyl theorem. We use the Peter-Weyl theorem, and other representation theoretic techniques in order to classify all the pairs (λ, μ) as well as describe conditions which ensure the existence of eigenfunctions. Finally, we produce new eigenfunctions on both compact Lie groups G and Riemannian symmetric spaces G/K .

Simona Nistor

Alexandru Ioan Cuza University of Iasi

Conformal-biharmonic stability of Einstein manifolds

Conformal-biharmonic maps are critical points of the conformal-bienergy functional, a fourth-order variational functional arising naturally in conformal geometry. In dimension four, this functional is conformally invariant, providing a natural generalization of the classical energy functional to higher-order variational problems.

In this talk we investigate the conformal-biharmonic stability of the identity map of compact Einstein manifolds. We prove that, for compact Einstein manifolds with non-negative scalar curvature, the conformal-biharmonic index of the identity map coincides with its classical harmonic index, except for the four-dimensional sphere, where a fundamentally different behavior occurs. This result establishes a close relationship between harmonic and conformal-biharmonic stability while highlighting the important role played by dimension four in conformal geometry.

Cezar Oniciuc

Alexandru Ioan Cuza University of Iasi

On biharmonic submanifolds in spheres

This talk presents an overview of older and more recent results on biharmonic and biconservative submanifolds in space forms, with particular emphasis on biharmonic and biconservative hypersurfaces in Euclidean spheres. We conclude by discussing some conjectures arising naturally in this area.

Alberto Richtsfeld
Stockholm University

Index theory for geometric elliptic differential operators of first order

This talk is concerned with index theory for first-order geometric elliptic operators beyond the setting of Dirac operators. After introducing chiral geometric operators, which include Dirac and Rarita–Schwinger operators as examples, I will describe a local index theorem obtained using methods from invariance theory. The theorem identifies the limit of the heat kernel supertrace with the characteristic form predicted by the Atiyah–Singer Index Theorem. I will also discuss Atiyah–Patodi–Singer boundary conditions and explain the relation between the approach of Bär and Bandara and the APS index arising in the b-calculus.

Oskar Riedler
University of Potsdam

Scalar-rigid submersions are Riemannian products

Scalar curvature is a very weak and flexible local invariant in Riemannian geometry. So it is surprising that coupling lower scalar curvature bounds with seemingly harmless topological conditions can recover very powerful rigidity statements, such as Llarull's theorem or the positive mass theorem.

In this talk I will begin by introducing some aspects related to the comparison geometry of lower scalar curvature bounds, focussing in particular on Llarull's theorem. After this I will discuss a recent rigidity theorem in this setting. This is joint work with Thomas Tony.

Antonio Sanna
University of Cagliari

Weakly critical points of r -energy functionals

There are two primary higher-order generalizations of the energy functional. The first was proposed by Eells and Sampson, while the second was proposed by Wang and Maeta. These two generalizations coincide up to the order $r < 4$. However, under specific conditions, we have the equivalence between the two functionals for any r . Additionally, there exists a sufficient condition that ensures the critical points for both functionals coincide.

Among the maps that satisfy the above mentioned condition, we focus on a specific family of rotationally symmetric maps from the n -dimensional Euclidean ball to the n -dimensional sphere. To study this family, we introduce a more general family of maps between models. These maps are not smooth at the pole, so the concept of weakly r -harmonicity is required. Furthermore, among the weakly r -harmonic maps we found, we also study their stability with respect to the two types of higher-order energies.

Theodoros Vlachos
University of Ioannina

Topological and geometric rigidity of nonnegatively curved submanifolds

We investigate the topology and geometry of compact submanifolds in space forms of nonnegative curvature that satisfy a lower bound on the sectional curvature, depending only on the length of the mean curvature vector of the immersion.

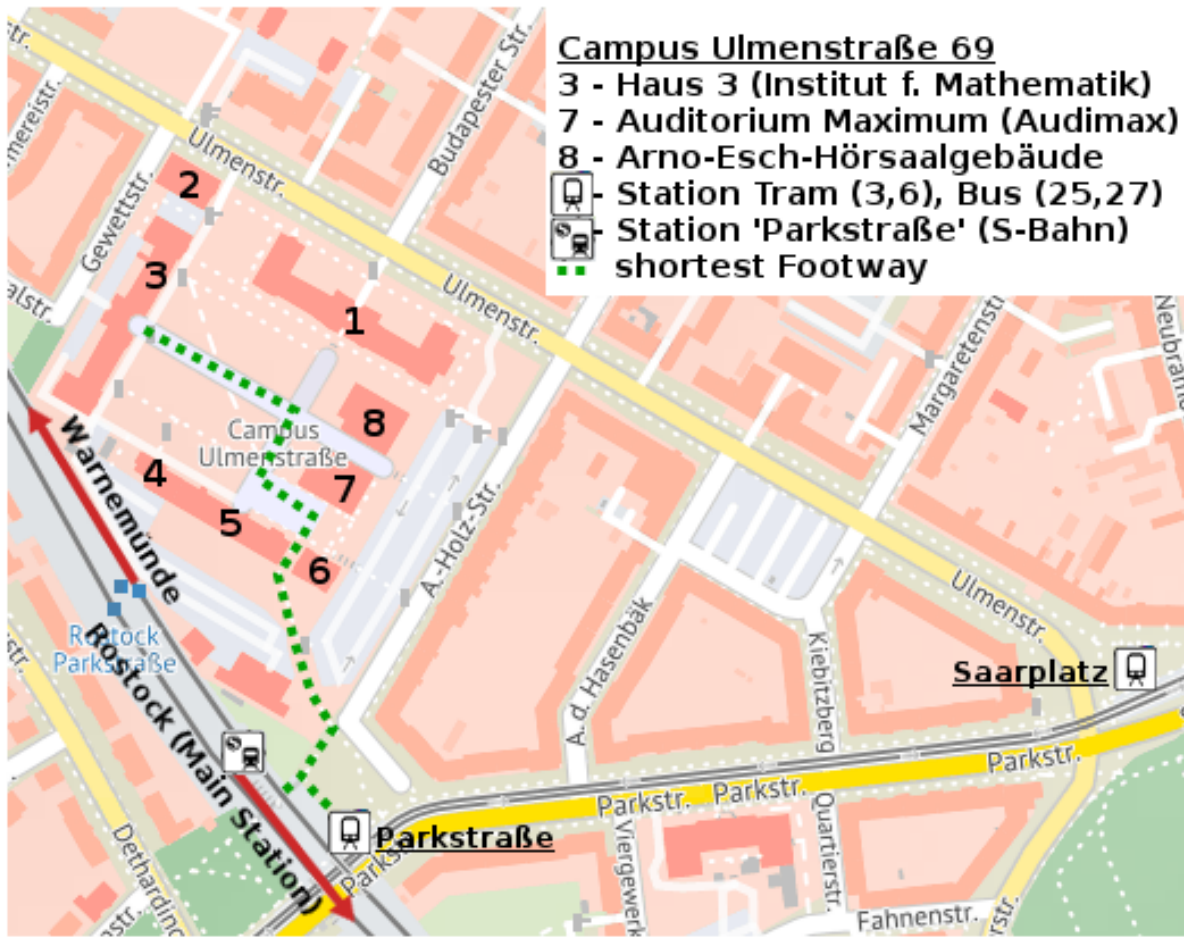
We show that this condition imposes strong constraints on either the topology or geometry of the submanifold. Additionally, we provide examples that demonstrate the sharpness of our result.

Biconservative Surfaces in Lorentzian Bianchi–Cartan–Vranceanu Spaces

Biconservative surfaces form an important class of submanifolds arising from the study of biharmonic maps and the stress-energy tensor associated with the bienergy functional. While biconservative surfaces in three-dimensional homogeneous Riemannian manifolds have been extensively investigated, the Lorentzian setting remains much less understood.

In this talk, we study timelike and spacelike biconservative surfaces in the Lorentzian Bianchi–Cartan–Vranceanu (LBCV) spaces $M_1^3(\kappa, \tau)$. We derive the Lorentzian counterpart of the biconservative equation and investigate its geometric consequences. In particular, we establish Lorentzian analogues of several classification results known in the Riemannian case. We characterize non-minimal constant mean curvature biconservative surfaces and show that they are Hopf tubes over curves of constant geodesic curvature. Furthermore, we consider rotational surfaces invariant under one-parameter groups of isometries and obtain classification results for timelike rotational biconservative surfaces. As a consequence, these surfaces are shown to reduce to Hopf circular cylinders.

These results provide new examples of biconservative surfaces in homogeneous Lorentzian three-manifolds and extend several results, which are known in the case of biconservative surfaces in three-dimensional BCV spaces, to their Lorentzian counterparts.



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