MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 23/1999

Differentialgeometrie im Großen

06.06.–12.06.1999

Die Tagung fand unter der Leitung von Werner Ballmann (Bonn), Jean-Pierre Bourguignon (Bures-sur-Yvette) und Wolfgang Ziller (Philadelphia) statt. Den über fünfzig aus vielen Teilen der Welt angereisten Teilnehmern bot sich ein interessantes, gut organisiertes Vortragsprogramm mit neuesten Forschungsergebnissen.

Jeder Morgen war einem bestimmten Gebiet der Differentialgeometrie gewidmet, zu dem es einen Übersichtsvortrag und zwei speziellere Vorträge gab. Nachmittags wurden jeweils zwei Vorträge gehalten, in denen unterschiedliche Einzelresultate dargestellt wurden. Am Mittwoch fand der traditionelle Spaziergang nach Sankt Roman statt.

Die zentralen Themen der Tagung lagen in den Bereichen „nicht-negative/positive Krümmung“ (neue Konstruktionen, Injektivitätsradiusschranken unter Pinchingbedingungen), „nicht-positive/negative Krümmung“ (idealer Rand, Starrheitsresultate, Einbettbarkeitsresultate), „Einstein-Metriken“ (neue Konstruktionen, scharfe Krümmungsschranken), „symplektische Geometrie“ (symplektische 4-Mannigfaltigkeiten, symplektische Faltung) und „isospektrale Mannigfaltigkeiten“ (neue Beispiele und Konstruktionstechniken).

Es bot sich viel Gelegenheit zu angeregten Diskussionen, die allen Teilnehmern neue mathematische Impulse gaben.

Vortragsauszüge (chronologisch geordnet):

Karsten Grove

Recent Developments in Nonnegative Curvature

(joint work with Wolfgang Ziller)

The two main obstructions on a manifold M to have positive sectional curvature, $\sec M \geq 0$, are (1) the Cheeger–Gromoll soul theorem and (2) Gromov's Betti number theorem. Additional obstructions on the fundamental group are derived from Toponogov's splitting theorem and the work by Fukaya and Yamaguchi on manifolds of almost nonnegative curvature. The only other known obstructions come from obstructions to positive scalar curvature on spin manifolds by Lichnerovicz and Hitchin.

The basic constructions of manifolds M with $\sec M \geq 0$ arise from taking products and quotients. The principal building blocks for this purpose are compact Lie groups.

In recent joint work with W. Ziller, we have extended the building blocks to include cohomogenity one manifolds with singular orbits of codimension 2. When this is combined with the above constructions, and a construction of principal bundles within the framework of cohomogenity one manifolds, the following are consequences:

Theorem A. *All four homotopy* $\mathbb{RP}^5$ *admit metrics of nonnegative curvature.*

Theorem B. *All 15 exotic Milnor* 7*-spheres admit metrics of nonnegative curvature.*

Theorem C. *All vector bundles over* $\mathbb{S}^4$ *admit complete metrics with* $\sec \geq 0$.

In A and B there are infinitely many such metrics, with different isometry groups.

Xiaochun Rong

Positive Pinching, Injectivity Radius, and Second Betti Number

In this talk, we explain the main idea of the following result of Fang and Rong:

Theorem A. *Let M be a compact simply connected manifold with positive pinched sectional curvature. If the second Betti number of M is zero, then the injectivity radius of M is bounded from below by a positive constant depending only on n and the pinching.*

This theorem is also independently obtained by Petrunin and Tuschmann. The main geometrical ingredients are

1. The fibration theorem of Cheeger–Fukaya–Gromov and its refinement by Rong.
2. The gluing theorem of Petrunin–Rong–Tuschmann.
3. The Grove–Searle theorem which asserts that if a compact positively curved manifold admits an isometric circle action with fixed point set of codimension 2, then it is diffeomorphic to a sphere, a lense space, or a complex projective space.

The main accomplishment in the proof of Theorem A is a topological finiteness theorem concerning certain collection on T^k-manifolds with the same weighted orbit space.

Wilderich Tuschmann

Finiteness and Second Homotopy

(joint work with Anton Petrunin)

Our results concern a diffeomorphism finiteness theorem and injectivity radius estimates for certain classes of closed Riemannian manifolds:

Theorem A. *For given m, C, D, there is at most a finite number of diffeomorphism types of simply connected closed m-dimensional manifolds M with finite second homotopy groups which admit Riemannian metrics with sectional curvature $|K(M)| \leq C$ and diameter* $\mathrm{diam}(M) \leq D$.

Theorem B. *Given any m and $\delta > 0$, there exists a positive constant $i_0 = i_0(m, \delta)$ such that the injectivity radius of any simply connected closed m-dimensionall Riemannian manifold with finite second homotopy group which satisfies the positive Ricci pinching condition* $\mathrm{Ricc} \geq \delta > 0$*, $K \leq 1$, is bounded from below by $i_0(m, \delta)$.*

Theorem B is also new in even dimensions and gives in the case of manifolds with finite π_2 an affirmative answer to a conjecture of Klingenberg and Sakai, starting that if M is a closed manifold and $0 < \delta \leq 1$, then there exists $i_0 = i_0(M, \delta) > 0$ such that the injectivity radius of any metric on M with positive sectional curvature $\delta \leq K \leq 1$ is bounded from below by i_0. It is to note that under this pinching condition F. Fang and X. Rong obtained a different and independent proof of Theorem B.

Theorem A in particular implies the following classification result: For given m, C, D, there exists a finite number of closed smooth manifolds E_i such that any simply connected closed m-dimensional manifold M admitting a Riemannian metric with $|K| \leq C$ and diameter $\leq D$ is diffeomorphic to a factor space $M = E_i/T^{k_i}$, where $0 \leq k_i = \dim E_i - m$ and T^{k_i} acts freely on E_i.

The proof of this theorem uses the notion of universal torus bundles. A simply connected manifold E is called a universal torus bundle of a simply connected closed manifold M if for some $0 \leq k \in \mathbb{N}$ the manifold E admits the structure of a T^k principal bundle over M and if moreover $\pi_2(E)$ is finite.

The above classification result leads to a homotopy group finiteness theorem and allows one to drop the π_2-assumption in Theorem A if $m = 5$, thereby explaining why for any given $0 < \delta \leq 1$ the first examples of infinite sequences of δ-pinched simply connected manifolds show up in dimension 7.

Question. *Let (M, g) be a simply connected closed manifold with positive sectional curvature and E its universal torus bundle. Does E admit a metric with nonnegative curvature which is invariant so that $E/T^k = (M, g)$?*

Conjecture. *For any $m \geq 4$ and $\delta > 0$ there exists $i_0 = i_0(m, \delta) > 0$ such that the injectivity radius of any metric with isotropic curvature $K_{\mathbb{C}}^{isotr} \geq \delta$ and sectional curvature $K \leq 1$ on a simply connected closed m-manifold is bounded from below by i_0.*

Mikhail Shubin

Magnetic Schrödinger Operators on Manifolds

Consider a magnetic Schrödinger operator on a Riemannian manifold (M, g):

$$H_{A,V} = d_A^* d_A + V : C^\infty(M) \to C^\infty(M),$$

where $d_A = d + iA$, $A \in \Lambda^1(M)$ is a real valued 1-form on M, called magnetic potential, d_A^* is the adjoint operator in $L^2(M)$, and V is a real valued function on M.

Theorem 1. *Assume that $V(x) \geq -Q(x)$, $x \in M$, where $Q(x) \geq 1$, and*

1. $|Q^{-\frac{1}{2}}(x') - Q^{-\frac{1}{2}}(x)| \leq C\,\mathrm{dist}(x', x)$,
2. $\int_0^\infty \frac{ds}{Q(x)} = \infty$ *along any curve* γ *going out to infinity (e.g.* $Q(x) \leq C\,\mathrm{dist}(x', x)^2$ *is sufficient).*

Then $H_{A,V}$ *is essentially self adjoint in* $L^2(M)$.

Let $B = dA \in \Lambda^2(M)$ be the magnetic field.

Theorem 2. *Assume that*

1. $|\nabla B| \leq O((1 + |B|)^{\frac{3}{2}})$, $x \in M$,
2. *for any* $\delta > 0$, $V(x) + \delta|B(x)| \to +\infty$ *as* $x \to \infty$.

Then $H_{A,V}$ *has discrete spectrum in* $L^2(M)$.

Theorem 2 is a joint result with V. Kondrat'ev. Condition 2 can be replaced by A. Molchanov's capacity condition (M). In the case $B = 0$ or $|B|$ bounded this condition M is necessary and sufficient for the discreteness of the spectrum.

Tristan Riviere

Some Progress towards Jaffe and Taubes Conjectures

We consider the abelian Yang–Mills–Higgs functional on all of $\mathbb{R}^2$:

$$G(u, A) = \int_{\mathbb{R}^2} |\nabla_A u|^2 + \kappa^2(1 - |u|^2) + |dA|^2,$$

where $u : \mathbb{R}^2 \to \mathbb{C}$ and A is a 1-form on $\mathbb{R}^2$ ($\nabla_A u := \nabla u - iAu$).
We define a weak homotopy class for any (u, A) such that $G(u, A) < \infty$ which corresponds to the degree of $u/|u|$ on ∂B_R for R large enough in the case where $|u| > 0$ on $\mathbb{R}^2 \setminus B_R$.
We prove that in the strongly repulsive case (κ large) there is no minimizer of G in the N-homotopy classes for $|N| \geq 2$ and that for $N = \pm 1$ there exists a unique minimizer of G (modulo translations and gauge invariance) in the corresponding homotopy class and that it is axially symmetric.

Bruce Kleiner

Recent Developments in Nonpositive Curvature

The lecture discussed various recent results that pertain to ideal boundaries of Hadamard spaces and natural actions on them.

- relations between the geometry of a nonpositively curved graph manifold M with the action of $\pi_1(M)$ on the ideal boundary of the universal cover $\tilde{M}$ (C. Croke, B. Kleiner)

- characterizations of symmetric spaces and Euclidean buildings by means of Tits metrics (B. Leeb)
- rigidity theoremss for quasi-isometries (Leeb–Kleiner, Bourdon–Pajot)

At the end of the talk several open questions were presented.

Jean-Marc Schlenker

Negatively Curved Surfaces in Hyperbolic 3-space

Efimov proved in 1963 that there is no complete, smooth surface in $\mathbb{R}^3$ with curvature $K \leq -1$. We extend this in $\mathbb{H}^3$ as follows: There is no smooth, complete surface in $\mathbb{H}^3$ with curvature $K \leq -1 - \epsilon < 1$. Analoguous results hold in $\mathbb{S}^3$ and in the anti-de Sitter space $\mathbb{H}^3_1$ for space-like surfaces. These results rest on a phenomenon of propagation of degenerations for solutions of hyperbolic Monge-Ampere equations.

Urs Lang

Lipschitz Maps into Hadamard Spaces

(Joint work with Branka Pavlovic and Viktor Schroeder)

We prove that every λ-Lipschitz map $f : S \to Y$ defined on a subset of an arbitrary metric space X possesses a $c\lambda$-Lipschitz extension $\bar{f} : X \to Y$ for some $c \geq 1$, provided Y is a Hadamard manifold which has pinched negative sectional curvature or is homogeneous. In the first case the constant c depends only on the dimension of Y and the pinching constant, in the second case on Y. We obtain similar results for large classes of Hadamard spaces Y in the sense of Alexandrov.

Andreas Kollross

Polar and Hyperpolar Actions

An isometric action of a compact Lie group on a Riemannian manifold is called polar if there exists a closed connected submanifold σ (called a section) which intersects the orbits orthogonally and meets all orbits. If the action has a flat section, it is called hyperpolar.

We present a classification of hyperpolar actions on the irreducible Riemannian symmetric spaces of compact type. Since, if $K \subset G$ is a symmetric subgroup, the action of $H \subset G$ on G/K is hyperpolar if and only if the action of $H \times K$ on G is hyperpolar, it is sufficient to consider hyperpolar actions on the compact simple Lie groups. The result can be stated as follows: If $U \subset G \times G$ acts hyperpolarly on G then there is U', such that $U \subset U' \subset G \times G$ and U' is one of the following: (i) a symmetric subgroup of $G \times G$, (ii) a group given by a cohomogenity one action on a sphere, complex or quaternionic projective space, or (iii) locally and after conjugation, $U' = H \times K \subset G \times G$, where (H, G, K) is one of seven exceptional triples (the actions are of cohomogenity one). Since cohomogenity one actions on compact irreducible symmetric spaces are hyperpolar, also a classification of cohomogenity one actions can be obtained from this result.

Burkhard Wilking

On Compact Riemannian Manifolds with Noncompact Holonomy Groups

We give the first example of a compact Riemannian manifold with a noncompact holonomy group. Furthermore, we prove structure results for these manifolds. The easiest example occurs in dimension five: It is a compact solvmanifold, i.e., a compact quotient of a solvable Lie group. Conversely, we show that each five-dimensional example is actually diffeomorphic to an infrasolvmanifold. For a general structure theory, one has to investigate the holonomy representation of the fundamental group of a compact Riemannian manifold M: It is defined on the subspace $V \subset T_pM$ that is fixed by the identity component $\mathrm{Hol}_0(M,p)$ of the holonomy group of M by $[\gamma] \in \pi_1(M) \mapsto \mathrm{Par}_{\gamma|V}$, where Par_γ denotes the parallel transport along γ. A crucial observation is that the holonomy representation of $\pi_1(M)$ is actually hidden in the fundamental group itself:

Theorem. *There is a finitely generated free abelian subgroup $L \triangleleft \pi_1(M)$ and a subgroup $H < \pi_1(M)$ such that*

1. *The representation $\tilde\rho : \pi_1(M) \to \mathsf{GL}(\mathbb{Z} \otimes_{\mathbb{Z}} \mathbb{R})$ that is induced by conjugation decomposes as $\tilde\rho = \tilde\rho_1 \oplus \tilde\rho_2$, where $\tilde\rho_1$ is equivalent to the holonomy representation.*
2. *$H \cap l = \{e\}$ and $H \ltimes L$ has finite index in $\pi_1(M)$.*

Using an argument of Cheeger and Gromoll, one can show that the holonomy group of a compact Riemannian manifold is compact if and only if the holonomy representation of its fundamental group has finite image. Combining this result with the proof of the above theorem one can show that a finite cover of a compact Riemannian manifold M with a noncompact holonomy group is the total space of a torus bundle over another compact Riemannian manifold B with $\dim M - \dim B \geq 4$.

McKenzie Wang

Recent Developments in Einstein Metrics

We discussed some recent results in Einstein manifolds and other results which may have some bearing on the search for Einstein metrics. These include

- Einstein metrics of different signs on the same manifold (Catanese-LeBrun, D. Kotschick),
- surgery and Yamabe invariants (J. Patean),
- odd dimensional simply connected manifolds with arbitrarily large b_2 (Boyer–Galicki),

- infinitely many cohomogenity 1 Einstein metrics on $\mathbb{S}^k$, $5 \leq k \leq 9$, and related constructions (C. Böhm).

Olivier Biquard

Asymptotically Symmetric Einstein Metrics and Quaternionic Geometry

I construct new Einstein metrics which are deformations of complex and quaternionic hyperbolic space, by two methods.

The first method relies on analysis and proves that Einstein deformations of complex and quaternionic hyperbolic spaces are in $1-1$ correspondence with some Carnot-Caratheodory metrics on the boundary at infinity. In the quaternionic case, a new structure at infinity emerges, which I call a quaternionic contact structure.

The second method is more algebraic: It actually uses twistor theory to prove that a real analytic quaternionic contact structure (in dimension different of 7) is the boundary at infinity of a unique quaternion-Kähler metric defined in a neighborhood.

Matthew J. Gorsky

L^2-curvature Estimates for Einstein 4-manifolds

In this talk, sharp L^2-curvature estimates for positive Einstein 4-manifolds were described. Applications included the study of the set of Einstein constants, and (in joint work with C. Le Brun) an improvement of Hitchin's inequality for Einstein manifolds of nonnegative sectional curvature. An interesting corollary is the following: Complex projective space is the unique Einstein 4-manifold of nonnegative sectional curvature with positive definite intersection form.

The proof of the main estimate involves introducing a variational problem, which amounts to a variant of the Yamabe equation. A test function is constructed for the functional using the self-dual component of the Weyl curvature. This test function shows that the infimum of the related energy is negative (using the Weitzenböck formula for harmonic Weyl tensors) and the L^2-estimate follows once the infimum of the energy is known to be negative.

Other applications of this technique were described.

Ursula Hamenstädt

Recent Developments in Symplectic Geometry

We present recent results in symplectic geometry. The topics discussed include

- Hofer metric for compactly supported Hamiltonian symplectomorphisms (after Hofer, Bialy-Polterovich),

- symplectic folding and applications (after Lalonde-McDuff, Schlenk),
- symplectic manifolds with boundary of contact type (after Cieliebak-Floer-Hofer-Wiesocki, Cieliebak),
- symplectic capacities for topological balls in $\mathbb{R}^{2n}$ with contact-type boundary.

Joachim Lohkamp

Curvature in Symplectic Geometry

In Riemannian and Symplectic Geometry there are "attracting constructions" based on a given Riemannian/Symplectic geometry. That is one may find new geometric structures just patching additional geometric "objects" to given base geometry. On the Riemannian side this leads to a curvature decreasing while on the symplectic area one finds symplectic submanifolds which arise as zero sets of bundles "attached" to the symplectic base manifold. The similarity of these results exceeds the basic existence results and we describe some new insights.

Denis Auroux

Symplectic 4-manifolds and Branched Coverings of $\mathbb{CP}^2$

Building upon the techniques of approximately holomorphic geometry on compact symplectic manifolds introduced by Donaldson, we show the following result:

Theorem. *Let (X^4, ω) be a compact symplectic 4-manifold; assume $[\frac{\omega}{2\pi}] \in H^2(X, \mathbb{Z})$, and let L be the line bundle such that $c_1(L) = [\frac{\omega}{2\pi}]$; fix a compatible almost complex structure J on X. Then for every large enough $k \in \mathbb{N}$ the bundle $L^{\otimes k}$ admits three approximately holomorphic sections (s_0, s_1, s_2) such that the corresponding projective map $f_k = (s_0 : s_1 : s_2) : X \to \mathbb{CP}^2$ is an approximately holomorphic branched covering, i.e., is everywhere locally modelled on one of the holomorphic maps $(x, y) \mapsto (x, y)$, $(x, y) \mapsto (x^2, y)$, $(x, y) \mapsto (x^3 - xy, y)$.*

Moreover, for large enough k the topology of the constructed branched covering is a symplectic invariant of X (it does not depend on the chosen almost-complex structure). This makes it possible to define invariants in the following way: Consider the branch curve $D \subset \mathbb{CP}^2$, which is an immersed symplectic curve with cusps. After a suitable perturbation, a generic linear projection $\mathbb{CP}^2 \setminus \{\text{point}\} \to \mathbb{CP}_1$ makes D a singular branched covering of $\mathbb{CP}^1$, with branch points, cusps, positive double points, and negative double points. Applying the brad group techniques of Moishezon one can then define the brad monodromy map $\rho : \pi_1(\mathbb{CP}^1 \setminus \{\text{points}\}) \to B_d$, where B_d is the reduced brad group on $d = \deg D$ strands. The curve D is then characterized up to isotopy by a bradfactorization $\Delta^2 = \Pi_i Q_i X_1^{\rho_i} Q_i^{-1}$, where Δ^2 is the generator of the centre of B_d, Q_i is any brad, X_1 is the half-twist, and $\rho_i \in \{1, \pm 2, 3\}$, up to simple algebraic operations.

One can also introduce a map $\theta : \pi_1(\mathbb{CP}^2 \setminus D) \to S_N$, where $N = \deg \rho_k$, which has to satisfy some simple properties; the purely combinatorial data (Q_i, ρ_i) (up to equivalence) and θ characterize the manifold X up to symplectomorphism.

Guofang Wei

A Lower Bound for Heat Kernel under Integral Ricci Curvature Bounds

(joint work with Xianzhe Dai)

We extend Cheeger-Yau's lower bound for heat kernel to integral Ricci curvature. In there we derive a new comparison of volume element integrated over the directional sphere. The error term is then controlled by this volume comparison and Gallot's upper bound estimate of the heat kernel and a result of Grigor'yan which furnishes us with a Gaussian upper bound for the heat kernel.

Kristopher Tapp

Open Manifolds with Nonnegative Curvature

In this talk, I explore consequences of Perelman's Theorem, which says that the metric projection π onto a soul is a Riemannian submersion, and moreover, the second fundamental form of the fibers is bounded. I prove:

1. The embedding of each fiber of π into the manifold is bi-Lipschitz. In particular, the ideal boundary of the manifold can be determined from a single fiber (at least if the soul is simply connected).
2. The volume growth of an open manifold of nonnegative curvature is less than or equal to the codimension of its soul minus the "amount of holonomy" in the normal bundle of its soul.

Finally, I show how to generalize work of Wu, which explores the question: What geometric bounds must be placed on the total space and base space of a Riemannian submersion in order that there are only finitely many fiber bundle isomorphism types among Riemannian submersions satisfying these bounds?

Carolyn Gordon

Recent Developments in Isospectral Manifolds

Two Riemannian manifolds are said to be isospectral if the associated Laplacians, acting on smooth functions, have the same eigenvalue spectrum. We describe techniques for constructing isospectral manifolds and give many examples illustrating various geometric invariants which are not spectrally determined.

Representation theoretic techniques may be used to construct isospectral manifolds with a common cover. In particular, Sunada developped an elegant and simple technique in 1985 which has led to a veritable industry in constructing isospectral manifolds, including for example huge isospectral sets of Riemannian surfaces (Brooks-Gornet-Gustafson). H. Pesce investigated, with interesting results, the extend to which generic isospectral manifolds with a common covering can be accounted for by Sunada's technique and generalizations.

One may also consider $\mathrm{spec}_p(M)$, the spectrum of the Laplacian of the Riemannian manifold M acting on p-forms. Various examples show that the different $\mathrm{spec}_p(M)$ contain different geometric information.

In recent years, many examples have been constructed of isospectral manifolds with different local geometry. The isospectrality can be proved by a technique involving Riemannian submersions. Examples show that the spectrum does not determine homogenity (Szabo), whether the curvature of a manifold with boundary is negative (Szabo-Gordon), and various other local curvature properties. D. Schüth constructed isospectral deformations of simply connected manifolds, including deformations of left invariant metrics on simple compact Lie groups.

Thomas Püttmann

Pinching Constants of Homogeneous Spaces of Positive Curvature

Pinching constants measure how much the local geometry of a compact Riemannian manifold with positive sectional curvature K deviates from the geometry of the standard sphere. They are defined as quotients $\delta(M,g) = \frac{\min K}{\max K}$ of the extremal values of the sectional curvature. We compute the pinching constants of all homogeneous metrics on the 13-dimensional Berger space B^{13} and of all homogeneous $\mathsf{U}(2)$-biinvariant metrics on the Aloff–Wallach space $W^7_{1,1}$. We prove that both these optimal pinching constants are $\frac{1}{37}$. So far the spaces B^{13} and $W^7_{1,1}$ were only known to admit metrics with pinching constants $\frac{16}{29\cdot 37}$. Moreover, we investigate the optimal pinching constants of homogeneous T^2-biinvariant metrics on the other Aloff–Wallach spaces $W^7_{k,l}$. It turns out that all these optimal pinching constants are given by a strictly increasing function on $k/l \in [0,1]$. In particular, all these pinching constants are $\leq \frac{1}{37}$.

Tobias H. Colding

Embedded Minimal Surfaces in 3-manifolds

In this talk we discuss recent joint work on embedded minimal surfaces in 3-manifolds. Part of the motivation for this study comes from the following question:

Question (Pitts-Rubinstein). *Let M^3 be a fixed closed Riemannian 3-manifold. Does there exist a uniform bound for the Morse index of all closed embedded minimal tori?*

The claim of Pitts and Rubinstein is that if this is the case for a sufficiently large class of metrics on $\mathbb{S}^3$, then the spherical space form problem can be solved affirmatively.

Recall that the spherical space form problem asks to show that any free action on $\mathbb{S}^3$ is topologically conjugate to an orthogonal action.

In this talk we will first discuss why the main point in answering the above question is to understand convergence of embedded minimal tori without area bounds. One of the main tools is a curvature estimate for simply connected surfaces. We also give some applications of this estimate to classical problems about minimal surfaces in $\mathbb{R}^3$.

E-Mail-Adressen:

Abresch, Uwe	abresch@math.ruhr-uni-bochum.de
Apostolov, Vestislav	apostolov@math.polytechnique.fr
Auroux, Denis	auroux@math.polytechnique.fr
Ballmann, Werner	ballmann@math.uni-bonn.de
Bangert, Victor	bangert@mathematik.uni-freiburg.de
Besson, Gerard	Gerard.Besson@fourier.uif.grenet.fr
Biquard, Olivier	biquard@math.polytechnique.fr
Böhm, Christoph	boehm@icarus.math.mcmaster.ca
Bourguignon, Jean-Pierre	jpb@ihes.fr
Brüning, Jochen	bruening@mathematik.hu-berlin.de
Burns, Keith	burns@math.nwu.edu
Calabi, Eugenio	calabi@math.upenn.edu
Colding, Tobias Holck	Colding@cims.nyu.edu
Courtois, Gilles	courtois@math.polytechnique.fr
Croke, Christopher	ccroke@math.upenn.edu
Eberlein, Patrick B.	pbe@math.unc.edu
Escher, Christine	tine@math.orst.edu
Gordon, Carolyn	carolyn.gordon@dartmouth.edu
Grove, Karsten	kng@math.umd.edu
Guijarro, Luis	luis.guijarro@uam.es
Gursky, Matthew J.	gursky@indiana.edu
Hamenstädt, Ursula	ursula@math.uni-bonn.de
Heintze, Ernst	heintze@math.uni-augsburg.de
Jost, Jürgen	jjost@mis.mpg.de
Katz, Neil N.	katz@math.sunysb.edu
Kerr, Megan	mkerr@wellesley.edu
Kleiner, Bruce	bkleiner@math.utah.edu
Kollross, Andreas	kollross@math.uni-augsburg.de
Lang, Urs	lang@math.ethz.ch
Leeb, Bernhard	leeb@mathematik.uni-mainz.de
Lohkamp, Joachim	lohkamp@math.uni-augsburg.de
Matveev, Vladimir S.	vmatveev@mpim-bonn.mpg.de
MinOo, Maung	minOo@mcmail.mcmaster.ca
Nabutovsky, Alexander	alex@math.toronto.edu
Pauly, Marc	pauly@topo.math.ucla.edu
Pedersen, Henrik	henrik@imada.ou.dk
Petersen, Peter	Petersen@math.ucla.edu
Püttmann, Thomas	puttmann@math.ruhr-uni-bochum.de
Riviere, Tristan	riviere@cmla.ens-cachan.fr
Rong, Xiaochun	rong@math.rutgers.edu

Rotman, Regina	rotman@math1.cims.nyu.edu
Samiou, Evangelia	samiou@ucy.ac.cy
Schlenker, Jean-Marc	schlenk@topo.math.u-psud.fr
Schüth, Dorothee	schueth@math.uni-bonn.ed
Schwachhöfer, Lorenz	schwachhoefer@mathematik.uni-leipzig.de
Shubin, Mikhail A.	shubin@neu.edu
Tapp, Kristopher R.	Ktapp@math.upenn.edu
Thorbergsson, Gudlaugur	gthorbergsson@mi.uni-koeln.de
Tuschmann, Wilderich	tusch@mis.mpg.de
Wang, McKenzie	wang@mcmail.mcmaster.ca
Weber, Matthias	weber@math.uni-bonn.de
Wei, Goufong	wei@math.vesb.edu
Weingart, Gregor	gw@math.uni-bonn.de
Wilking, Burkhard	wilking@math.uni-muenster.de
Yamaguchi, Takao	takao@math.kyusku-u.ac.jp
Ziller, Wolfgang	wziller@math.upenn.edu

Berichterstatter: Thomas Püttmann

Tagungsteilnehmer

Prof.Dr. Uwe Abresch
Institut f. Mathematik
Ruhr-Universität Bochum
Gebäude NA

44780 Bochum

Prof.Dr. Vestilav Apostolov
Mathematical Institute
Oxford University
24 - 29, St. Giles

GB-Oxford OX1 3LB

Dr. Denis Auroux
Centre de Mathematiques
Ecole Polytechnique
Plateau de Palaiseau

F-91128 Palaiseau Cedex

Prof.Dr. Victor Bangert
Mathematisches Institut
Universität Freiburg
Eckerstr. 1

79104 Freiburg

Prof.Dr. Gerard Besson
Laboratoire de Mathematiques
Universite de Grenoble I
Institut Fourier
B.P. 74

F-38402 Saint-Martin-d'Heres Cedex

Dr. Olivier Biquard
Centre de Mathematiques
Ecole Polytechnique
Plateau de Palaiseau

F-91128 Palaiseau Cedex

Dr. Christoph Böhm
Institut für Mathematik
Universität Augsburg

86135 Augsburg

Prof.Dr. Jean-Pierre Bourguignon
Institut des Hautes Etudes
Scientifiques
Le Bois Marie
35, route de Chartres

F-91440 Bures-sur-Yvette

Prof.Dr. Jochen Brüning
Institut für Mathematik
Humboldt-Universität

10099 Berlin

Prof.Dr. Keith Burns
Dept. of Mathematics
Lunt Hall
Northwestern University
2033 Sheridan Road

Evanston , IL 60208-2730
USA

Prof.Dr. Eugenio Calabi
Department of Mathematics
University of Pennsylvania
209 South 33rd Street

Philadelphia , PA 19104-6395
USA

Prof.Dr. Tobias Holck Colding
Courant Institute of
Mathematical Sciences
New York University
251, Mercer Street

New York , NY 10012-1110
USA

Prof.Dr. Gilles Courtois
Centre de Mathematiques
Ecole Polytechnique
Plateau de Palaiseau

F-91128 Palaiseau Cedex

Prof.Dr. Chris B. Croke
Department of Mathematics
University of Pennsylvania
209 South 33rd Street

Philadelphia , PA 19104-6395
USA

Prof.Dr. Patrick B. Eberlein
Dept. of Mathematics
University of North Carolina
Phillips Hall CB 3250

Chapel Hill , NC 27599-3250
USA

Christine Escher
Dept. of Mathematics
Oregon State University
Kidder Hall 368

Corvallis , OR 97331-4605
USA

Prof.Dr. Carolyn Gordon
Dept. of Mathematics and Computer
Science
Dartmouth College
6188 Bradley Hall

Hanover , NH 03755-3551
USA

Prof.Dr. Karsten Grove
Department of Mathematics
University of Maryland

College Park , MD 20742
USA

Prof.Dr. Luis Guijarro
Departamento de Matematicas, C-XV
Universidad Autonoma de Madrid
Ciudad Universitaria de Cantoblanco

E-28049 Madrid

Prof.Dr. Matthew John Gursky
Dept. of Mathematics
Indiana University at Bloomington
Swain Hall East

Bloomington , IN 47405
USA

Prof.Dr. Ursula Hamenstädt
Mathematisches Institut
Universität Bonn
Beringstr. 1

53115 Bonn

Prof.Dr. Ernst Heintze
Institut für Mathematik
Universität Augsburg

86135 Augsburg

Prof.Dr. Jürgen Jost
Max-Planck-Institut für Mathematik
in den Naturwissenschaften
Inselstr. 22 - 26

04103 Leipzig

Prof.Dr. Neil N. Katz
Mathematisches Institut
Universität Bonn
Beringstr. 1

53115 Bonn

Prof.Dr. Megan Kerr
Department of Mathematics
Wellesley College

Wellesley , MA 02e81
USA

Prof.Dr. Bruce Kleiner
Dept. of Mathematics
University of Utah

Salt Lake City , UT 84112-0090
USA

Dr. Andreas Kollross
Institut für Mathematik
Universität Augsburg
Universitätsstr. 14

86159 Augsburg

Prof.Dr. Urs Lang
Department Mathematik
ETH-Zentrum

CH-8092 Zürich

Prof.Dr. Bernhard Leeb
Mathematisches Institut
Universität Tübingen

72074 Tübingen

Joachim Lohkamp
Institut für Mathematik
Universität Augsburg
Universitätsstr. 14

86159 Augsburg

Prof.Dr. Vladimir S. Matveev
Prospekt Pobedy 344 - 36

454021 Chelyabinsk
RUSSIA

Prof.Dr. Maung Min-Oo
Department of Mathematics and Statistics
Mc Master University
1280 Main Street West

Hamilton , Ont. L8S 4K1
CANADA

Prof.Dr. Alexander Nabutovsky
Institut des Hautes Etudes Scientifiques
Le Bois Marie
35, route de Chartres

F-91440 Bures-sur-Yvette

Prof.Dr. Marc Pauly
Universite Libre de Bruxelles
Campus Plaine C.P. 218
Bd du Triomphe

B-1050 Bruxelles

Prof.Dr. Henrik Pedersen
Institut for Matematik og Datalogi
Odense Universitet
Campusvej 55

DK-5230 Odense M

Prof.Dr. Peter Petersen
Dept. of Mathematics
University of California
405 Hilgard Avenue

Los Angeles , CA 90095-1555
USA

Dr. Thomas Püttmann
Fakultät für Mathematik
Ruhr-Universität Bochum

44780 Bochum

Prof.Dr. Tristan Riviere
CMLA
ENS Cachan
61, Avenue du President Wilson

F-94235 Cachan Cedex

Dr. Xiaochun Rong
Dept. of Mathematics
Rutgers University
Busch Campus, Hill Center

New Brunswick , NJ 08903
USA

Prof.Dr. Regina Rotman
Institut des Hautes Etudes Scientifiques
Le Bois Marie
35, route de Chartres

F-91440 Bures-sur-Yvette

Dr. Evangelia Samiou
Department of Mathematics and Statistics
University of Cyprus
P.O.Box 537

1678 Nicosia
CYPRUS

Prof.Dr. Jean Marc Schlenker
Mathematiques
Universite de Paris Sud (Paris XI)
Centre d'Orsay
Batiment 425

F-91405 Orsay Cedex

Dr. Dorothee Schüth
Mathematisches Institut
Universität Bonn
Beringstr. 1

53115 Bonn

Lorenz Schwachhöfer
Mathematisches Institut
Universität Leipzig
Augustusplatz 10/11

04109 Leipzig

Prof.Dr. Mikhail A. Shubin
Department of Mathematics
Northeastern University

Boston , MA 02115
USA

Prof.Dr. Kristopher R. Tapp
Rittenhouse Laboratory 209
University of Philadelphia
S 33rd Street

Philadelphia , PA 19104-6395
USA

Prof.Dr. Gudlaugur Thorbergsson
Mathematisches Institut
Universität zu Köln
Weyertal 86-90

50931 Köln

Dr. Wilderich Tuschmann
Max-Planck-Institut für Mathematik
in den Naturwissenschaften
Inselstr. 22 - 26

04103 Leipzig

Prof.Dr. McKenzie Y. Wang
Department of Mathematics and
Statistics
Mc Master University
1280 Main Street West

Hamilton , Ont. L8S 4K1
CANADA

Dr. Matthias Weber
Mathematisches Institut
Universität Bonn
Beringstr. 1

53115 Bonn

Prof.Dr. Guofong Wei
Dept. of Mathematics
University of California

Santa Barbara , CA 93106
USA

Gregor Weingart
Math. Institut der Universität
Bonn
Beringstr. 1

53115 Bonn

Prof.Dr. Takao Yamaguchi
Graduate School of Mathematics
Kyushu University
6-10-1 Hakozaki

Fukuoka 812-8581
JAPAN

Dr. Burkhard Wilking
Mathematisches Institut
Universität Münster
Einsteinstr. 62

48149 Münster

Prof.Dr. Wolfgang Ziller
Department of Mathematics
University of Pennsylvania
209 South 33rd Street

Philadelphia , PA 19104-6395
USA