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OBITUARY

# In memoriam Thomas Friedrich (1949–2018)

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**Abstract**
Thomas Friedrich, who founded the journal 'Annals of Global Analysis and Geometry' together with Rolf Sulanke in 1983 and acted as editor in chief for more than 3 decades, died in Marburg (Germany) on February 27, 2018, at the age of sixty-eight of COPD and lung cancer. Besides sketching Thomas's biography and scientific work, it is our goal in this obituary to tell the founding story of 'his' journal. This will reflect his life and character, and will provide a remarkable insight into twentieth century science policies as well as the changes that scientific publishing has undergone in the past decades.

**Keywords** Thomas Friedrich · Killing spinor · Dirac operator · Friedrich's estimate · Scientific publishing

## 1 The life and work of Thomas Friedrich

The impact of history and politics on the private and professional life of Thomas cannot be overestimated, and may come as a surprise to current generations.

He was born in Schkeuditz near Leipzig on 12 October 1949, in a country that had barely existed for a week. The GDR (German Democratic Republic) was founded on Soviet-occupied territory on 7 October 1949, with its capital in East Berlin. His grandmothers were furriers, his grandfathers printers, all rather typical jobs in the industrial strongholds of Leipzig before World War II. His father Kurt Friedrich (1922–1979) had been drafted at the age of 18 right at the beginning of the war, and after being held as a POW in the Soviet Union, he returned home in 1948. He was among the few to survive the hell of the Stalingrad

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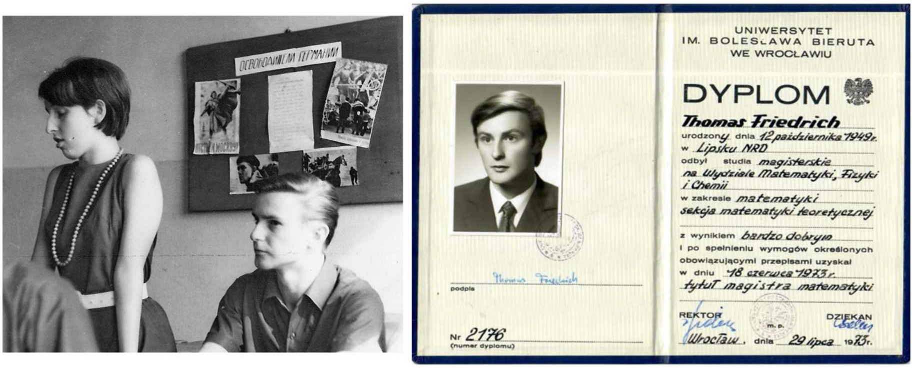
battle. In later years, Thomas's father worked as a sales representative for the *Leipziger Messe* ('Leipzig Fair'), where he was mostly responsible for trade contacts with the Soviet Union, while his mother Ruth Friedrich (1924–2007, born Schildknecht) spent most of her career as a clerk for the state pension fund.

At a very early age, Thomas helped out his parents in the small grocery store they were running in Leipzig at the time. By watching them do the accounting every evening, he learnt to compute by the age of three, thus training his mental arithmetic skills even before entering primary school.

He attended school in Leipzig with brilliant grades in mathematics and science, and hence he was recommended to go, after 8th grade, to the *Erweiterte Oberschule* (EOS—'extended secondary school', a four-year school that lead to the *Abitur*), which was reserved for less than 10 % of children. A particular feature of secondary education in the GDR at the time was the combination of the *Abitur* with an apprenticeship; Thomas was on the way to become a cooling system technician. His maths teacher recognised his exceptional talent for mathematics and recommended him to apply to the special two-year math programme of the *Arbeiter- und Bauernfakultät* (ABF—'Faculty of Workers and Farmers') at the University of Halle.

It is worth saying a few words about this East German institution, especially because its name does not convey its purpose and is often interpreted mainly as a political term. ABFs were founded as separate faculties at all major universities as an alternative way to reach the Abitur for students whose school education had been interrupted by the war and were too old to attend a normal secondary school. By the mid-sixties, the main purpose of the ABFs had been fulfilled and most would be gradually closed. The ABF in Halle, on the other hand, was transformed into a specialised boarding school preparing the best pupils for studying abroad, which at the time meant the Soviet Union for the majority, but included also the other socialist countries.

In 1967, the GDR had for the first time the opportunity to send a larger group of students to attend maths programmes at Polish universities, starting the following year. Thomas decided to apply for this and began intensively learning Polish with his classmates. After his Abitur, he therefore read mathematics at Wrocław University under Roman Duda (who became deputy minister of national education in 1991–1993) and Witold Roter, specialising in topology and differential geometry. From his study book, one can infer that he took classes with many renowned mathematicians like Władysław Narkiewicz, Czesław Ryll-Nardzewski, and Andrzej Hulanicki. Hugo Steinhaus and Bronisław Knaster were retired professors at Wrocław University, but still attended seminars and colloquium talks regularly. Barely 25 years after the German attack on Poland that started WW2, the extended stay in Poland of a noticeable group of German students was more than a private decision—it was a diplomatic challenge and their personal contribution towards a reconciliation between the two nations. In those years, Poland became Thomas's second home country. Many scientific contacts and activities (for example, at the Banach Center in Warsaw) made him a frequent visitor. He was very interested in its political and scientific development and supported Polish mathematics on many occasions. In 1972, he married his fellow student Bożena Friedrich born Wieloch, with whom he had two sons, Michael and Stefan Friedrich.




Thomas at the ABF (Elke Warmuth on the left; courtesy D. Edler) around 1967 and his mathematics degree from Wrocław University, dated 29 July 1973.

Thomas graduated in 1973 with distinction and joined the differential geometry group led by Rolf Sulanke at Humboldt-Universität zu Berlin. Just one year later, he submitted his doctoral thesis (Dr. rer. nat.) entitled *Eine Verallgemeinerung der Morse-Theorie und ihre Anwendungen auf die Integralkrümmungen*[1] He claimed that he had mostly written it on the train commuting between Berlin and Wrocław. From 1977 to 1978, Thomas spent a year at the Lomonosov Moscow State University, and visited it for extended periods of time regularly in the early eighties. He liked to point out the incredible level of mathematical research in Moscow at the time, and the very special atmosphere there. He maintained most contacts with the Chairs of Mathematical Analysis (headed by Nikolay V. Efimov) and of Differential Geometry (headed by Petr K. Rashevsky) at the Department of Mechanics and Mathematics. In 1979, he defended his habilitation thesis (Dr. sc. nat.) entitled *Einige differentialgeometrische Untersuchungen des Dirac-Operators einer Riemannschen Mannigfaltigkeit*[2]. One year later, he was promoted to *Dozent*, which can be viewed as being roughly equivalent to associate professor.

At this time, Thomas obtained his presumably most important scientific result; without a doubt, the one that triggered the most active and far-reaching research thereafter, and the one that established his scientific reputation[3].

In 1928, Paul Dirac had introduced the differential equation for the state function of a spin 1/2 particle, the so-called Dirac equation, i.e. the eigenvalue equation of the Dirac operator $D$, which is a first-order differential operator [8]. In 1932, Erwin Schrödinger studied the Dirac operator at least locally on semi-Riemannian manifolds [15]. In particular, he compared the square of the Dirac operator $D$ with the Laplacian $\Delta$ and observed that the difference depends only on the scalar curvature $R$ of the manifold,

$$D^2 = \Delta + \frac{1}{4} R.$$

However, the Dirac operator $D$ cannot be defined globally on any Riemannian manifold $M^n$: rather, one needs a complex vector bundle equipped with endomorphisms satisfying the

[1] ‘A generalization of Morse theory and its applications to integral curvatures’.

[2] ‘Some differential-geometric investigations of the Dirac operator of a Riemannian manifold’.

[3] The following paragraph is heavily inspired by Thomas’s review [12] of the book [7], which was written with the purpose to give a short historical account on Dirac operators. All efforts of the first author to convince Thomas to write a more detailed historical report on the topic had previously failed.

Clifford relations. This restricts the topological type of the manifold, since the first and second Stiefel–Whitney classes have to vanish—these are the so-called spin manifolds. For example, all odd-dimensional complex projective spaces are spin, whereas the even-dimensional ones are not. At the *Mathematische Arbeitstagung* in Bonn in 1962, Michael F. Atiyah laid out the rigorous foundations of the Dirac operator as a first-order elliptic operator for Riemannian spin manifolds and discussed its index. At that moment, the Dirac operator became one of the basic elliptic operators in analysis, geometry, representation theory, and topology. Shortly after, André Lichnerowicz used the Dirac operator together with the general index formula for the proof that the $\hat{A}$-genus of a compact Riemannian spin manifold of dimension divisible by 4 and with positive scalar curvature vanishes. This was the first topological obstruction to the existence of metrics with positive scalar curvature to be discovered. Not aware of Schrödinger's result, Lichnerowicz computed once again the square of the Dirac operator. If the scalar curvature is positive, there are no harmonic spinors, i.e. the index is zero. Nigel Hitchin generalised this result to any dimension in 1974. He explained many properties of the Dirac operator depending on the underlying metric and he computed some spectra explicitly. In particular, he discovered that in contrast to the Laplacian acting on exterior forms, the dimension of the space of harmonic spinors is a conformal invariant which can (dramatically) change with the conformal class.

Within this circle of ideas, Thomas had the extraordinary insight to take up the systematic investigation of the *geometric* properties of the Dirac operator on its own, rather than concentrating on its topological applications. Peter Wintgen, a senior member of the differential geometry group at Humboldt University, found this brilliant idea---but with a rather strange justification: 'This is a perfect topic, nobody else is going to do that in the coming decades, so you have it for yourself!' He could not have been more wrong. Presumably, no one was aware at that moment that Thomas was on the verge of opening and shaping a whole new research topic. As a consequence, the research group at Humboldt University quickly grew to an exceptional size, with scientific contacts in eastern and western countries alike. A first series of articles by Thomas was devoted to basic properties of the Dirac operator (like the dependence of the spectrum on the choice of a spin structure) and are now used as a source of exercises in any course on the topic.

The Schrödinger–Lichnerowicz formula bounds the eigenvalues $\lambda$ of the Dirac operator of a compact Riemannian spin manifold $(M^n, g)$ by $\lambda^2 \geq R_{\min}/4$, where $R_{\min}$ denotes the minimum of the scalar curvature. In 1980, Thomas observed that this estimate is never the best possible in case $R_{\min} > 0$. Indeed, the optimal inequality reads [9]

$$\lambda^2 \geq \frac{n}{4(n-1)} R_{\min}.$$

Let us comment on this result a bit further, as it conceals many remarkable facets and allows for a glimpse of Thomas's scientific creativity.

First of all, it implies that the Dirac operator behaves quite differently from other elliptic operators like the Laplacian. Solutions exist not only on spheres, but as is shown in [9] also on the 5-dimensional Stiefel manifold $SO(4)/SO(2)$. Hence, an Obata-type theorem known for Laplacians does not hold for Dirac operators.

Secondly, the proof uses some novel object—a special connection on the spinor bundle that is different from the Levi-Civita connection. As he used to tell, this had basically been a *mathematische Spielerei*, just playing around with the objects, and came as a surprise to him. Later, from 2001 on, he began to study systematically metric connections with torsion together with the first author, thus rejuvenating the topic and opening it to completely new areas—manifolds with special geometric structures.

After this, the logical thing to do was to examine the situations where equality occurs in Friedrich's estimate (as it had become known). We know that if the lower bound is an eigenvalue of $D^2$, the space must be Einstein and the eigenspinor $\psi$ satisfies the real Killing spinor equation,

$$\nabla_X \psi \; = \; \frac{1}{2}\sqrt{\frac{R}{n(n-1)}} X \cdot \psi,$$

where $X \cdot \psi$ denotes the Clifford multiplication of the spinor $\psi$ by the vector $X$. Spaces with real Killing spinors and their link to special geometric structures have been investigated in dimensions $4 \leq n \leq 8$ by Friedrich/Kath and Grunewald (see [6,13] for detailed accounts and references). Einstein–Sasaki manifolds admit Killing spinors in all odd dimensions; in dimensions 6 resp. 7, the existence of a Killing spinor is equivalent to the manifold being nearly Kähler resp. nearly parallel $G_2$. Oussama Hijazi, then a PhD student of Jean-Pierre Bourguignon, discovered a conformal estimate for the first eigenvalue $\lambda$ of the Dirac operator that depends on the lowest eigenvalue of the Yamabe operator, thus refining the Friedrich estimate. Moreover, Hijazi and Bourguignon observed that a compact Riemannian manifold with a Killing spinor cannot admit parallel forms. In particular, this implies for Kähler manifolds that the previous lower bound can never be an eigenvalue of the Dirac operator. The optimal lower bound for Kähler manifolds was proved by Klaus-Dieter Kirchberg in 1986. Ten years later, Wolfram Kramer, Uwe Semmelmann, and Gregor Weingart proved the optimal lower Dirac bound for quaternionic Kähler manifolds.

Lichnerowicz added a new idea to the subject in 1987. He considered a second, universal, first-order differential operator acting on spinors, the so-called twistor operator. Its kernel is a conformal invariant and consists of all spinor fields $\psi$ satisfying the differential equation

$$\nabla_X \psi + \frac{1}{n} X \cdot D\psi \; = \; 0.$$

Real and imaginary Killing spinors are special solutions of the twistor equation. Such a spinor field vanishes only at isolated points, and outside this discrete set, the twistor spinor is conformally equivalent to a Killing spinor or a parallel spinor. This was the starting point of exciting developments intertwining complex geometry and spinorial techniques.

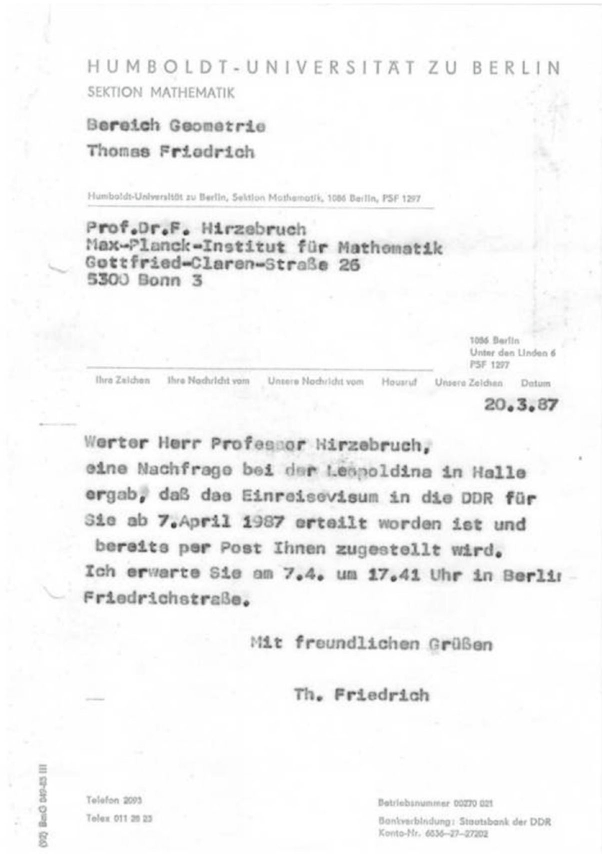
Finally, yet another aspect of this amazing story was uncovered around 2001, propelled by the collaboration with the first author. If we consider Friedrich's equality case, there are two impending observations to be made: nearly Kähler manifolds and nearly parallel $G_2$-manifolds are special instances of Riemannian manifolds with structure group reducing to SU(3) and $G_2$, but whose Riemannian holonomy does not lie in these subgroups, and many interesting examples arise as Riemannian non-symmetric homogeneous spaces. As such, they carry a canonical connection with parallel curvature and torsion by the Ambrose–Singer theorem, which therefore does *not* coincide with the Levi-Civita connection. In fact, Alfred Gray had defined these two classes of manifolds in 1971 with an idea of 'weak holonomy' (as opposed to the holonomy of the Levi-Civita connection) in mind. Boosted by the developments in superstring theory, many people began studying manifolds admitting $G$-reductions and compatible connections, including Thomas's own research group. (We refer to [1,2] for detailed surveys that include historical references.) The papers [5,10] on Dirac operators of connections with skew torsion and on the holonomy of such connections were the first highlights of this enlarged mathematical landscape. In [3], the authors deduce by advanced twistorial techniques an eigenvalue estimate for Dirac operators with skew torsion that coincides with Friedrich's inequality in the case of vanishing torsion. In one of his last research papers, Thomas and collaborators described SU(3)- and $G_2$-manifolds via a spinorial field equation for the intrinsic spinor, thus providing a suitable modern framework for the previous characterisation of nearly Kähler manifolds and nearly parallel $G_2$-manifolds through Killing spinors [4].

As a mathematician with broad scientific interests, Thomas also worked in areas other than spin geometry, such as the theory of surfaces and gauge theory, to name but a few. It is perhaps not so widely known that Thomas and Herbert Kurke [11] proved, roughly at the same time as Nigel Hitchin [14] did, but using different ideas, the celebrated result that a complete, connected, anti-selfdual Einstein 4-manifold with positive scalar curvature (and hence with Fano twistor space) is isometric to either the round sphere $S^4$ or the projective plane $\mathbb{CP}^2$ with the Fubini-Study metric.

Let us return to Thomas's biography. In 1981 he organized with Rolf Sulanke a conference on *Differential Geometry and Global Analysis* in Garwitz. This event is deeply linked to the foundation of the journal 'Annals of Global Analysis and Geometry', and will be discussed in detail in the next section. A yellowed folder that Thomas kept in his private archive entitled *Kapitalistisches Ausland* ('capitalistic foreign countries') is proof of how difficult it was to establish and maintain scientific contacts with western countries, and the multiple efforts that Thomas and Sulanke made to improve the situation. All this required relentless perseverance and dedication. Starting with an (unsuccessful) invitation to Oberwolfach extended by Wilhelm Klingenberg in 1977, the documentation reflects a slowly increasing number of invitations to Humboldt University—again some successful, some not—and of return invitations to western universities and research institutes. A massive amount of typewritten letters is testimony of the tremendous challenges related to visa problems and scheduling.

In 1982, Thomas was able to visit the University of Maryland upon the invitation of Alfred Gray, and the University of Montpellier upon the invitation of Pierre Molino (where he also met Alexander Grothendieck). In the spring of 1984, he visited the École Polytechnique in Paris (the hosts were Jean-Pierre Bourguignon and his then PhD student Oussama Hijazi). In the summer of 1989, he travelled to Nantes, invited by Horst Ibisch.

Contacts with West Germany were at times difficult, partly due to the special status of the divided city of Berlin. Flying from West Berlin's Tegel airport, for example, was usually not allowed, although it would have been the most convenient option. (Thomas could hear the planes taking off and landing from his home in East Berlin's Pankow neighbourhood.) While Friedrich Hirzebruch, the director of the Max-Planck Institute for Mathematics in Bonn, had been a regular visitor to different places in the GDR outside Berlin; it took Thomas until spring 1987 to obtain the permission to host Hirzebruch at Humboldt University (see the following letter, of many).



HUMBOLDT-UNIVERSITÄT ZU BERLIN
SEKTION MATHEMATIK

Bereich Geometrie
Thomas Friedrich

Humboldt-Universität zu Berlin, Sektion Mathematik, 1086 Berlin, PSF 1297

Prof.Dr.F. Hirzebruch
Max-Planck-Institut für Mathematik
Gottfried-Claren-Straße 26
5300 Bonn 3

1086 Berlin
Unter den Linden 6
PSF 1297

Ihre Zeichen | Ihre Nachricht vom | Unsere Nachricht vom | Hausruf | Unsere Zeichen | Datum 20.3.87

Werter Herr Professor Hirzebruch,
eine Nachfrage bei der Leopoldina in Halle ergab, daß das Einreisevisum in die DDR für Sie ab 7.April 1987 erteilt worden ist und bereits per Post Ihnen zugestellt wird.
Ich erwarte Sie am 7.4. um 17.41 Uhr in Berlin Friedrichstraße.

Mit freundlichen Grüßen

Th. Friedrich

Telefon 2093
Telex 011 28 23

Betriebsnummer 00270 021
Bankverbindung: Staatsbank der DDR
Konto-Nr. 6636-27-27202

Thomas's letter to Friedrich Hirzebruch saying he would pick him up at 'Friedrichstraße' border station on 7 April 1987, at 17:41.

In return, Thomas eventually attended the *Mathematische Arbeitstagung* in Bonn the same year and gave a research talk. Thomas was appointed full professor at Humboldt University.

In 1989, at the age of 40, Thomas was already a well-established mathematician, and was leading together with Sulanke a growing, internationally recognised research group. Despite being a convinced communist, Thomas faced a variety of difficulties caused by internal politics (some beyond his responsibility, such as problems initiated by members of his group; others presumably due to his unconditional habit of expressing his opinion out loud, and not always in the most diplomatic way). Yet he managed to overcome all these problems—for the sake of mathematics. This is when the Iron Curtain fell as part of a long series of political changes. In Berlin, the situation culminated on November 9. At a press conference, the unofficial Politbüro spokesman Günter Schabowski was caught off-guard and in a somewhat improvised answer said that 'New travel regulations would apply from *now*'. This was taken literally by many citizens who made their way to Berlin's inner border with the intention of crossing over, at least to have a look on the other side (as Thomas recalled, his teenage children urged him to do the same, as they had never seen the West, and the nearest crossing was just 5 minutes away from their home). That night's events set in motion a process that could no longer be stopped, and eventually led to the reunification of the two Germanies on 3 October 1990.

As most GDR citizens, Thomas had mixed feelings about the events, which could easily turn into the subject of evening-long discussions with him. While he felt that changes were absolutely necessary in the GDR, he was not convinced that one should simply adopt West Germany's political system, nor that such a fast reunification would be beneficial. Rather, he had been in favour of a slower familiarisation of the two states, and strongly advocated that GDR citizens should be given the opportunity (and the time) to build their own opinion, and reform their state according to their own views. Not uncommonly for such a sharp mind, he made a realistic and ultimately prophesising assessment of the social and political challenges to come.


Hiermit berufe ich
auf der Grundlage der Hochschullehrerberufungsverordnung (HBVO)
vom 6. November 1968

Herrn Hochschuldozent Dr. sc. nat.

THOMAS FRIEDRICH

mit Wirkung vom 1. September 1987 zum

ORDENTLICHEN PROFESSOR

für Globale Analysis
an der Humboldt-Universität zu Berlin

Berlin, den 1. September 1987

Ernennungsurkunde

IM NAMEN DES KURATORIUMS DER
HUMBOLDT-UNIVERSITÄT ZU BERLIN

ERNENNE ICH
UNTER BERUFUNG IN DAS BEAMTENVERHÄLTNIS AUF LEBENSZEIT

HERRN

PROFESSOR DR. THOMAS FRIEDRICH

MIT WIRKUNG VOM

1. FEBRUAR 1993

ZUM

Universitätsprofessor

BERLIN, DEN 18. JANUAR 1993

HUMBOLDT-UNIVERSITÄT ZU BERLIN
DIE PRÄSIDENTIN

HUMBOLDT-UNIVERSITÄT ZU BERLIN 1

Thomas had two separate professor appointments at the same university, from two German states. On the left, the appointment signed by Prof. Hans-Joachim Böhme, minister of higher education in the GDR in 1987. On the right, the one signed by Prof. Marlis Dürkop-Leptihn, president of Humboldt University in 1993.

At a personal level, Thomas felt the immediate impact of the changes in a dramatic way. The transition process, and progress, varied greatly from place to place. Berlin was obviously at the centre of the attention (and hence of the disputes). *All* professors working at Humboldt University (including Thomas and Sulanke) lost their positions. Those not working for the *Ministerium für Staatssicherheit* (MfS—'Ministry for State Security', the official state security service of the GDR), and not charged with other crimes, would have to reapply for their own job, provided a position in the same area was reopened. All running PhD grants were cancelled (with only vague options for a somewhat distant future), which applied to several young members of the group (some of whom fought hard to be granted permission to graduate before the changes took place). Tenured researchers, other than professors, were pressured into signing new, temporary contracts, again with only vague promises of a further contract at a later time (as happened to Thomas's first wife Bożena and several members of the research group[4]). Factories closed overnight, resulting in Thomas's son Michael losing his apprenticeship as an electronic engineering technician. The Academy of Sciences of the GDR with its large 'Karl Weierstrass Institute of Mathematics' was shutdown[5]. As anybody from all over Germany was free to apply for the announced positions, there was fierce competition for the few reopened professorships at Humboldt University, and the outcome was far from predictable. All in all, the uncertainty of the whole situation was crushing.

During this time, daily life at the university continued nevertheless—classes were taught, exams were taken. Strangely, it was also a time of high scientific liberty. Thomas used to recall that from an organisational point of view, this was his favourite time at the university. The old authoritarian bureaucrats[6] were gone, the new ones had not yet taken over, so scholars were basically left to their own devices to reshape institutes, directorial boards, and study regulations as seemed fit to them. Unfortunately, the situation did not last.

Although Thomas never admitted so, the affront of having to renounce his professorship and apply anew was a major blow to his self-esteem. On top of that, the brutal academic overhaul was impacting his large research group, and Thomas felt compelled to find ways to ensure that team members kept their job and continued to receive a salary. He understood that the only solution was to apply for West-German research grants *immediately*, which he did even before knowing whether he would be hired again. This resulted in 1992 in the foundation of the Collaborative Research Center 288 'Differential Geometry and Quantum Physics' (the first joint CRC between scientists from East and West Berlin, involving mathematicians and physicists from Humboldt Universität, Technische Universität and Freie Universität) and the Graduate School 'Geometry and nonlinear Analysis'. Both were extremely successful and secured positions for many, though not all, members of the research group. All of Thomas's students with permanent jobs in academia today (see Appendix B) were members of these projects at some moment and greatly benefitted from them.

June 1997 was a turning point in Thomas's life, which his colleagues and friends considered mostly unexpected at the time. Like many times in the past, he attended as coorganiser the 'Workshop on Geometric Methods in Physics' held in the middle of the primeval Białowieża Forest in Poland, not far from the border with Belarus. It was there that he met the first author, Ilka Agricola, a young graduate in theoretical physics from Munich who had just returned from an extended research stay at Rutgers University and was on the point of taking up a PhD position in representation theory at the University of Erlangen. Accidentally, Thomas had a vacant assistant position in his group and swiftly offered it to Ilka in order to convince her to join his group in Berlin instead of going to Erlangen.

The story, as perceived by outsiders, was that she thus became his PhD student, and eventually, over time, his life partner. But Thomas, foreseeing all sorts of unjustified gossip, was cannier. From the beginning, it had been clear to both that moving to Berlin would imply (sooner, rather than later) the beginning of a romantic relationship. While she wanted to

[4] Hiring a West-German (!) lawyer specialised in labour law was the only chance to win this battle. This, however, entailed skills, courage, and money.

[5] Although the now existing institute of same name in Berlin is somewhat a continuation of the old institute, there was no continuity in hiring: none of the East German professors working at the previous Weierstrass Institute were reappointed there, and contrary to the predecessor, the new institute does not cover all areas of mathematics.

[6] He liked to use the old-fashioned German term 'Obrigkeit' for this: *Die alte Obrigkeit war weg, die neue noch nicht da.*

pursue for her PhD the topic of the research project she had started at Rutgers, he insisted her to learn spin geometry and spectral theory of Dirac operators in parallel. They agreed on the rules of a collaboration under a work contract, should the relationship fail. Happily, they never needed to test these rules. In 2003, Thomas and Ilka married and on Christmas day became parents of Julius Friedrich Agricola. In the same year, they were awarded the honorary medal of Charles University Prague for their work towards the replenishment of the mathematical institute's library, which had been destroyed in the summer 2002 flood. Over the years, they wrote together two textbooks (one on global analysis, one on elementary geometry) and more than a dozen research papers, and they made several research trips, for example to the Erwin-Schrödinger Institute in Vienna, the National University of Córdoba in Argentina, and Seoul National University in South Korea. Ilka finished writing her habilitation thesis while their son was sleeping in the cradle, and she won a major research grant from the Volkswagen Foundation. This enabled her to continue her career at Humboldt University with her own PhD students and post docs. Together with Thomas's students and affiliated researchers, they formed a research group of impressive size now lead by Thomas and Ilka equally. In 2008, Ilka was appointed full professor at Marburg University, and so the family moved there. The rather charming little medieval university town was a welcome change for all of them, compared to the hectic daily life in the capital.

Left: The first author and Thomas "visiting Paul Dirac" in Cambridge, 2011. Right: Thomas at his favourite café in Marburg, October 2017 (private property).

Thomas was still commuting back and forth between Marburg and Berlin, and when he turned 60 in 2009, he decided to start working part-time. His health was getting worse, he resented the stress of commuting to Berlin and would rather spend more time with the family, and although he was a very dedicated academic teacher, he was getting tired of the heavy teaching load. Finally, in 2015, he retired from Humboldt University, but continued to teach a few classes in Marburg just for fun.

Thomas's ailment slowly infiltrated his life like a poison: barely noticeable at the beginning, but progressing over the years. When he finally quit smoking in 2012, after particularly bad bronchitis, the affliction had become chronic and treatments would only delay the inception of COPD. In 2017, he was diagnosed with early-stage lung cancer. After much thought, it was decided not to undergo a risky surgery. During the particularly bitter winter of 2018 Thomas caught an infection that was just too much for his weakened body. He passed away at Marburg University hospital on 27 February 2018, weighing just 38 kg. He was buried in Marburg at the Hauptfriedhof Rotenberg cemetery. His gravestone from local sandstone shows the inequality carrying his name, and an inscription on the back explains the mathematical background.


Thomas's resting site at Hauptfriedhof Rotenberg, Marburg (private property).

Our warmest thanks go to Thomas's best friend over five decades, his classmate, fellow mathematician and colleague Dr. Elke Warmuth (Humboldt University) for her everlasting support. We are also truly grateful to Prof. Dr. Rolf Sulanke for his involvement in the writing of this note and for providing many pieces of first-hand information.

## 2 The foundation of the journal 'Annals of Global Analysis and Geometry'

The first plans for the journal go back as early as May 1980, when Thomas and Sulanke wrote an internal 'concept paper' for starting the discussion within the Department and the University. Their proposal was for an occasional publication collecting research articles in English, already entitled 'Annals of Global Analysis and Geometry', covering the following areas:

- differential geometry,
- Lie groups and representation theory,

- global problems of real and complex analysis,
- algebraic topology and topology of manifolds,
- applications of the aforementioned areas to problems in theoretical physics.

For the first publication year, they considered 1982, with 1000 copies to be produced in offset printing. There would be no royalties for the authors, but 50 free reprints of accepted articles. The two editors in chief, Thomas and Sulanke, would be supported in their work by an international editorial board. As an original feature, the concept paper mentions explicitly the option to translate unpublished articles by Russian mathematicians for publication in 'Annals of Global Analysis and Geometry'. In 1984, a joint assessment was planned for checking the options for a transformation into a regular journal.

The concept paper also mentions their motivation. At the time, the only specialised journal in the area was the 'Journal of Differential Geometry', founded in 1967 and published (then, and now) by Lehigh University, Pennsylvania, US. But this was practically unavailable in eastern European libraries, papers took a long time to be printed (meaning a systematic delay in the access to new research results), and obtaining the permission to publish in it was difficult for most mathematicians in communist countries. Given how fast the topic had been expanding at the time, they saw a niche in the market for a second publication in the area based in Europe which would result in increased possibilities of cooperation between geometers from western and eastern Europe, a speedier (and cheaper) access to recent results, and enhanced publication options for eastern European researchers.

The political situation at the time was ambivalent, to say the least. Although the *Neue Ostpolitik* ('new eastern policy') between 1969 and 1974 had led to the normalisation of relations between the Federal Republic of Germany (FRG) and eastern Europe, particularly the German Democratic Republic (GDR), implementing the changes was still tedious at a local level. For example, permission to travel to conferences in West Germany was rarely granted. The atmosphere in the mathematical community was divided, due to events that unfolded at the 1978 ICM in Helsinki (the Russian mathematician Gregori A. Margulis was awarded the Fields Medal, but was not allowed to attend the meeting). In Poland, the strikes of the banned trade union Solidarność at the Gdańsk shipyard triggered a political crisis that culminated in the martial law of December 1981. This, in turn, made it impossible to hold the 1982 ICM in Warsaw (it took place a year later, in August 1983). Despite all these problems, it was clear to Thomas and Sulanke that there was no alternative to pushing for increased scientific exchanges, and they were not afraid to get in trouble with the political authorities every now and then if it served the good of mathematics and research.

The discussions in the Department quickly led to contacts with Dr. Walter, editor of VEB[7] Deutscher Verlag der Wissenschaften, Berlin (VdW for short hereafter) and finally to the signing of a first contract in August 1981. As sketched in the concept paper, it stipulated a loose series of article collections called 'Annals of Global Analysis and Geometry' and edited by Thomas and Sulanke. Manuscripts would be prepared for offset printing by departmental secretaries. Each volume would be printed in about 1000 copies, with 50 free reprints for authors. The size was 8 printing sheets per issue, resulting in 128 pages. Indeed, all volumes in the old contracts were counted in 'printing sheets' (*Druckbögen*), each such sheet comprising 16 pages in the bound issue. This was necessary for estimating the production costs (in particular, of paper). In fact, due to the chronic shortage of raw materials in socialist countries, the 'allocation' of a contingent of printing paper was one of the main issues of the project. It was counterbalanced only by the prospect of acquiring western currency, and the consequent

[7] VEB, abbreviation of Volkseigener Betrieb: The Publicly Owned Enterprise was the main legal form of industrial enterprises in GDR.

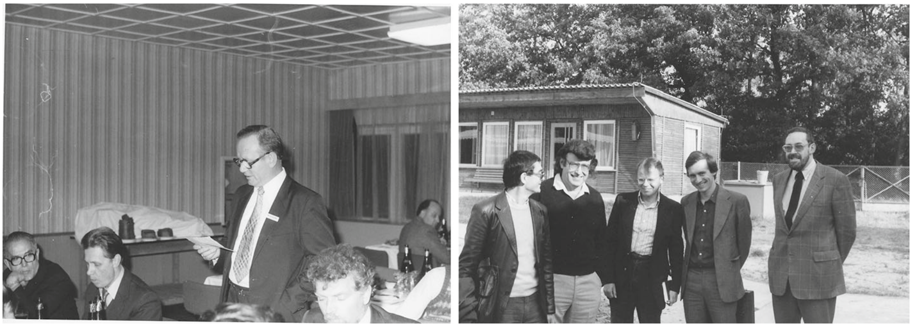
beneficial outfall (scientific and monetary) for all parties involved. This appeal was irresistible to the authorities, and probably had a substantial influence on its speedy realisation.

In parallel, Thomas and Sulanke were organising the conference *Differential Geometry and Global Analysis*, to be held in Garwitz (a small village half-way between Berlin and the Baltic Sea) on 5–10 October 1981. On this occasion, they would gather the chosen editors and hold the first meeting of the editorial board. Organised jointly by the Department of Mathematics of Humboldt University Berlin and the Institute of Mathematics of the Academy of Sciences of the GDR[8], it turned out to be the biggest conference on the topic ever held in the country. Around 120 scholars participated, of which 60 were from the GDR, 40 came from the Eastern Block and 20 from the West. The list of plenary talks leaves no doubt on the event's extremely high standard and profile:

(1) Bertram Kostant (US), Geometric quantization and a review of the orbit method.
(2) Werner Müller (GDR), Spectral theory for Riemannian manifolds with cusps and Selberg's trace formula for rank 1 lattices.
(3) Misha A. Shubin (USSR), Index theories and spectral distribution functions of unfredholm operators.
(4) Thomas Friedrich (GDR), Spectral properties of the Dirac equations on Riemannian manifolds.
(5) Wilhelm Klingenberg (FRG), Closed Geodesics.
(6) Andrei V. Bizadse (USSR), Construction of exact solutions of some important classes of partial differential equations.
(7) Yuri I. Manin (USSR), Extension of holomorphic vector bundles and Yang-Mills fields.
(8) B. Helffer (France), Asymptotic behaviour of the spectrum of globally elliptic pseudodifferential operators in $\mathbb{R}^n$.
(9) Victor J. Ivrii (USSR), On precise spectral asymptotics for elliptic operators acting in fiberings over manifolds with boundary.
(10) Karsten Grove (Denmark), Old and new results on diameter and curvature.
(11) Nicolaas H. Kuiper (France), Geometric class and degree of tight surfaces.
(12) Sigurdur Helgason (US), Differential operators and Fourier transformations on symmetric spaces.
(13) Alfred Gray (US), The formula of Weyl and Steiner for Riemannian manifolds.
(14) Bert-Wolfgang Schulze (GDR), Pseudodifferential boundary problems without the transmission property and applications.
(15) Alexander S. Mishchenko (USSR), $C^*$-algebras and pseudodifferential operators.
(16) Bogdan Bojarski and Tadeusz Iwaniec (Poland), Some new aspects in the analytical theory of quasiconformal mappings, $n \geq 3$.

At this stage, the journal had a contract and a proposed editorial board. But in order to truly take off, it needed a sales partner for the western countries. For this, Dr. Walter from VdW suggested North Holland Publishing Company. Thomas wrote to them in late 1981, alas to little avail.

[8] Academy of Sciences of the German Democratic Republic (*Akademie der Wissenschaften der DDR*), founded in 1946 by the Soviet Military Administration in Germany to continue the long tradition of the Prussian Academy of Sciences and the Brandenburg Society of Sciences. It was dissolved in 1993.



Impressions from the Garwitz conference: Rolf Sulanke standing (left), Yuri Manin, Bertram Kostant, Wilhelm Klingenberg, Boris Komrakov, and Alfred Gray (right) (private property).

On 21 April 1982, Thomas was connecting at Schiphol Airport in Amsterdan on his way to the University of Maryland. There, he met Dr. Sevenster from North Holland (NH), and recorded the results of the negotiations in his travel diary. While Thomas was pressing for a first issue to appear in 1982, this seemed too early to Dr. Sevenster, who was keener on 1983. More importantly, NH strongly preferred a regular journal because occasional book series would not be ordered by libraries, and therefore sales margins would be smaller. Hence, Dr. Sevenster suggested that VdW should write another letter to NH with a concrete proposal for a proper journal. Its distribution and sale in eastern countries would be assured by VdW, in western countries by NH.

As a result, a new contract was signed in June 1983 between VEB VdW as publisher and Humboldt University, with Thomas and Sulanke acting as authorised representatives of the rector, Prof. Dr. Helmut Klein[9]. The new format was: one volume per year with three issues and a total of 24 printing sheets, thus making 384 pages. Again, the nominal size of an issue consisted of 8 printing sheets, or 128 pages. The estimated number of copies was 750. The typesetting of the final manuscripts was the responsibility of the university and the prepared manuscripts should be sent for printing to VdW three months in advance.

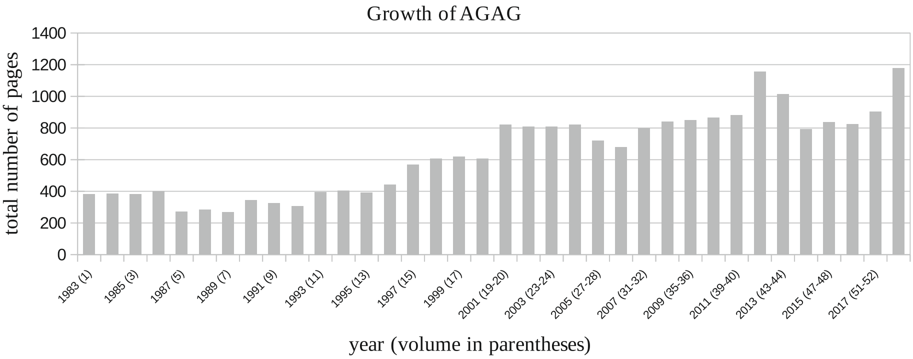
The final contracts with NH were prepared by VEB VdW. Due to this, unfortunately, there remains no written proof of the contacts with NH and, later, Kluwer Academic Publishers[10]: they were lost in the dissolution of VEB VdW in 1993. Finally, the first volume of AGAG appeared as planned in 1983 with three issues of resp. 136, 118, and 128 pages.

Given the insecurity of the whole situation, it was far from clear that the journal would survive the political changes of 1989. The dismissal of all professors and the complete reorganisation of Humboldt University made it hard to guarantee the smooth production of manuscripts, which completely relied on the availability of well-trained departmental secretaries. Moreover, the new rectorate—contrary to Thomas's beliefs—was convinced that having a scientific publication was not a core duty of a university, and hence was dispensable.

[9] Helmut Klein (1930–2003), read maths, physics, and pedagogy; he served four consecutive terms as rector from 1976 until 1988.

[10] Strictly speaking, NH had been part of Elsevier since 1970, but the journal was advertised under the brand 'North Holland'. The ownership structure of the publishing companies involved is somewhat hard to follow.

As a result of very intense negotiations, Thomas managed to negotiate a new contract for AGAG in 1992. It had two crucial points. First, they agreed on a remuneration from Kluwer for the preparation of the camera-ready manuscript, which paid the salary of a part-time secretary. This was Inge Gröger, wife of Prof. Dr. Konrad Gröger, one of the mathematics professors of the Department. After her retirement in 1998, the production of manuscripts was transferred to the publisher. The second point was the expected increase in the journal's size, which passed from 3 to 4 issues per year in 1993, to 6 issues in 1997, to two volumes[11] of 4 issues each in 2001. The growth of the journal over the years is illustrated in the following chart:




The responsible publishing editors at Kluwer then and until 1998 were Dr. D. J. Larner and Dr. Paul Roos. Around 1998 Dr. Liesbeth Mol took over from them, followed by Lynn Brandon (2002–2012).

In the meantime, Kluwer Academic Publishers merged with Springer Verlag (decided in 2002, but enforced in 2004) to form (after some further mergers) Springer Nature as we know it today. For the publishing of AGAG, this had no major changes except for a brand new logo on the cover. For a short period, Jörg Sixt edited the journal (2012–2016) before it returned to the hands of Lynn Brandon. To the day, 'Annals of Global Analysis and Geometry' has published a total of 1326 articles (including 18 errata), 56 volumes…and is still going pretty strong.

## Appendix A. AGAG editors over the years

Since its founding in 1984, the journal has always been steered by a pair of editors in chief, with equal rights and duties but varying appointments:

When Duzaar took over after Sulanke retired in 1995, a tradition-of-sorts began whereby one managing editor should be closer to differential geometry, while the other belonged more to geometric analysis. Over time this choice has served well the broad and complementary reach of the journal, as attested by its name.

[11] It may seem strange at first to have two volumes per year instead of a single larger one. It was due to the traditional point of view that a 'standard' volume should consist of 4 issues of 100 pages each, and was the basis for all accounting matters. Furthermore, in a time when electronic publishing was still in its infancy, the release of issues with sufficient volume, as early as possible, was crucial for readers and libraries.

The AGAG Editors-in-Chief

| | | |
|---|---|---|
| Rolf Sulanke (1983–1995) | Frank Duzaar (1995–2017) | Verena Bögelein (2018–) |
| Thomas Friedrich (1983–2014) | Ilka Agricola (2015–) | |

Since the journal's inception, the editors in chief have relied on an editorial board (EB) varying between 15 and 20 members. The founding EB consisted of the following 19 mathematicians. Here and later in this section, those who participated in the Garwitz conference (some as young postdoctoral researchers) are marked with *.

The Founding Editors (sorted by term of appointment)

| | |
|---|---|
| 1983–1989 | Marcel Berger, Bertram Kostant*, Yurii Manin*, Andrzej Trautman |
| 1983–1992 | Janos Szenthe*, Anders Melin* |
| 1983–1995 | Herbert Kurke, Krzysztof Maurin, Tom Willmore |
| 1983–1996 | Paul Günther (until year of death) |
| 1983–1997 | Ernst Ruh |
| 1983–1998 | Alfred Gray* (until year of death) |
| 1983–2000 | Alexander S. Mishchenko*, Arkady L. Onishchik |
| 1983–2011 | Victor Guillemin, Bert-Wolfgang Schulze* |
| 1983–2015 | Jürgen Eichhorn*, Oldrich Kowalski* |
| 1983–today | Nigel Hitchin |

In 1993, a second major reshaping of the EB took place (the first one happening in 1989). It is noteworthy that two women were appointed, namely Helga Baum* (1993–2000) and Ursula Hamenstädt (1993–2012).

Other people serving on the EB at some time include (in alphabetical order): Dmitri V. Alekseevsky*, Claudio Arezzo, Olivier Biquard, Yurii V. Egorov, Thomas Fiedler*, Dirk Ferus, Simon Gindikin, Victor J. Ivrii*, Ruth Kellerhals, Peter Michor, Hans-Bert Rademacher, Tudor Ratiu, Tristan Rivière, Antonio Ros, Mikhail Shubin*.

Today the editorial board consists of a well-balanced mixture of scholars from all continents (again in alphabetical order): Ben Andrews (Australia), Vestislav Apostolov (Canada), Ulrich Bunke (Germany), Anna Fino (Italy), Nigel Hitchin (UK), Stefan Ivanov (Bulgaria), Jorge Lauret (Argentina), Claude LeBrun (US), Li Ma (China), George Marinescu (Germany), Jinsung Park (Republic of Korea), Simon Salamon (UK), Iskander Taimanov (Russia), Yoshihiro Tonegawa (Japan), Guofang Wang (Germany).

## Appendix B. The students of Thomas Friedrich

The following mathematicians wrote their doctoral thesis ('Dr.rer.nat') under the supervision of Thomas Friedrich (all at Humboldt University). Before 1989, the PhD was called 'Promotion A'. Those who stayed in academia and obtained permanent positions at German institutions are marked with *; one student became a professor in South Korea (marked with **). The year indicates the year of graduation.

(1) Helga Baum*, born Dlubek (1980),
(2) Hartmut Strese (1980),
(3) Sonja Sulanke (1980),

(4) Ralf Grunewald (1986),
(5) Lutz Habermann* (1987),
(6) Ines Kath* (1989),
(7) Katharina Habermann*, born Neitzke (1993),
(8) Uwe Semmelmann* (1995),
(9) Andreas Schmitt (1996),
(10) Klaus Mohnke* (1997),
(11) Eui Chul Kim** (1999),
(12) Ilka Agricola* (2000),
(13) Pablo Ramacher* (2001),
(14) Nils Schoemann (2006),
(15) Christof Puhle (2007),
(16) Sebastian Heller (2008),
(17) Mario Kassuba (2009—joint supervision with Ilka Agricola).

Thomas further advised Olga Pokorna (1990), who was awarded a PhD at Charles University Prague. The following people prepared their habilitation thesis in his research group. Until 1989, this bestowed the title 'Dr.sc.' (Doktor scientiae), similar to the title 'Doktor nauk' accorded in the Soviet Union. It was also called 'Promotion B', which sometimes leads to confusion with the regular PhD. From 1989 Humboldt University started conferring the 'venia legendi' as a habilitation, although with no specific title attached.

(1) Klaus-Dieter Kirchberg* (1987)— *Der erste Eigenwert des Dirac-Operators einer geschlossenen Kählerschen Spin-Mannigfaltigkeit positiver Skalarkrümmung*,
(2) Helga Baum* (1989)— *Vollständige nichtkompakte Mannigfaltigkeiten mit Killing-Spinoren / Spektralinvarianten des Dirac-Operators auf dem Moduli-Raum der Eichfeldtheorie*,
(3) Ulrich Bunke* (1995)— *A gluing formula for the* $\eta$*-invariant*,
(4) Christof Puhle (2012)— $G$*-structures and connections with torsion*.

Margarita Kraus* (2002) started the habilitation (*Eigenwertabschätzungen für den Dirac-Operator*) in Berlin, but eventually finished and submitted it in Regensburg. Because of her personal ties to Thomas, the first author of this article defended her habilitation thesis (*Dirac operators, holonomy and string theory*) at the University of Greifswald (2004), although it was largely prepared in Berlin.

We thank Prof. Simon Chiossi (Universidade Federal Fluminense / Rio de Janeiro, Brazil), who was twice a postdoc in the research group (2005-2008 in Berlin and 2012–2014 in Marburg), for his invaluable comments and devoted proofreading of preliminary versions of this manuscript. We also thank all friends and colleagues who helped us clarify details in the history when no written records were available.

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Participants to the conference 'Dirac operators in differential geometry and global analysis', held in memory of Thomas Friedrich at Będlewo Conference Center, 7–11 October 2019 (courtesy H. Tadano).