Friedrich Hirzebruch (1927–2012)

Michael Atiyah and Don Zagier, Coordinating Editors

Friedrich Hirzebruch (universally known as Fritz) died on May 27, 2012, at the age of eighty-four. He was the outstanding German mathematician of the postwar years who helped to restore mathematics in his country after the devastation of the Nazi era. Appointed at a very early age to a full professorship at the University of Bonn, he remained there for the rest of his very active life and moved the center of gravity of German mathematics from the traditional centers of Göttingen and Berlin to Bonn. The famous *"Arbeitstagungs"* (more properly *Arbeitstagungen*), which he established in Bonn in 1957, have been running annually or biannually ever since and are a focal point of mathematics worldwide. They carried his personal imprint in their content, attendance, and style, being always broad, topical, and informal and doing much to educate succeeding generations and to foster cross-fertilization. Many new ideas and collaborations grew out of these encounters. Another lasting contribution to mathematical research in Germany and in the world is the Max Planck Institute for Mathematics, which he founded, operating on the same lines and creating bonds between mathematicians from many countries, including those that were otherwise cut off from the international scene.

Although Fritz, given his multiple roles, retired several times, he remained active till the very end and was preparing to attend a conference in his honor in Poland when he was struck down.

In this introduction we will give an overview of Fritz's life and of some of his most important achievements. More detailed accounts will then follow in the individual articles by the two coordinating editors, with the one by Atiyah concentrating on the work in topology and the years before 1970, and the one by Zagier on the work in number theory and the years after 1970. The subsequent articles by the invited contributors describe further aspects of his personality, his scientific work, and the role that he played in the mathematical lives of many individuals, organizations, and countries.

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Friedrich Hirzebruch in 2006 at the Max Planck Institute.

Friedrich Ernst Peter Hirzebruch was born on October 17, 1927, in Hamm, Germany, to Dr. Fritz Hirzebruch and Martha Hirzebruch (née Holtschmit). His father, who was the headmaster of a secondary school and himself an inspiring teacher of mathematics, gave him his first introduction to

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the subject—including, when he was nine years old, the proof that $\sqrt{2}$ is irrational—and the love of it that was to last throughout his life.

Still a teenager, Fritz was drafted into the German army during the final year of World War II, but his military career was mercifully short and he was never sent into combat, being assigned instead to an antiaircraft battery with the task of computing artillery trajectories. He was even able to attend some scientific courses, though when his commanding officer asked him on one such occasion to confirm that winter and summer are caused by the earth's varying distance to the sun and Fritz dared to contradict him, pointing out that then the seasons in Germany and Australia would coincide, he was punished for insubordination. In the final months of the war the Americans put him into a prisoner of war camp, and even there he managed to do mathematics (partly on toilet paper, still preserved today). He was released in July 1945 and entered Münster University that winter.

The city and the university lay in ruins and conditions were very difficult, with lectures being held only at long intervals, but he had very good teachers, especially Heinrich Behnke, from whom he learned the function theory of several complex variables, and Behnke's assistant, Karl Stein, a former pupil of his father's. His third teacher was Heinz Hopf, a German who had gone to Switzerland before the Nazi takeover and who invited the young Fritz, first to be his house guest and then for one and a half years to be a research student at the ETH in Zürich. Fritz returned to Münster with the essentials of a beautiful doctoral thesis about the resolution of certain singularities in complex surfaces. Already this earliest work showed the characteristics of all of his mathematics: elegance and brevity of thought and exposition, an effortless synthesis of sophisticated theoretical ideas with insights inspired by nontrivial concrete examples, and the fusion of ideas from analysis, topology, and number theory.

In 1952 came the development that was not only to be a turning point in Fritz's mathematical career but, as it transpired, to have a major influence on the later development of mathematics in Germany and in Europe: he was invited to the IAS in Princeton, where he remained for two years. At the IAS, he came into contact with many of the most brilliant mathematicians and most exciting new ideas of the period and where he made the two discoveries with which his name is most strongly associated: the Signature Theorem and the Hirzebruch-Riemann-Roch Theorem. Those years and also the early years in Bonn, when the core of Fritz's research was still in topology and its applications to algebraic geometry, will be discussed in detail in the contribution by Michael Atiyah.

Friedrich Hirzebruch ca. 1985 in Bonn.

This period also included three major events in Fritz's personal life: his marriage to Inge Spitzley in August 1952 just before taking the boat to Princeton, and the birth of his first two children, Ulrike (1953) and Barbara (1956). His third child, Michael, was born a little later, in 1958. Inge, known to and loved by countless mathematicians, was a big part of everything he built up during his life. Both of his daughters later studied mathematics and eventually worked in related areas (Ulrike in mathematical publishing and Barbara as a schoolteacher), while Michael was to become a doctor. Ulrike's contribution to this article gives us a vivid picture of Fritz as a father.

When Fritz returned to Germany in 1956 to take up his duties at his new chair in Bonn, he had a clear ambition and a mission: to establish a center that would attract mathematicians from all over the world. After the First World War, German mathematics had been ostracized by the international community, led by France. This lasted for many years and embittered relations. Fortunately, the 1945 generation of French mathematicians, led by Henri Cartan, was more enlightened, and prewar mathematical friendships were rapidly renewed. The Münster school members under Heinrich Behnke were welcomed back into the field by Cartan, while Fritz, part of the Behnke team,

Karl Stein, Reinhold Remmert, Friedrich Hirzebruch, and Henri Cartan in the 1950s.

Friedrich Hirzebruch with Gerd Faltings in the MPIM Library ca. 2000.

played a full role in this rapprochement. So with his Princeton contacts, including Kodaira from Japan and the new talent emerging from Paris (Serre, Borel, Grothendieck, …), Fritz was well placed to reintegrate German mathematics into the world community. Contacts with Britain came initially via the Cambridge geometry school of Hodge and Todd and later the younger generation (Atiyah, Adams, Wall, …). The division of Germany and, more generally, the cold war partition of Europe were particularly challenging, but Fritz spent many years of his life forging links between East and West, including notably the German Democratic Republic and the Soviet Union.

He achieved his goals remarkably quickly. At Bonn University he built up the mathematics department to a high level, doubling the number of full professors and attracting people such as Klingenberg, Tits, Brieskorn, and Harder. The *Arbeitstagung*, which he established in 1957, soon served as a worldwide meeting point and attracted many who would never otherwise have returned to Germany. But Fritz's main goal stemmed from his experience in Princeton: to set up a visitors' center modeled after the IAS. A first attempt to create this as a Max Planck Institute failed because of the opinions of various referees (including Courant and Siegel) that, at least at that time, there were better ways to use both Fritz's talents and the taxpayers' money to further mathematical research in Germany. But some ten years later, when the German Research Council (DFG) set up a new research program for German universities whose units (called *Sonderforschungsbereich* or "Special Research Domains", abbreviated SFB) would be supported for a limited period of time, Fritz presented his ideas of a visitor center to the decision committee and came back with two SFBs: one (SFB 40, with himself as *Sprecher* or chairman) for theoretical mathematics and one (SFB 72, with Rolf Leis and Stefan Hildebrandt) in a more applied direction. With his Sonderforschungsbereich, he started the envisaged visitor program on a limited basis. This turned out to be so successful that when the support ended and Fritz applied for a takeover from the Max Planck Society, his project no longer met with the former reservations, and a permanent Max Planck Institute for Mathematics was founded in Bonn in 1981 and has been flourishing ever since. Through the Arbeitstagung, the Sonderforschungsbereich, and finally the Max Planck Institute, Fritz created an extensive visitor program that he guided with his many outstanding qualities: his personal tastes in mathematics were broad and generous—he was no narrow specialist; his international contacts were extensive; his efficiency became legendary; and above all, he encouraged an informal and friendly atmosphere, far removed from the traditional rigidity of German academia.

After about 1970 the main thrust of Fritz's mathematical work slowly moved from pure topology and algebraic geometry to the connections of these domains with number theory. They will be discussed in more detail in the contribution by Don Zagier. During these years he also became more and more active and influential in the development of mathematics, both nationally and internationally. These activities, which will be described in more detail later, included most notably his unflagging efforts to build up relations with the countries of the Eastern Bloc, his many contributions to rehabilitating Germany's image after the years of the Third Reich and to creating new scientific and human bonds with Israel, his two presidencies of the German Mathematical Union, and his roles as first president of the European Mathematical Society (described by Bourguignon) and as honorary president of the International Congress of Mathematicians in Berlin in 1998.

During all the years before the Iron Curtain fell, Fritz indefatigably kept up contacts with mathematicians in the Eastern Bloc, no matter how much effort this required and how unavailing it seemed. Russian mathematicians were always invited to the Arbeitstagung, though only once—perhaps because of an oversight by the Russian bureaucracy?—were some of them allowed to come: in 1967, Anosov, Manin, Postnikov, Shafarevich, and Venkov took part, and all of them gave a talk. But these efforts were not in vain, because, as we learned later, the yearly invitations to come to Germany, even when they had to remain unanswered, often helped their recipients by demonstrating to the authorities their visibility in the West. Fritz himself was seen quite positively by those same authorities and in 1988 was elected as a foreign member of the Academy of Sciences of the USSR. After 1990, of course, many more

possibilities of exchange opened up, and the MPIM today is never without some Russian conversation in its corridors. Another Eastern country that he became deeply involved with was Poland. His contributions here, in particular in connection with the Stefan Banach International Mathematical Center in Warsaw, are recounted by Stanisław Janeczko.

By a coincidence that seemed willed by fate, Fritz was elected twice to the presidency of the DMV (German Mathematical Society) at key moments in the history of postwar Germany and postwar German mathematicians: in 1961 when the Berlin Wall was built, and again in 1989–90 when it fell. The separation of Germany into two blocks fell in the middle of his first term, and he solved the problem of the inability of the East German mathematicians to cross into West Berlin by repeating in its entirety the first DMV meeting that he chaired after the separation. But of course such makeshift measures could not last, and soon the DMV was split into a new East German branch (MGDDR = Mathematische Gesellschaft der DDR) that for almost three decades was no longer officially connected with the West German one. When the political world changed again and the two halves of Germany were reunited, Fritz was able to preside over the reunification also of the Mathematiker-Vereinigung and to ensure that the transition took place in a spirit of reconstruction rather than of recrimination or retaliation.

For several years after the wall fell, he traveled nearly every week to Berlin, where he had the task of helping the nearly two hundred mathematicians of the previous Karl Weierstrass Institute of the East German Academy of Science to find new positions. The individual cases were very dissimilar, and the solutions he came up with were varied. The cases where no adequate solution could be found haunted him, and he sometimes spoke to his friends at the institute of the sorrow he felt, but in the vast majority of cases provisional or permanent positions could be set up, whether in temporary Max Planck Working Groups, in permanent new institutes that he helped establish, or in schools or universities in Germany or abroad. His contacts with the GDR during its years of isolation and the respect in which he was held on both sides of the previous dividing line made him effective in this role in a way that no one else could have been, and his achievements, though little known to outsiders, were received with enormous gratitude by the people involved.

Of the many other countries with which Fritz built up or maintained intensive contacts, two must be mentioned individually. One is Japan, which Fritz visited many times, starting in 1972, and from which a huge number of visitors came, first to the Sonderforschungsbereich and later to the Max Planck Institute, at a period when the possibilities of scientific interchange between Japan and Europe were still severely limited. His contributions are described in detail by Kenji Ueno. The other is Israel, which is dealt with by Mina Teicher. Fritz almost never mentioned overtly, but very clearly also never forgot, what Germany had done in the years of the Third Reich, and a leitmotif of much of what he did in his life was to help reestablish an image of the country that would be characterized by decency and tolerance.

Not surprisingly, Fritz was showered with many distinctions of every imaginable kind. His first half dozen honorary doctorates came roughly at the same times and with the same frequency as his grandchildren, and he used to make jokes about this ongoing race, but with only three children, the competition was an unequal one and the doctorates finally won 15:6. He was a full or associate member of more than twenty academies, in several of which he was scientifically active, and also of the order "Pour le Mérite", which has as its members Germany's most distinguished scientists, writers, and artists and to which he was particularly attached. Among the many prizes that he received the most notable were the Japanese Seki Prize, usually given to institutions and which he received for his role in developing the contact between Japanese and non-Japanese mathematicians; the Lobachevsky Prize and the Lomonosov Medal from the USSR; the Polish Stefan Banach Medal; the German Krupp Prize and Georg Cantor Medal; and, most important of all, the Israeli Wolf Prize, which he received in 1998 and which, quite apart from its immense prestige, had a huge symbolic significance. At one point the honors were arriving so thick and fast that his secretary once famously remarked, after checking his morning's mail, "Wir haben heute keine Ehrungen bekommen!" ("We didn't get any honors today!")

That "we" somehow characterizes in two letters what was so exceptional about Fritz and the way he made those around him feel. We hope that the articles collected here will convey to those who did not know him some feeling for this extraordinary personality.

The Hirzebruch signature dish being admired by Lily Atiyah and Fritz, Edinburgh, 2010.

Michael Atiyah

Fritz Hirzebruch played a major part in my life, particularly over the early formative period. He became a close personal friend, a long-term collaborator, and, through the Arbeitstagung, my introduction to the mathematical world. I learned a good deal from him on how to write papers, how to present talks, and, most importantly, how to handle people. In short, he was an ideal role model.

I first met Fritz in 1954 when I was a young graduate student and he visited Cambridge at the invitation of Hodge, my supervisor. Hodge and Todd had been much impressed by what Fritz had been doing at Princeton and were keen to be briefed on the Riemann-Roch Theorem and Chern classes. What I remember about the occasion is how friendly and informal Fritz was. Although he was already an assistant professor at Princeton and I was merely a graduate student, there were no barriers between us, and we quickly established a friendship which blossomed over the subsequent years. We met again at the Amsterdam ICM of 1954 and then, for a longer period, when I went on a postdoctoral fellowship to the Institute for Advanced Study in Princeton.

The Princeton Years

Those Princeton years were, for me, for Fritz, and for many others the "golden years". Algebraic geometry and topology were being transformed by the new ideas of the French School. Sheaves and spectral sequences from Leray combined with complex analysis by Henri Cartan produced powerful machinery to tackle classical problems. This was taken up by Kodaira and Spencer, while Serre burst on the scene with spectacular applications to both algebraic topology and algebraic geometry. When I arrived in September 1955, brilliant young mathematicians were absorbing the new ideas and carving out new routes for the future. I remember in particular the gang who regularly attended Kodaira's lectures: Fritz, Serre, Bott, Singer.

This had been for Fritz the experience that transformed him from a promising novice to a world figure capable of competing with the greatest talents of the time. Within a short period of time he came up with two great triumphs. Both were based on the innovative way of associating multiplicative classes to formal power series in one variable. First there was his formula

$$\mathrm{Sign}(M) = \int_M \mathcal{L}(M) = \int_M \prod_{i=1}^{n} \frac{x_i}{\tanh x_i},$$

$$\text{where (formally)} \quad p(M) = \prod_{i=1}^{n} (1 + x_i^2)$$

for the signature of a $4n$-dimensional manifold in terms of the Pontrjagin classes $p_j(M)$. This was a beautiful application of Thom's new cobordism theory. But Fritz's second triumph, his generalization (now known as "HRR" or Hirzebruch-Riemann-Roch)

$$\chi(X, V) = \int_X \mathrm{ch}(V)\,\mathrm{Td}(X)$$

of the Riemann-Roch Theorem, was even more impressive. Here $\chi(X, V) = \sigma$ (from $q = 1$ to $q = m$) of $(-1)^q \dim H^q(X, V)$ is the holomorphic Euler characteristic $\sum_{q=0}^{m} \dim H^q(X, V)$ of the sheaf cohomology groups of a holomorphic vector bundle V (of dimension d) over a complex projective algebraic manifold X of dimension m. The Chern character is defined in terms of the total Chern class $c(V)$ by

$$\mathrm{ch}(V) = \sum_{i=1}^{d} e^{x_i},$$

$$\text{where (formally)} \quad c(V) = \prod_{i=1}^{d} (1 + x_i),$$

and the Todd class $Td(X)$ is defined similarly in terms of the total Chern class $c(X)$ of the tangent bundle of X by

$$\mathrm{Td}(X) = \prod_{j=1}^{m} \frac{y_j}{1 - e^{-y_j}},$$

$$\text{where (formally)} \quad c(X) = \prod_{j=1}^{m} (1 + y_j).$$

Of course HRR built on fundamental work by Kodaira, Spencer, and Serre, but the proof was a tour de force that had the hallmark of Fritz's own mathematical style.

Characteristic classes had been developing for many years, from the algebraic geometry of the Italian School through significant advances by Todd and the later topological approach of Steenrod and Chern. But all this emphasized their geometrical origin and significance. It was Fritz, in collaboration with Borel, who took the dual route of cohomology and, connecting it to the theory of Lie groups, gave Chern classes their formal algebraic setting, which has now become standard. With his command of this algebra and with his insight into the right algebraic framework, Fritz had developed his theory of multiplicative sequences, which provided the right tools to tame the horrendous-looking formulae.

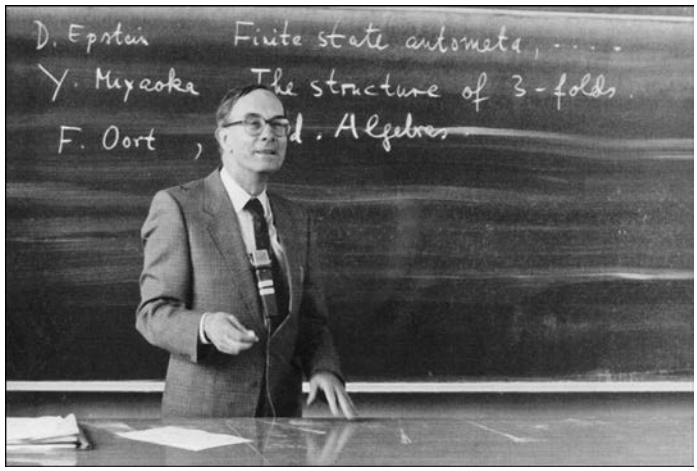
When Todd, no slouch at algebraic computations, had computed the first half dozen "Todd polynomials", it had been a matter of brute force. In the hands of Fritz as "magician" the calculations became elegant and transparent. After seeing this, Todd remarked that he now had to reverse the earlier view he had held of the "Princeton School" that, while they might be good at general theory, they were not adept at calculations. The old maestro conceded defeat to the young contender.

It was fortunate for the new generation like me, eager to learn about the great advances in algebraic geometry, that Fritz was also a brilliant expositor. His book *Neue Topologische Methoden in der Algebraischen Geometrie* (Springer, 1956) gave an impeccably clear account of sheaf theory, Chern classes, and all the new machinery that culminated in the Hirzebruch-Riemann-Roch Theorem. The book and its subsequent English edition *Topological Methods in Algebraic Geometry* (with appendices by R. L. E. Schwarzenberger, one of my early students) has remained the standard work for over fifty years.

The Early Arbeitstagungs

When Fritz returned to Germany as a full professor at the University of Bonn, a new day dawned for German mathematics. With his enthusiasm, ability, efficiency and drive, Fritz soon transformed Bonn into a major center of the mathematical world. Modelled on Princeton, it aimed to introduce into Europe the features that had so attracted Fritz and others across the Atlantic.

Because of the friendship I had forged with Fritz in Princeton and because of the proximity of Cambridge to Bonn, I was fortunate to have been invited to the very first of the annual meetings that became the famous Arbeitstagung. I went on attending these meetings for almost thirty years. It became an obligatory part of the academic calendar where new results were announced, many famous mathematicians regularly attended, and the whole event was under the careful but loving care of the "maestro". Fritz's talents were fully exploited, but not exposed, in these annual gatherings. With their relaxed atmosphere, the Rhine cruises and the skillful selection of speakers by what has been described as "guided democracy", the Arbeitstagungs were unique. Happy family gatherings they may have been, but much serious mathematics was always being presented and fostered. Ideas flowed, collaborations emerged, and successive years reflected the latest movements.

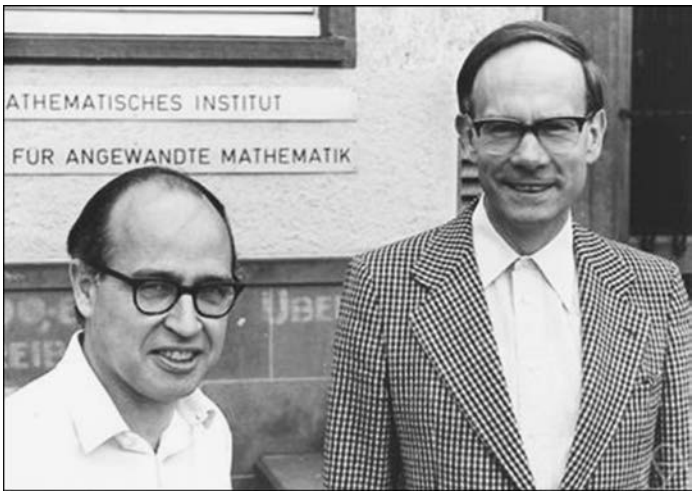


Program discussion at the Arbeitstagung, 1987.

Moreover, as the years passed, Fritz was always keen to attract new talent, and he encouraged me to send promising graduate students to attend. I was happy to respond, and, over the years, my students were introduced to the international scene through the Arbeitstagung. Graeme Segal, Nigel Hitchin, Simon Donaldson, Frances Kirwan, and many others came and became, in their turn, regular participants.

But if the entire series of Arbeitstagungs became highpoints of the academic calendar, the initial one (in 1957) on a very modest scale was particularly noteworthy for launching Grothendieck. He had just developed his brilliant new approach to the Hirzebruch-Riemann-Roch Theorem, based on K-theory. I remember him lecturing for many hours on his ideas. In fact he seemed almost to monopolize the timetable, but the novelty and importance of his work fully justified the time devoted to it. The fact that the program was sufficiently generous and flexible to allow this to happen was an early indication of the way Fritz wanted the Arbeitstagungs to work. No set plans, and full steam ahead for novel and exciting mathematics.

Grothendieck's explosive entry on the scene was a hard act to follow, but the Arbeitstagungs in those early years saw a succession of new and exciting results, including Milnor's discovery of exotic spheres and their subsequent realization



Michael Atiyah and Friedrich Hirzebruch in front of Mathematisches Institut Bonn, 1977.

by Brieskorn (a student of Fritz) via isolated singularities of algebraic varieties (a study initiated by Fritz). In fact, so many new ideas filled the Arbeitstagung air that most of my own work (and probably that of many others) emerged from this background. We learned many new things from disparate fields, and cross-fertilization became the norm. I will elaborate on this in the next section.

My Collaboration with Fritz

In the three years 1959 to 1962 Fritz and I wrote eight joint papers, all concerned with topological K-theory and its applications. This had emerged naturally from the early Arbeitstagungs and in particular from Grothendieck's K-theory in algebraic geometry, as expounded in the very first Arbeitstagung. But there were many other ingredients in the background, notably the Bott periodicity theorem.

Topological K-theory was mainly developed by Fritz and me in 1959 when we both had a sabbatical term at the IAS in Princeton. A preliminary account appears in [1], and we planned to write an expanded version in book form. In fact, we never had time for this project, but a book [4] did eventually appear under my name based on a Harvard course of lectures.

These joint papers are a mixture of general theory and concrete problems. For example, [3] showed that the famous Hodge conjectures were false for integer cohomology (still leaving the case of rational cohomology as one of the Clay Institute Millennium Prize problems). Other papers were related to some of Fritz's earlier Princeton period, such as his discovery of a relation between Steenrod squares and the Todd polynomials [2]. Some of our joint papers appeared in German (written by Fritz), while others appeared in English (written by either of us), but one appeared in French (written by neither of us!). That one gave bounds on the smallest dimension in which various manifolds could be embedded. While a primitive version was an idea of mine, the final very polished version was an exquisite illustration of Fritz's elegance with algebraic formulae. But my mathematical interaction with Fritz extended far beyond these joint publications and the three years they cover. Much of my work was influenced in one way or another by Fritz, and a later publication [5] is one of my favorites. Here we proved that a spin manifold that admits a nontrivial circle action has vanishing $\hat{A}$-genus. This emerged as a new application of index theory, which first appeared in the Arbeitstagung program of 1962. Fritz took great interest in the development of index theory, which owes so much to his pioneering work.

While our later mathematical paths may appear to have diverged, this is only superficially true. We met frequently in Bonn and elsewhere, and we followed each other's work with great interest. One notable example is Fritz's beautiful results on the resolution of the cusp singularities of Hilbert modular surfaces (as explained by Don Zagier). His key result gave the signature defect of such a cusp singularity as the value of a suitable L-function of the number field. He then conjectured that this result would continue to hold in higher dimensions for arbitrary real number fields. This was one of the main sources of inspiration that eventually led to the index theorem for manifolds with boundary [6] and its application [7] to prove Fritz's conjecture.

Fritz also followed with great interest the exciting interaction between geometry and physics of recent decades. He organized several meetings of mathematicians and physicists (in Bad Honnef in 1980 and in Schloss Ringberg in 1988, 1989, and 1993). He also extended [8] the work of Witten and others on the elliptic genus, a subject close to his heart.

Final Comments

I knew Fritz and was a close friend for nearly sixty years. We were mathematical brothers and shared a common love of geometry in the broadest sense. We had very similar tastes, even if I could never match Fritz's algebraic virtuosity. I was a great admirer of his lecturing style, and, with my limited German, I found he was the only German lecturer I could understand. He was also a magician who carefully crafted his lecture so as to produce a surprise at the end. Alluding to this skill of his, I once said that "rabbits do not appear out of hats unless they are put there!"

A close mathematical partnership leads to a close personal friendship and also evolves from it. This extends to families on both sides. Lily and I got

to know Fritz and Inge in Princeton when we both had small children, and we have remained close friends ever since, meeting occasionally in Bonn, Oxford, Edinburgh, Barcelona, and elsewhere. In Bonn, at all the Arbeitstagungs, Inge was always a welcoming hostess, and the friendly atmosphere of the Hirzebruch family was an important ingredient in the success of both the Arbeitstagungs and the MPI.

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Don Zagier

Entering Fritz's Orbit

My first meeting with Fritz Hirzebruch was a never-to-be-forgotten moment in my life (not least because I also met Egbert Brieskorn and Silke Suter, my future wife, on the same day). It was May 1970 and I was not yet nineteen. I had been a precocious but incompetent topology graduate student in Oxford for two years, the first under the supervision of Michael Atiyah, who tried to teach me the basics I should have learned as an undergraduate, and the second with no real supervision, because Atiyah had left for Princeton in 1969. I had been studying Professor Hirzebruch's books and papers on applications of the signature theorem to constructing exotic spheres and the like and had found some amusing formulas relating these to cotangent sums and other elementary number theory, which I had sent to him, inquiring on the same occasion about the possibility of coming to Bonn to complete my D.Phil. studies under his supervision (an idea supported by Atiyah). He had responded with an invitation for a short visit to meet both him and Professor Brieskorn,

Thirty-two years later at the eightieth birthday of Sir Michael Atiyah, Edinburgh, April 20–22, 2009.

who would be in Bonn for a few days, and now received me with all the friendliness and interest in my work that he would have shown if I had been an established mathematician and which as a beginner I had certainly not expected.

That first meeting lasted several hours (in the evening Hirzebruch had to go home, but Brieskorn invited me to a Chinese restaurant to continue the discussion) and resulted in new research projects for me and invitations to come to Bonn a month later for my first Arbeitstagung (also memorable!) and again in the fall as Hirzebruch's doctoral student. (I remained immatriculated in Oxford, and Hirzebruch received a salary of £5 a year for his work.) As my advisor, he met me frequently, listened to my reports with great attention, and made such minimalistic comments that I always felt the new ideas that emerged were my own, although I did sometimes wonder why everything was working out so much better than it ever had before.

My actual thesis was on a somewhat different subject from the cotangent sums that had provided the initial contact with Hirzebruch, but during the two years that I spent in Bonn as his student and *Studentische Hilfskraft*, we also had many more discussions about those things, and he gave a course on the subject which turned into our joint book [2] on relations between index theorems and elementary number theory. One of the topics treated in that book, the calculation of invariants of torus bundles over the circle, was to lead him later to his beautiful discoveries, discussed below, on the geometry of Hilbert modular surfaces. Some of this work and of Hirzebruch's own work in this area is beautifully told in his article [1], whose introduction ends with the words

> In the second half of this lecture we shall point out some rather elementary

Silke Suter, Friedrich Hirzebruch, and Don Zagier, 1982 in Bonn at the MPI.

> connections to number theory obtained by studying the equivariant signature theorem for four-dimensional manifolds. Perhaps these connections still belong to recreational mathematics because no deeper explanation, for example of the occurrence of Dedekind sums both in the theory of modular forms and in the study of four-dimensional manifolds, is known. As a theme (familiar to most topologists) under the general title "Prospects of mathematics" we propose "More and more number theory in topology."

As we will see, these last words were to be prophetic in his own case.

I had intended to come to Bonn only for the time needed to complete my thesis, but ended up staying there for my whole life. This development, which I could never have imagined (not only because I knew no German when I came and had no relationship with the country, but also because I am half Jewish and much of my father's family had perished in the concentration camps), was due exclusively to Hirzebruch's tremendous personality and to the atmosphere that he created. In the first period after my thesis, I began working more and more intensively with him, first on cotangent sum-related topics and then on Hilbert modular surfaces. Part of this collaboration took place on long train trips to Zürich, where he was giving a course on the latter subject and where I regularly accompanied him because it was the only chance to get him to myself for long periods at a time. In the evenings we often ate together at the elegant *Zunfthäuser* (guild halls turned into restaurants) of Zürich, gradually becoming better friends and increasing our alcohol consumption from a modest single glass each at the beginning to a full bottle. On one occasion this was increased to one and a half bottles, and Professor Hirzebruch formally proposed the use of "Du" and first names. Henceforth he was always "Fritz" to me, and so he shall remain for the rest of this article. During these years I also got to know his family well, and this too made Bonn become a true home. His daughters, Barbara and Ulrike, also attended my course on elementary number theory. Both had real mathematical talent, but in the end neither one opted for a research career, though Ulrike wrote a master's thesis on elliptic surfaces with three exceptional fibers that is still quoted regularly today.

Fritz's Work in Number Theory

Fritz had already done earlier work that is important in the theory of algebraic and arithmetic groups, most notably his fundamental papers with Armand Borel about homogeneous spaces (in particular, the determination of their characteristic classes) and his proportionality principle, which has proved enormously important in the theory of automorphic forms. But starting around 1970 his interest in the relations between topology and number theory became much more intense and led to what one might call a second spring in his mathematical research career. The high point of this was his work on Hilbert modular surfaces, which I now briefly describe.

In the classical theory of modular forms a crucial role is played by the modular curve $\mathfrak{H}/\mathrm{SL}(2,\mathbb{Z})$ ($\mathfrak{H}$ = complex upper half-plane) and its cousins. The higher-dimensional generalization of this curve is the Hilbert modular variety $\mathfrak{H}^n/\mathrm{SL}(2,\mathcal{O}_K)$ associated to a totally real number field K. Here $\mathcal{O}_K$ is the ring of integers of K and $\mathrm{SL}(2,\mathcal{O}_K)$ is the Hilbert modular group, embedded into $\mathrm{SL}(2,\mathbb{R})^n$ by the n different real embeddings of K and hence acting naturally (and discretely) on $\mathfrak{H}^n$. This variety can be compactified by adding "cusps" to give a projective algebraic variety X_K, but these cusps are highly singular points, with the boundary of a small neighborhood of each cusp being a T^n-bundle over T^{n-1} rather than a $(2n-1)$-dimensional sphere. In particular, for $n = 2$ these neighborhood boundaries are precisely the torus bundles over a circle that Fritz had already been studying in connection with the equivariant index theorem, and it was this that led him to the study of Hilbert modular surfaces.

He set himself three main goals:

(i) to describe the geometry of X_K and calculate its numerical invariants,

(ii) to give for $n = 2$ the resolution of the singularities at the cusps, and

(iii) to apply this to the classification of X_K in the sense of the theory of algebraic surfaces.

He achieved these goals in a series of papers published between 1970 and 1980, partially in collaboration with A. van de Ven and me in the case of part (iii). Each part was mathematics of the highest order. The calculations of the numerical invariants involved deep results from both differential geometry and number theory, including Günter Harder's extension of the classical Gauss-Bonnet theorem to noncompact manifolds like Hilbert varieties and classical results of Hecke, Siegel, and Curt Meyer about Dedekind zeta functions and class numbers of number fields and their relationship to cotangent sums. The resolution of the singularities in terms of periodic continued fractions was an amazingly beautiful result in itself and also spawned many generalizations, including the theory of toroidal compactifications (work of Mumford, Faltings, and many others) that now plays a central role in the theory of mirror symmetry. The results in part (iii), which culminated in the complete determination of the position of the Hilbert modular surfaces within the Kodaira classification, provided a beautiful collection of algebraic surfaces having particularly interesting properties because of the interplay between their transcendental aspects (description as quotients of $\mathfrak{H}^2$) and their algebraic aspects (description as projective varieties). This interplay leads to many insights that are not available for varieties possessing "merely" an algebraic description. All aspects of the theory are described in the masterful exposition [3].

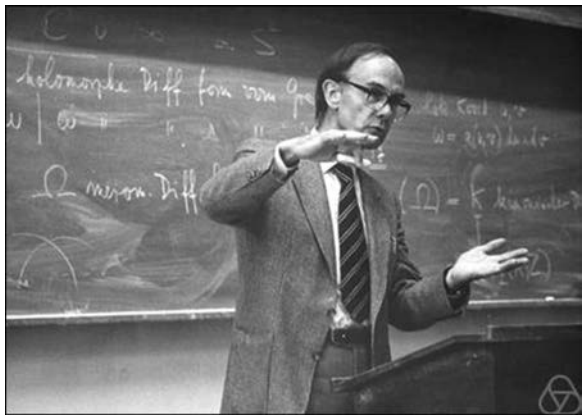
Fritz's investigation of the geometry of the Hilbert modular surfaces led him to an intensive study of the modular curves T_N ($N \in \mathbb{N}$) that are naturally embedded in these surfaces. This led to a joint paper with me [4] showing that the generating function $\sum_N [T_N]\, q^N$ of the classes of these curves in the second homology group of the surface is itself a modular form in one variable, a result that in turn has given rise to many later applications and generalizations (work of Kudla-Millson and many others). There is another amusing anecdote connected with this. Serre, who had studied Fritz's work on the topological invariants of Hilbert modular surfaces, wrote him a letter pointing out a coincidence between the numbers occurring here and the formulas for the dimensions of certain spaces of modular forms. His letter and Fritz's giving the explanation in terms of our modularity result crossed in the mail, a nice example of a question being answered before it is received. I should perhaps also mention that this collaboration was one of the most exciting mathematical events of my own life and, I think, meant a lot to Fritz too. On the day when we sent off the final manuscript, we celebrated with a dinner together with our families in a fancy restaurant at which Barbara famously reacted to the bill by computing how many portions of French fries she could buy with the same money.

Don Zagier and Friedrich Hirzebruch at the Leonhard Euler Congress, June 10–12, 2007, St. Petersburg.

In later years Fritz worked on many other topics at the interface between number theory and topology that for lack of space I will not describe in detail. A prime example arose in the late 1980s when Ochanine and Witten introduced elliptic genera, which attach modular forms to manifolds. Not surprisingly, Fritz was very interested in this development and wrote some beautiful papers and a book [6] (joint with his students Th. Berger and R. Jung) on this topic. Other topics included the study of Fuchsian differential equations (alone and in collaboration with Paula Cohen) alluded to above and his really beautiful work applying the Miyaoka-Yau inequality and other deep results about characteristic classes of surfaces to classical questions going back to Sylvester (1893) about configurations of points and lines in the plane [7].

Final Remarks

Fritz Hirzebruch was the most important person in my life outside my own family, and it is impossible for me to say everything he meant to me. It is he who taught me how to be a mathematician, but more important than this were his human qualities: his empathy, his gentleness with everybody, and his ability to correct without criticizing. His moral rectitude and the straightness of the path he followed made one wish to also act in a way he would approve of. In many almost invisible ways, he made the people around him slightly better people and the world around him a slightly better world.



Friedrich Hirzebruch giving a talk in Berlin, 1980.

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Yuri I. Manin

Friedrich Hirzebruch was eighteen years old in December 1945 when he started his study at Münster University. Reminiscing about this time in 2009 he wrote:

> Wenn ich damals einen kurzen Lebenslauf abgeben musste, dann enthielt er immer den Satz "Von Mitte Januar 1945 bis zum 1. Juli 1945 durchlief ich Arbeitsdienst, Militär und Kriegsgefangenschaft." (In those days, whenever I had to supply a short CV, it always contained the sentence: "Between mid-January 1945 and July 1, 1945, I served fatigue duty, military duty, and was detained as prisoner of war.")

This statement puts a double distance between the present day and painful youth of war years, defies any attempt to express this pain more eloquently, and does so by silence.

After settling in Bonn in 1956, Hirzebruch put great effort into the restoration of the European mathematical community, destroyed, like so many other institutions and lives, by the war. The brilliant idea of annual Arbeitstagungen and later the founding of the Max Planck Institute for Mathematics (MPIM) bore rich fruit. Hirzebruch struggled for the new Europe, like Henri Cartan in France, using all the influence that he possessed as an internationally renowned researcher.

My first close contact with Fritz and Inge Hirzebruch came in 1967. I spent six weeks at the Institut des Hautes Études Scientifiques in Bures–sur–Yvette, where Grothendieck taught me the "fresh-from-the-oven" project of motivic cohomology. After that I got permission and a German entry visa, which enabled me to visit Bonn and to participate in the Arbeitstagung on my way back to Moscow.

The blissful stress of study with Grothendieck and of Paris magic did something to my body, but in Bonn, Inge and Fritz treated me as their son and helped my healing. Their kindness and generosity forever remain in my memory.

In 1968 an abrupt end came to these budding direct contacts between mathematicians of Western Europe and their colleagues in the Soviet Union and Eastern Europe. The next generation, coming after Hirzebruch's and then mine, had different concerns. As one of those young men recalled recently, "We thought it highly likely we would be blown off the planet, and that, somehow, it was up to us—children after all—to prevent it." [1]

We were not blown off the planet. The existing order of things again started to seem stable—or stagnating. I had not the slightest premonition that this epoch would also pass during my life and that almost a quarter of a century afterwards I would meet Fritz again and become a colleague of his in the MPIM. After 1990 and the fall of the Berlin Wall, Friedrich Hirzebruch, through an immense effort, helped many mathematicians from East Germany find jobs and continue their scientific lives in a new environment.

Mathematics is a *travail de longue haleine*. Leonard Euler (born in Basel and working in St. Petersburg), inspired perhaps by the seven

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[1] *"It was about Cold War", letter by Geoffrey Wells, LRB, 5 April 2012.*

bridges of Königsberg (mostly destroyed by bombings in 1944 and 1945), discovered the notion of *Euler characteristic* of a graph. This notion had evolved during two centuries and by the time Friedrich Hirzebruch was maturing as a mathematician, found reincarnation as an alternating sum of dimensions of cohomology groups of (invertible) sheaves on an algebraic manifold. The celebrated *Riemann–Roch–Hirzebruch formula* of 1954 (described by Atiyah) expressed this number through geometric invariants of the base, crucially using the *Todd genus*, discovered by J. A. Todd from Liverpool. At the first Arbeitstagung in 1957, Alexander Grothendieck, son of a Russian anarchist and an eternal exile in France and everywhere else, presented its great generalization.

Perhaps the Riemann–Roch–Hirzebruch–Grothendieck Theorem, which fused and crowned efforts of a dozen great spirits from all corners of Europe, deserves to be put on the flag of the united Europe more than any other symbol.

Gerard van der Geer

The first time I saw Hirzebruch was when he visited my thesis advisor, Van de Ven, at Leiden University, where I was a Ph.D. student. I got to know him slightly better when Van de Ven took me to Bonn, where we visited Hirzebruch for a few days in 1974 to discuss Hilbert modular surfaces. At the time I was quite surprised to see how seemingly relaxed he was, though he must have been extremely busy at the time. He took ample time to talk to us, and the same happened about a year later when I visited him alone.

He invited me as a postdoc in 1977 to the Sonderforschungsbereich Theoretische Mathematik, the predecessor of the present Max-Planck-Institut. Shortly after my arrival there we celebrated his fiftieth birthday, the beginning of a long series of similar celebrations.

What struck me when we discussed mathematics was his instinct for the beauty of mathematics, and in fact all that he did bore the hallmark of elegance. The charming way he could lead the program discussion for the Arbeitstagung was another instance of this.

During my time in Bonn he would often invite me to his office and ask my opinion or even advice. In the beginning this surprised me, though I found out that weighing opinions of various people was part of his way of forming an opinion or coming to a decision. This applied especially to his preparation for the Arbeitstagung, where in the month before he was collecting suggestions for speakers and titles. It was surprising to see how he managed, seemingly without effort, to have the outcome of the public program discussions be guided by the ideas he had assembled.

The Fine Hall faculty in 1956. First row: Wigner, Tucker, Bargmann. Middle: Hirzebruch, Fox, Moore, Steenrod, Feller. Back: Spencer, Church, Artin, Wilks, Milnor, Tukey.

In 1981 he invited me to join him for a Summer Academy of the Studienstiftung in Alpbach in the Tirolean Alps in Austria. This was a two-week seminar where we would work with twenty-five very bright German students on a topic, studying in the morning, hiking in the afternoon. This was the first of seven such summer schools, the last one held in 1997. That was a fantastic experience, and during these seven summer schools I got to know Hirzebruch very well. From an awe-inspiring and paternal mathematician he became a very good friend. Professor Hirzebruch became Fritz. How difficult it was in the beginning to use "Du" instead of "Sie"! He enjoyed these days enormously and often in the later years would recall the happy days in Alpbach.

The charming way in which he would lead the summer school and discourse with students only fed my admiration for him. We would have lectures by students and ourselves in the morning and go hiking the whole afternoon. After dinner there would be interdisciplinary talks, because the Sommerakademie comprised groups from various disciplines, ranging from astronomy, say, to linguistics. After those talks we would gather in the Roter Salon of the Böglerhof Hotel for a beer and discussions with the students. Around 11 p.m. we would change location with our group to the disco, where we would dance—yes, Fritz too!—and continue to discuss as far as the noise admitted, and where we awarded drinks for prize-winning solutions to the exercises and problems. In the early hours of the morning we would return to

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At the third Arbeitstagung in 1959: Thom, Grothendieck, von Viereck, Milnor, and Dombrowski.

our rooms and decide whether quick preparation for the lecture the next morning was better done then or after sunrise. To do things efficiently was another lesson he taught by example.

In the later years, besides recalling Alpbach, he would often refer to the "golden fifties", the years he spent in Princeton, where he proved his landmark Riemann-Roch Theorem. For somebody who lived as a young man in the horrible Nazi time, those years must have been paradise. Inspired by this and his desire to rebuild mathematics in his own country, he formed the idea to have such an institute in Germany. That he succeeded in creating in Bonn one of the world's best mathematical research institutes is just one proof of his many talents. That it possesses such a pleasant atmosphere is another.

I often noted how he exerted a positive influence on other people just by being there. Or, even without him being there: I often noticed that faced with a difficult situation or decision, I asked myself how Fritz would have acted in such a case, and how much it helped. He was a wonderful person.

John Milnor

In 1955–56 Fritz and I were fellow assistant professors at Princeton. I don't believe that I really got to know him that year. However, I was certainly very much impressed by his mathematics. His *Neue topologische Methoden in der algebraischen Geometrie* had just appeared and was extremely exciting.

This was a time when many radically new ideas were beginning to completely transform the field of topology. Both Norman Steenrod's theory of cohomology operations and Jean-Pierre Serre's thesis, which brought the previously intractable study of homotopy groups under control, provided powerful new algebraic tools for studying homotopy theory. René Thom's ingenious geometric arguments exploited the work of both Serre and Steenrod to provide a completely new way of studying smooth manifolds. Hirzebruch's book added a whole new dimension, grounded in algebraic geometry and the study of complex manifolds. His theory of multiplicative sequences provided an important complement to Thom's work. For the first time, this brought Bernoulli numbers into topology, where they are related not only to groups of differentiable spheres but also to stable homotopy groups of spheres and the Adams conjecture.

I certainly got to know Hirzebruch well in the following years. He jumped from an assistant professorship in Princeton to a full professorship in Bonn and almost immediately established the annual Arbeitstagung, a true stroke of genius: It provided an annual get-together for mathematicians from all over Europe and from the US who wanted to follow the latest developments in topology and geometry. The relaxed atmosphere and low-keyed organization were a marvel of benevolently supervised democracy. The annual excursion on the Rhine provided a special opportunity for interaction. Visits to Bonn in the following years were always a pleasure, and Fritz and Inge's hospitality was much appreciated.

Mina Teicher

I want to start with the day that Hirzebruch received the Wolf Prize. It was on May 12, 1988, in the Knesset (the parliament) of Israel in Jerusalem—a very structured ceremony in the presence of the president of the country and five hundred guests.

Hirzebruch was sixty years old at the time he was awarded the Wolf Prize. He was the youngest person and only the second German to have received it.

Two prizes in mathematics were awarded, and Hirzebruch was chosen to respond on behalf of himself and the other laureate. He came to the podium to deliver his speech. With his strong and direct voice, he expressed his gratitude to the Wolf Foundation for awarding them the prize.

He then added a few sentences on behalf of himself only. When he completed his speech, the audience was dead silent for a few seconds, and then with tears in their eyes they started to clap in a fashion that is usually not seen in the academic world. They clapped and clapped more and more. He had spoken from his heart and had exposed his soul:

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> …As a professor at the University of Bonn, I am one of the successors of the famous mathematicians Felix Hausdorff and Otto Toeplitz. Hausdorff committed suicide in 1942, together with his wife, when deportation to a concentration camp was imminent; Toeplitz emigrated to Israel in 1939 and died there the following year. The memory of these mathematicians is with me always on this trip.

In these three sentences he managed to create continuity between the mathematical community in Bonn before and after the Nazis, to establish links between the Jews in Germany and the Israeli society, and to penetrate the hearts of the listeners.

Hirzebruch's first visit to Israel was in 1981 by the invitation of Piatetski-Shapiro, my Ph.D. advisor at the time. He was widely welcomed for being the great mathematician he was, as well as for his leadership role in reestablishing mathematics in Europe after WWII. But it was only in the late 1980s that he started to be actively involved in the mathematical research infrastructure in Israel.

Hirzebruch had a fundamental role in the Emmy Noether Institute of Bar-Ilan University. Following his advice, we prepared an application for a joint German-Israeli Minerva center in mathematics. We named the center after one of the greatest scientists of the twentieth century and one of the first female mathematicians, the German-Jewish mathematician (who fled to the USA in the early 1930s) Emmy Noether. The application was submitted to the Minerva Foundation (a subsidiary of the Max Planck Society), and in 1991 it was approved.

The inauguration ceremony of the Emmy Noether Institute took place in the house of the Israeli ambassador in Bonn in July 1992. A binational Beirat was appointed by the Bar-Ilan University and the BMBF. Hirzebruch was appointed by the deputy minister of the BMBF as the chairman of the Beirat. He served as chairman for twelve years, a role he took on with great commitment. He contributed his valuable time (when appointed he was still the director of MPIM in Bonn), his endless energy, his deep wisdom, and his vast experience to the success of the center. In 2000 he received an honorary degree from BIU for his contributions.

Two major conferences in algebraic geometry were held in the center in his honor. "Hirz 65" was held in May 1993 and attracted an international audience, including Fields medalists, directors of research institutes worldwide, collaborators, former students—all came to pay respect. "Hirz 80" was held in May 2008 and was one of the last big conferences he attended. Again, five Fields medalists attended, four Wolf Prize winners, and more. Fritz came, accompanied by his wife, Inge, and his son, Michael. He was very pleased to meet old friends, attended ALL the talks, and enjoyed the celebrations and the tours to the Golan Heights and Jerusalem. Unfortunately, on the day before the last, during a tour in the Western Wall caves, he fell and broke his leg, but then was most concerned that the conference was continuing as planned and kept apologizing for disturbing the agenda!

At the award of the Stefan Banach Medal in Warsaw, October 26, 1999.

I was reflecting on the times (circa 1975) when, for me, the name Hirzebruch was the title of a yellow book *Topological Methods in Algebraic Geometry*, which, as part of my M.Sc. studies, I had to read and then give a shorter proof of the Hirzebruch-Riemann-Roch Theorem in the special case $n = 3$. In spring 1988 I participated in a special semester in Bonn on algebraic surfaces, coorganized by Hirzebruch. Ten years later, in summer 1998, we organized together a special semester in the MPI, "Topology of Algebraic Varieties". He gave brilliant lectures, presenting complex geometrical structures in a simple and natural way, demonstrating beautiful examples. I learned more about the skills that helped him reestablish the mathematical community in Europe after the war. He never forgot that mathematics is made of—and by—mathematicians. Listening and attending to everybody's needs, "combining" people, making his own friends into friends of one another. A man who followed his values with no exception. A noble man.

Kenji Ueno

When I was a graduate student of the University of Tokyo, Professor Kodaira often told us his memories of his time in the US. The most unforgettable one is the following.

> A young German mathematician came to the Institute for Advanced Study. He calculated the Todd genus of several algebraic manifolds. I wondered what he was really trying to prove. But suddenly he proved the Riemann-Roch theorem for all algebraic manifolds. In that summer I wrote a letter to J-P. Serre that Hirzebruch proved the Riemann-Roch theorem, while I could only prove that the Hodge manifolds were algebraic.

Kodaira had proved the Riemann-Roch Theorem for algebraic threefolds by using the theory of harmonic integrals. He was trying to prove the theorem step-by-step as he could not foresee that one could prove it in a single step. Hirzebruch used cobordism theory to prove it. This was a completely new approach and paved the way for the Atiyah-Singer index theorem.

In December 1971 Kodaira told us that Hirzebruch would visit Japan the following February and deliver a series of talks at the University of Tokyo. So many times we had heard the name of Hirzebruch from Kodaira and also consulted his famous book *Topological Methods in Algebraic Geometry*, but we had never expected that we would have a chance to meet him in Japan. His lectures were the IMU lectures, which means that the IMU supported his visit to Japan. At that time the Japanese economy was growing but still not strong enough, so that the Japanese government supported universities very little. We had the research grants of the Ministry of Education, but strangely enough it was forbidden to use them for either inviting foreign scholars or for visiting foreign institutes. For that we had to apply for another grant, which was quite difficult to get. This restriction was continued for a long period and only removed around fifteen years ago. Therefore, at that time it was almost impossible to invite foreign scholars with Japanese funds.

In January 1972 the title of his talks was announced. To my surprise his talks were on the resolution of cusp singularities and Hilbert modular surfaces. In February Hirzebruch came to Japan. The lecture room was full of people. His talk was so clear and beautiful that I thought I understood every detail. Of course, this was his magic, and later I realized that I had missed many important points. In his lectures he posed several exercises and problems related to the subject. Since the classification theory of algebraic and analytic surfaces was popular among us, some of his problems were not difficult. After the lecture Kodaira introduced us to Hirzebruch. Before his next talk I visited him and showed him answers to some of his problems. He was pleased and encouraged me to study further. At that time I was invited to Mannheim University, and Hirzebruch was kind enough to give me suggestions. He asked me to attend the Arbeitstagung in Bonn and promised to send an invitation letter.

After Tokyo he visited Kyoto and gave several lectures. Many young active Japanese mathematicians attended his lectures and solved several problems posed by him. He asked them to apply to the SFB 40 in Bonn University. Soon some of them got invitations to Bonn. At that time in Japan there were several programs to visit foreign universities as graduate students but very few possibilities to visit foreign countries as researchers, so that his advice was very helpful for young Japanese mathematicians.

At the beginning of that March I went to Mannheim University. In June I received an invitation letter to the Arbeitstagung from Hirzebruch. He never forgot his promise. The Arbeitstagung was very interesting. I met there many mathematicians whose names I knew only from their papers. In October 1972 I was invited to the SFB 40 and stayed there half a year. Then I came back to Tokyo to get my Ph.D. and went back to Bonn the following spring.

At Bonn University I got a room in the same building where Hirzebruch had his office. Almost every day I saw him working hard not only on administrative works but also discussing mathematics with students and many mathematicians. He was busy enough, but he always attended important seminars and colloquium talks. Also, at teatime he came down to the tearoom and discussed mathematics with us. He was very kind to answer our questions and always encouraged us to do mathematics. If the questions were not in his fields, he introduced us to the appropriate mathematicians.

In the 1970s the only possible way to invite foreign scholars to Japan was to use the JSPS (Japan Society for the Promotion of Science) program. Hirzebruch's second visit to Japan was under this program. He stayed mainly in Kyoto and had discussions with many young Japanese mathematicians. After that he visited Japan several times. He always advised young mathematicians to apply to the SFB 40 and later the Max Planck Institute for Mathematics. Following his advice,

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many young Japanese mathematicians applied to Bonn and many of them had chances to visit Bonn. They could not only concentrate on their research but also collaborate with foreign mathematicians, often in different fields. During the mid-1990s more than one hundred Japanese mathematicians visited Bonn.

In 1997 the Mathematical Society of Japan (MSJ) awarded the Seki-Kowa Prize to Hirzebruch for his outstanding contribution to the Japanese mathematical community in giving many young Japanese mathematicians the opportunity to study and collaborate with mathematicians from all over the world. At the same time the MSJ had applied for the Order for Hirzebruch through the Ministry of Education. The Japanese government awarded him the Order of the Sacred Treasure, Gold and Silver Star, which was the highest order for foreigners except politicians and diplomats. In November 1997 the ceremony was held at the Ministry of Education, and the vice minister awarded him the order. In the ceremony Hirzebruch answered that he would accept the order on behalf of all the Japanese and German mathematicians who had once stayed in Bonn and collaborated together, the secretaries and staff of the SFB 40 and the Max Planck Institute for Mathematics who helped their activities, and the Deutsche Forschungsgemeinschaft and Max Planck Gesellschaft for supporting them financially. His speech deeply impressed officials of the Ministry of Education who were present at the ceremony.

Hirzebruch loved mathematical talks, and his talks were always clear. Once when he visited Kyoto, I asked him to give a lecture for high school students. At that time every two weeks I organized a mathematics lecture for high school students at the Kyoto University. He gave a beautiful lecture on the regular icosahedron. The high school students enjoyed his talk and were impressed by how deeply he loved mathematics.

It is really sad that I cannot talk with him anymore. He always talked with a gentle smile and never failed to encourage us to do mathematics. I am quite sure that his warm memory and his encouragement to do mathematics will survive in all mathematicians who once met him.

Graeme Segal

The month I spent in Bonn as a second-year graduate student in the autumn of 1964, when I first encountered Fritz Hirzebruch, remains one of my most vivid memories. When I think of all he must have been involved in I am humbled to think of his kindness in spending so much time, not just

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Shiing-Shen Chern, Samuel Eilenberg, and Friedrich Hirzebruch, 1956 in Mexico.

in talking to me about my work but in making sure that my wife, Desley, and I were at home and happy in what was for us a strange new world.

For a young Australian, Germany then was an overwhelmingly formal place. After two years I had just about become accustomed to the increased formality of England, but in Germany it attained another level. In retrospect I see that the country was poised on the brink of a great change in social style, and I think this was essential to Fritz's magic. On one side he was the perfect German professor of the old school: although only thirty-eight, he had already served a term as dean of the Faculty of Sciences and was a figure of manifest authority. (My status rocketed with the very genteel elderly lady in whose house we were lodging when one day the Herr Professor arrived in person to pick me up.) He gave wonderful lectures, but what I most remember about them was his use of the German language—his long, elegant, articulated sentences in which every clause clicked faultlessly into place. Mathematicians had long since ceased to lecture like that in English; I wonder whether it still happens in Germany?

But there was another side, as Fritz had become part of the Princeton mathematical world with its very different manners. He had attracted Jacques Tits to Bonn as his closest colleague, and they called each other "Fritz" and "Jacques" in public, which was constantly remarked upon to me—sometimes with a definite hint of disapproval—by the *Assistenten* in the department. (Peter Pears and Julian Bream came and gave a recital in Bonn at the time, and the informality of their dress and demeanor on stage also caused a flutter.) I had no idea then of Fritz's great achievement

in rebuilding German mathematics from the late 1950s on, but it seems to me that a big part of his success must have come from his ability to shine in two, at least, very different styles at once, with always just the tiniest suggestion of ironical detachment from each. He evidently had a remarkable ability to see what was needed and what was possible for the mathematical world and a perfectly pragmatic way of pursuing it, with almost nothing showing of amour propre. Foreign mathematical visitors like me saw little of his "Germanic" style beyond the legendary clockwork perfection of the arrangements for the annual Arbeitstagung, but, looking back, I marvel at how, in gathering together such an outstanding panoply of diverse mathematicians from all over the world in his institute, he managed to seem—and indeed to be—so uniformly benevolent, sometimes in the face of much that was surely alien and even offensive to his own nature. I sometimes felt he had a special affinity with the Japanese visitors, whose reserved manners had something in common with his own.

I shall not try to talk about Fritz's mathematical work, as I don't feel the best-placed person to do that. I always admired his taste for beautiful concrete geometric examples and all he could extract from them, though I never myself worked quite in his area. But I cannot resist mentioning one of his earliest achievements. When I became a graduate student in 1962 the first suggestion made to me by my first supervisor, Sir William Hodge, was to try to read Hirzebruch's *Neue topologische Methoden in der algebraischen Geometrie*, which had just appeared. It was far above my head then, but it begins with the piece of algebra whereby a formal power series gives rise to a multiplicative characteristic class for vector bundles. I was bewildered but tremendously intrigued by this, and I remember struggling with the proof that the only series $f(x)$ such that the coefficient of x^m in $f(x)^{m+1}$ is 1 for all m is the famous one

$$f(x) = x/(1 - e^{-x})$$

which defines the Todd genus. I can only say that almost everything I have ever thought about in mathematics, in K-theory, index theory, elliptic cohomology, deformation quantization, or whatever has involved what I learned then.

Stanisław Janeczko

The political changes in Poland in 1990 (Eastern Europe) caused many necessary reorganizational efforts. One of the institutions in trouble was the Stefan Banach International Mathematical Center (BC) in Warsaw. It needed a new basis and structure for a secure and prosperous existence. Friedrich Hirzebruch, being at that time president of the European Mathematical Society, offered his help and great involvement to reconstruct the BC and to form new conditions for European cooperation. During the meeting of the Executive Committee of the EMS in Budapest, the letter of Intent on Cooperation between the Institute of Mathematics of the Polish Academy of Sciences and the EMS was discussed and signed *in order to secure the fruitful continuation of the activity of the Stefan Banach International Mathematical Center*. It was President Friedrich Hirzebruch's personal effort, made with care and concern, for the fruitful future activity of the BC. We found him enormously friendly and deeply involved in any possible undertakings. His pragmatism, careful attitude, and firm support allowed all the good working elements of the former activity of the BC to be maintained.

The agreement was signed on 30 March 1993, and the first meeting of the new Banach Center Council, with three representatives of the Executive Committee of the EMS, four representatives from Poland, and three representatives from the founding countries, was organized on 25 October 1993. Friedrich Hirzebruch agreed to serve as its chairman. The council and mainly the chairman started to work very hard to adapt the BC to the new but still unstable reality. As a master and friend of all of us, Hirzebruch visited the Banach Center every year and taught us how to be supportive and really helpful to other colleagues; how to be honest, objective, constructive and not discouraging to other applicants, how to improve the atmosphere for successful research, how not to be "divisive" and troublemaking, and how to be gentle and responsible in formulating opinions about others. He taught us that mathematics is unity, that there are no better or worse branches of mathematics, but that it is engagement in research and striving for perfection that are of key importance. He was always supportive of the director of the institute in the latter's difficult fights and efforts. He was an excellent advisor during my period of directorship, always patient and understanding, friendly, with impeccable manners. He made an enormous effort to help the institute in its fight to maintain the basic properties. Under his chairmanship the first eight years, despite the material difficulties which we all suffered in Poland, the Banach Center was very successful and prosperous.

In 1997 Friedrich Hirzebruch became a member of the Polish Academy of Sciences. The next year an Algebraic Geometry Conference in Honor of F. Hirzebruch's Seventieth Birthday was organized in the Banach Center in Warsaw. It was an unusual event with extreme importance also for Polish

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mathematicians. Then in 1999 he got a prestigious award of the Polish Academy of Sciences—the Stefan Banach Medal.

Since my first visit to the Max Planck Institute for Mathematics in Bonn in 1984, through our daily meetings and walks along the paths in the pleasant neighborhood of the institute to my last visit there in November 2011, I experienced Fritz's generous, warm, and extremely eager ideas and advice on mathematics as well as on everyday life. He was always so pleased with mathematicians' new achievements and at the same time deeply worried about his colleagues' material status and the financial conditions of mathematics in general. He showed us that we have to be extremely careful not to lower the value of mathematics and not to isolate it from the global efforts of mankind.

It was an extreme pleasure and satisfaction for me when he agreed to come to Warsaw in May 2012 to celebrate his birthday, to meet with all the Polish friends and former scholars of MPI. We were very happy to prepare this event to thank him for all that he had done for the Banach Center, the Institute of Mathematics, and Polish mathematicians. Unfortunately, a few days before the symposium started, Fritz had an accident at home and was not able to come. The letter, perhaps his last letter (which can be found on the website of the Banach Center) was brought to us by his son, Michael, and his daughter-in-law, Anne Hirzebruch. It was the most meaningful gift which we never expected to get—to be in Friedrich Hirzebruch's great mind and soul till the last days of his life.

Jean-Pierre Bourguignon

Some Personal Recollections

Personally, over the last forty years, I owe a lot to Friedrich Hirzebruch for his unfailing support and continuous inspiration. I met him in Bonn in 1970 while I was visiting Wilhelm Klingenberg as a very young researcher in differential geometry. It was really during the academic year 1976–77, spent in Bonn with my family as guest of the Sonderforschungsbereich 40, that I got to know him better.

The Arbeitstagung, a major mathematical event that he organized with his Bonn colleagues for more than thirty years, offered each year in June a broad overview of the most exciting mathematics of the time. It was an exceptional place to meet mathematicians of all sorts, famous and less famous, senior or just beginning. Like many young mathematicians, I benefited a lot from it, directly through the new perspectives gained by listening to the lectures and indirectly through the great number of encounters, some of which had a great impact on my professional life.

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Friedrich Hirzebruch lecturing on Chern classes at IHÉS, November 17, 2011.

He was always curious to know what kind of mathematics was on your mind and showed special interest in young mathematicians. Also worthy of remark was his determinedly proactive attitude towards women mathematicians at a time when gender equality was not given much priority. Several women colleagues consider that they owe him a lot because of his continued support.

The numerous encounters with him that followed the wonderful year in Bonn gave me ample opportunity to witness his many talents: as an outstanding mathematician of course, but also as a remarkably clear lecturer, an efficient communicator, and an exceptionally talented manager. Some of them were quite unexpected for me, such as accompanying him to a press conference with German journalists to discuss the development of mathematics in his country.

He was a great supporter of the collaboration between the Institut des Hautes Études Scientifiques (IHÉS) and the Max-Planck-Gesellschaft (MPG). He represented the MPG on the board of directors of IHÉS for several years. Both he, as director of the Max-Planck-Institut für Mathematik, and Sir Michael Atiyah, as founding director of the Isaac Newton Institute in the Mathematical Sciences, endorsed immediately the idea of the European Post-Doctoral Institute (EPDI) which I proposed in the fall of 1994 shortly after becoming the director of IHÉS. Already in 1995 the three institutions could join forces to get young postdocs to move around Europe. For the inaugural ceremony in

Bures-sur-Yvette, Hirzebruch gave a very inspiring speech on the role of institutes in mathematics.

A Very Early and Critical Involvement in European Mathematical Affairs

All along his career, Friedrich Hirzebruch had a lot of interactions with Henri Cartan, a dedicated European very early on: his first interaction was in relation to Cartan's efforts to renew contact between German and French mathematicians after the Second World War. Indeed, as early as November 1946, Henri Cartan lectured in the Lorenzenhof in Oberwolfach.

In this connection, Friedrich Hirzebruch wrote the following: "The 'Association Européenne des Enseignants' (European Association of Teachers) was founded in Paris in 1956. Henri Cartan was president of the French section. As such he took the initiative to invite participants from eight European countries to a meeting in Paris in October 1960. Emil Artin, Heinrich Behnke and I were the German members. The second meeting of this committee was in Düsseldorf in March 1962. As a result, the 'Livret Européen de l'Etudiant' (European Student's Record) was published and distributed by the Association. The booklet contained a description of minimal requirements for basic courses. It was supposed to increase the mobility of students from one country to another. The professor of one university would mark in the booklet the contents of courses attended by the student. The professor at the next university would then be able to advise the student in which courses to enroll. The booklet was not used very much." This was indeed the early form of the by now well-established "Erasmus Program".

A lot about their relationship can be learned from reading the letter that Friedrich Hirzebruch wrote in 1994 to Henri Cartan on the occasion of his ninetieth birthday.

The European Council of Mathematics (EMC) opened the way to the European Mathematical Society (EMS). The foundational meeting of the EMS was held in October 1990 in Madralin and was not an easy affair, as opposite views on the structure of the EMS were presented by some delegations: should it be a federation of societies or a society with individual members? Friedrich Hirzebruch, who had agreed to be considered as the first EMS president, led to success the rather tense meeting behind closed doors between supporters of the conflicting positions. The next day the new society could be created with statutes ensuring a good balance between individual members and member societies, a feature that still remains operational to this day.

Under Friedrich Hirzebruch's leadership, the EMS developed successfully. A lot had to be achieved in a short time to take advantage of the dynamics that accompanied the creation of the society. Among milestones of his mandate, one can single out the setting up of the first European Congress of Mathematics in Paris in 1992 and laying the groundwork for the *Journal of the European Mathematical Society* (JEMS) that was finally created in 1999.

To my great surprise, he asked me to become his successor as EMS president in 1994 to serve for the second term, 1995–98, another great honor that he bestowed on me.

Final Visit to Paris

In November 2011 Hirzebruch came to IHÉS on the occasion of a conference in honor of the centenary of Shiing-Shen Chern, a close friend of his since 1953, whom he described as "one of the greatest mathematicians of the 20th century [and] for me a fatherly friend whom I owe very much." He lectured brilliantly on Chern classes and was able to meet Chern's daughter, Mae Chern. At the end of his lecture, he told me, "I am afraid that this will be my last visit to Paris." It is very sad to remark that he was indeed right.

Matthias Kreck

After my oral *Vordiplom* examination in the summer of 1968, I asked Hirzebruch whether I could attend his seminar. "Of course, but it is rather difficult," was his reaction. He was right; I was not prepared to follow that seminar. But it gave me the chance to become familiar with some of the other students and assistants in his group, such as Klaus Jänich, Erich Ossa, and Walter Neumann. A year later I asked Hirzebruch whether I could write my diploma thesis with him and the answer was the same: "Of course." Often when he supervised a diploma thesis, he asked one of his assistants to help him, which meant that he gave the assistant the major part of the responsibility, but he followed what was going on. In my case he asked Klaus Jänich to supervise me and that was wonderful. At that time Jänich had started to systematically investigate invariants which share a fundamental property with the most important manifold invariants, such as the Euler characteristic and the signature, namely, that they are invariant under cutting and pasting. In this way I became a friend of two of Hirzebruch's best friends: the signature and the Euler characteristic. This has been a lifelong friendship, with the signature in particular playing a role in many of my papers.

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Around 1969 Jänich received an offer from Regensburg and asked me to join him there with the aim of becoming his assistant and to write a Ph.D. with him. I felt very honored and agreed. Soon after my arrival in Regensburg both Jänich and I discovered that we had almost opposite political opinions. This was a great pain for Jänich, so that he felt unable to continue working with me. To resolve the situation he wrote a letter to Hirzebruch asking him whether he would be willing to take me back: "Perhaps you can deal with this young man." The answer: "Of course." In this way I came back to Bonn and became Hirzebruch's Ph.D. student (in parallel with Don Zagier).

My Ph.D. time was difficult. Hirzebruch had started his fundamental work on Hilbert modular surfaces and gave a course about it. He asked me to take notes (which he used to write his beautiful Enseignement survey article). He didn't give me a specific problem to work on. Instead he pointed at certain invariants occurring in connection with the resolution of singularities, which are some sort of signature defects, and suggested that I investigate them further. He had proven some relations to L-functions and had a rather general conjecture which he mentioned. This was all too hard for me and I became rather frustrated. After about a year, I decided to give up and to study Protestant theology. When I told this to Hirzebruch, he looked unhappy but said, "Of course, I understand," at the same time clearly thinking what would be the best for me in this situation. He suggested that we should meet in the near future again and look at what I had done so far. "Perhaps what you have proven so far is already enough for a Ph.D.," he said. This was extremely kind, since I had not done very much. We met, and he suggested certain things which I could realistically work out, and we agreed on a plan which would lead to my Ph.D. within a year.

I defended my Ph.D. in July 1972 and immediately started an intensive three-month course in Hebrew, which is a prerequisite to study theology. After this course I went to Hirzebruch to finally say good-bye and thank him for all his support. He was very friendly and asked how the Hebrew course was going and whether I was looking forward to starting my theological education. Then he continued: "I have just lost another assistant who became a professor at another university. Would you be willing to be my assistant? Of course, I know that you need most of your time for theology, but I will give you enough free time. I also know that you don't want to do mathematical research; this is not necessary. I need your help with supervising seminars, other students, courses, examinations, etc. Do you agree?"

Princeton, 1967, in the house of Louise and Marston Morse. Inge and Fritz Hirzebruch with their children, Ulrike, Barbara, and Michael.

I found this extremely generous and agreed. Whether he had an ulterior motive I really don't know. But in any case, his offer bore fruit. After more than two years of not thinking about mathematical research, I found myself thinking about a mathematical problem in my theology courses. I did not tell this to Hirzebruch; this was just for my own personal fun. I did not even consult the literature to find out what was known. Within a few weeks I could solve half of the cases and told this to Hirzebruch. He looked rather skeptical and asked, "Do you know that this is a well-known problem which had been attacked by mathematicians like Thom, Browder, and Sullivan?" I had no idea and immediately said that my solution must be wrong. "Why? Let me hear," was his answer. I explained the idea to him, and he said, "This has a chance; write it up in detail. And if you can do the (much harder) remaining cases, this is your Habilitationsschrift."

Based on this result, in 1976 I received an offer as professor at Wuppertal University, even before my Habilitation was formally finished. This was also the time when I had to begin my final examinations in theology. I asked my friends:,"What should I do? The devil is tempting me." Their reaction was, "If you have not learned more about the devil, you better go back to mathematics."

When I told Hirzebruch that I would accept the offer from Wuppertal, I could see from his face that he was pleased. But his reaction also made it clear that if I had decided to stay in theology, he would have respected this equally.

Whenever I think about mathematics I am influenced by my teacher, Friedrich Hirzebruch. My strongest impression is of the enthusiasm

Inge and Fritz Hirzebruch on the boat trip to Remagen, Mathematische Arbeitstagung, 2007.

for mathematics he lived; this was a relaxed and friendly enthusiasm. He was always open for discussions with me, either about questions I had or to share his mathematical ideas. I was impressed by his clear thinking and writing, his ability to bring different mathematical areas together, and his deep insights. And also by his always visible humanism, both within and outside mathematics. I am so grateful that I had the chance to have close contact with Hirzebruch and that he always treated me like his friend. I will never forget him.

Ulrike Schmickler-Hirzebruch

Since my childhood I have always been convinced that I had a very special father. I am the eldest of three children and was born in 1953 (my father was twenty-five years old) in Princeton, New Jersey, where my father spent a productive time at the Institute for Advanced Study from 1952 to 1954. These were the formative years of his mathematical career but also of his family life. My father met my mother, Inge, also a mathematics student, for the first time in Münster in 1947. After a few occasions where they saw each other again, it became clear that they should get married, which they decided on in 1952 before my father left Germany for Princeton. He arrived in Hoboken, NJ, in August 1952 with the Holland-America oceanliner *Ryndam*; my mother came over in November on the *Maasdam*, and a few days later they married. With a settled married life, my father could be "free" to concentrate on his scientific work.

There are a lot of letters from my parents to their parents in Germany—in those days it was the only way to communicate. I was amused when I recently read in a birthday letter from my father to his father (Dec. 12, 1953):

> …The last days were mathematically very exciting, so exciting that I almost did not eat anything. I worked during the night until 4:30, once until 6:30. Results came out that I had already wanted to prove for quite some time, but that had seemed to be very difficult.…(I assume that Ulrike gets the credit. They say here that babies, as long as they are less than 6 months old, know everything about mathematics, but they can't tell it.)

Starting from 1956, my father was a professor in Bonn. In 1957 he organized the first annual international meeting Mathematische Arbeitstagung. My siblings and I got to know this group of mathematicians in our early childhood on the boat trips and at the parties held in our apartment. The Arbeitstagung was a special event also for us. My father's enthusiasm was contagious, and his love for mathematics included his mathematical friends.

We were "infected" at an early age by mathematical problems: for example, on our Sunday walks in the forest: "Just think of a number, multiply it by 4, add 10…and so forth. And what is your result?" Then he told every one of us the individual chosen number. Also at lunch he often surprised us with beautiful simple problems, for example, with the trick of how to quickly multiply two numbers between 10 and 20 (he had learned this trick from his father, a math teacher and director of a secondary school) and easy ways to construct magic squares. This and much more happened without any prior planning.

My father generally accepted what we did and how we did it. Without much consideration, I decided to study mathematics, and later so did my sister, Barbara. Because of the pleasure it gave me, I accepted the challenge, all the more so since at that time there were only a few female students in the mathematics diploma program in Bonn. My sister, Barbara, wanted to be a math teacher. My brother, Michael, wanted to study medicine, which in later years would be very helpful for my father.

As a father he had authority through his reliability, personal credibility, and his familiar smile as a sign of his helpfulness and warmth towards us. My father gave us cautious advice; sometimes, maybe, he was a bit too cautious. He was extremely balanced.

From my student days, I remember that my father lent me some books that I saw on the bookshelves of his study. I could take them to my home to work with them. There was discipline: he

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would keep track accurately, and his name was written in the book; but from the expression in his face I knew if I liked the book, I would own it someday. An arrow from his name to "Ulrike" then indicated this transfer. For my father, books also had been important in his youth when he was lucky to learn from the math books his father owned.

I also remember some Sundays when I came to my parents' home an hour before lunchtime. I extremely enjoyed this hour with my father in his study. With a light hand he could show me the relationship between mathematical objects and beautiful concrete examples. A small hint was enough; I immediately understood his explanations—the combination of teacher and father was wonderful.

Later, in my professional life, I met my father a couple of times at mathematics meetings. In a few of his lectures, he deliberately included—just for me, and unnoticeable to others—a phrase or an expression with which he wanted to tease me a little.

My father had three children and six grandchildren. He took each of us seriously. We miss his loving nature and how he could clearly express individual good wishes for us. His nice simple words, enriched with caring humor, always hit the nail on the head.

My parents were a good team for almost sixty years. They complemented each other well. My mother encouraged my father in his organizational efforts, and she joined him on his ways, especially, whenever she could, on trips and visits to mathematical places.

My mother sometimes refers to the statement by Mephistopheles in Goethe's *Faust* II: "How are merit and luck linked together." His personal actions and a few good coincidences (for instance, being at the right time at the right place) shaped my father's life. We are very grateful that my father had the good fortune to bring his life to a full end and that, shortly before his death, he was still able to give two mathematical lectures, which had always been such a great pleasure for him.

Note: All photos are courtesy of either the Hirzebruch family or the Max Planck Institute.

Friedrich Hirzebruch's grave on Poppeldorfer Friedhof in Bonn.