The Art and Artists **of Numbers**

For many, mathematics is nothing more than an accumulation of abstract formulas and dry recipes for calculating. Not so for **Friedrich Hirzebruch**, Founding Director of the **Max Planck Institute for Mathematics** in Bonn, Germany. He had already succumbed to the beauty of the subject in his youth. As the "doyen of German post-war mathematics," Hirzebruch made this city on the Rhine an attractor for researchers the world over.

TEXT **ELKE MAIER**

"In principle, the functioning of a mathematical institute is extremely simple," wrote the Dutch mathematician Hendrik W. Lenstra Jr. in 1984: "A large stack of paper, blank on both sides, goes in the front. A specialized staff of typists, university lecturers and exercise group leaders have the task of making all of the sheets unusable on one side. The stock of paper processed in this manner is then distributed equally among the mailboxes of the mathematicians, who then have a go at the other side. The paper, now completely unusable, leaves the building at the rear."

The Max Planck Institute for Mathematics is accommodated in an historic palace in the center of Bonn, just a five-minute stroll from the main train station. The scientists here still like to work with paper and pencil even today, mostly by themselves in their offices. However, promptly at 4 p.m. each day, they leave their desks in order to meet for a traditional cup of tea and chat about mathematical problems. The originator of this social ritual was Friedrich Hirzebruch. With his persistent effort to promote scientific exchange, he instituted not only the tea tradition, but also the institute itself.

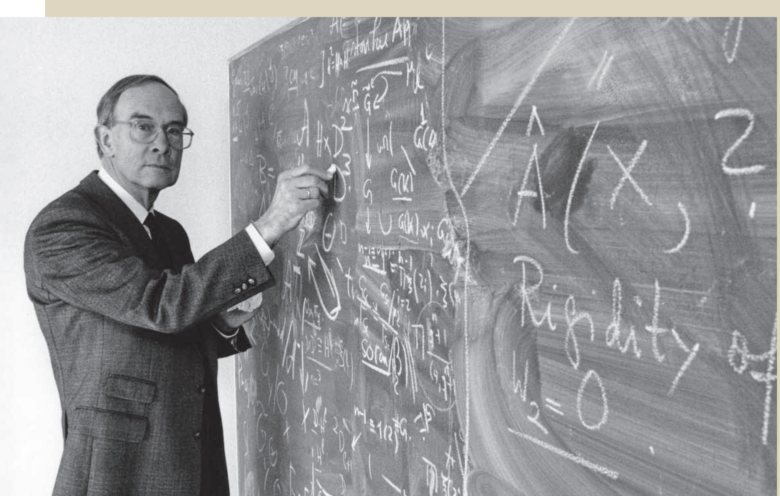
Friedrich Hirzebruch was born October 17, 1927 in Hamm, in the German province of Westphalia. As the son of a mathematics teacher, he came into contact with the world of numbers very early. At age 9, he was already concerning himself with the question of why the square root of two is an irrational number. At 16, Hirzebruch was drafted into the Air Force auxiliary. While he kept a lookout for enemy aircraft in the sky above, he observed spherical triangles in the nocturnal firmament and other figures in the stars, and performed calculations in his head about their geometry. He used his time in an Allied prisoner of war camp to derive mathematical proofs – on toilet paper.

After the war ended, Hirzebruch was ordered to a work detail in a British barracks. Shortly thereafter, he was released: "A British officer who spoke fluent German spoke with me about my intention to study at university and was so taken with the idea that he declared my work time over, brought me home in his Jeep and encouraged me to do nothing other than mathematics …," he recalled later.

Following this good advice, Friedrich Hirzebruch began his university studies in mathematics in Munster, Germany, in December 1945. There, he made the acquaintance of Heinrich Behnke, who introduced him to complex analysis and geometry. Another influential instructor was Heinz Hopf from ETH Zurich, from whom he got to know topology. This discipline is concerned with the particular properties of geometric shapes that remain invariant under transformation – for instance, the surface area of a cube made of modeling clay that can very easily be transformed into a sphere.

In 1950, Hirzebruch eventually received his doctoral degree with his dissertation on four-dimensional Riemann surfaces. The brilliant mathematician Bernhard Riemann had founded an entire branch of geometry in the 19th century. Up until then, the 2,000-year-old teachings of Euclid were customary. However, these teachings are inadequate when curved objects, such as bent surfaces, are involved.

Riemann was the first to learn how the angles, lengths, intervals and volumes of spaces in any dimension whatsoever can be determined. That became the framework for the theory of rel-



Science on the blackboard: In his lectures, Friedrich Hirzebruch knew how to instill his fascination with mathematics in his listeners.

Photo: MPS/Wolfgang Filser

Among his students: Friedrich Hirzebruch chatted with junior scientists about mathematical questions in the library. His "Champagne Problems," for which he awarded a bottle of sparkling wine when solved, were popular.

ativity some 50 years later, for now Einstein could show that the gravitational force causes a curvature of space-time – similar to how a sphere leaves a dent in a stretched cloth.

Having completed his doctoral degree, Friedrich Hirzebruch took up an assistant professorship in Erlangen, Germany. Shortly afterwards, he received an invitation that would influence his future career. He was given the chance to work at the famous Institute for Advanced Studies in Princeton. The institute functioned as a forge for new ideas and was a magnet for the international research elite. While the sciences lay fallow in Germany after the war, Albert Einstein and logician Kurt Gödel, as well as respected German mathematician Hermann Weyl, who had emigrated to the US in 1933, were all there.

Following a nine-day crossing by ship, Friedrich Hirzebruch was met at the harbor by Donald Spencer on August 18, 1952. He was to work closely with him at Princeton over the coming two years, as well as with the other eminent mathematical authorities Armand Borel and Kunihiko Kodaira, who would be awarded the Fields Medal a short time later.

The atmosphere at the institute captivated Hirzebruch right from the beginning. Spencer, Borel and Kodaira introduced him to methods that were as yet unknown in Germany, and that had ex-

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» What does mathematics mean to him [Hirzebruch]?
"It is captivating because of the beauty of the ideas and the coherence of its various parts, because of the brilliance of the proofs, the diversity of the problems, and also because of its 6,000-year history. Mathematical problems that were discussed hundreds of years ago are still topics of conversation today."

otic names like "coherent analytic sheaves," "vector space bundles" and "Thom's cobordism." Hirzebruch seized on these new ways of thinking, developed them further and created his own mathematical tools. The thesis he wrote to obtain his German post-doctoral lecturing qualification, entitled *Topological Methods in Algebraic Geometry*, was published in book form and brought together the findings of this period. It remains a standard work to this day.

Hirzebruch's main effort was also finally successful in Princeton: the point of departure for his most famous discovery was a theorem in which Bernhard Riemann and his student Gustav Roch had unified algebra, analysis and geometry in a single, compact formula. Put simply, the Riemann-Roch theorem deals with the question of how many algebraically defined functions of a particular kind exist whose zeroes and poles fulfill specific conditions. Hirzebruch radically generalized this theorem and expanded it to an arbitrary number of dimensions.

Many mathematicians had already had great difficulty with this problem. The enthusiasm was correspondingly huge when this twenty-something solved the problem: "I felt as though I was in paradise," gushed Italian mathematician Francesco Severi after having heard Friedrich Hirzebruch at a congress. Even viewed somewhat more soberly, the Hirzebruch-Riemann-Roch theorem certainly figures among the most important achievements of mathematics in the 20th century. It also plays a role in the string theory of modern theoretical physics.

Besides the international esteem, this theorem brought Friedrich Hirzebruch a professorship in Bonn. And because he had experienced in Princeton how important the international exchange for the development of ideas can be, he wanted to bring something of that atmosphere to the Rhine.

His first step was to organize a workshop, which he called an *Arbeitstagung*. The meeting of mathematicians from all over the world first took place among a small circle in 1957 and grew over time from a kind of family meeting into an annual event with more than 200 guests. Hirzebruch's idea was unusual in that there was no fixed schedule of events. Instead, the guests themselves decided jointly who should give a talk on what topic. Many of the lectures were held off the cuff, allowing some proofs that had been finished at the last minute to be presented brand new.

New ideas were born not just in the conference rooms, but during the traditional boating trip on the Rhine, as well. And one newspaper or another reported that some of what originated from that trip received sonorous names – honoring the steamer on which the researchers cruised along the Rhine.

The *Arbeitstagung* was a complete success from the beginning. However, nearly a quarter century would pass before Hirzebruch realized his dream and was able to found a research center along the lines of the institute in Princeton. The comments on his first application were somewhat sobering: "It appears doubtful whether the quite abstract area which he worked on previously can be fruitfully developed," wrote one of the referees in 1960, and he believed it possible, indeed likely, "that this entire direction will reach a dead end within a few years."

Friedrich Hirzebruch didn't let himself be disconcerted by this. The next big chance came a few years later. The German Research Foundation (DFG) had instituted special research reports. This time, Hirzebruch's application was successful. And thus, in 1969, Special Research Report No. 40 (SFB Nr. 40) at the University of Bonn was prepared, entitled "Theoretical Mathematics."

Thanks to Hirzebruch's dedication, this temporary grant became the forerunner of the Max Planck Institute for Mathematics in 1981. Under his leadership, it developed into an international center. Between 70 and 80 scientists work here for up to two years and bring ideas from the world over to Bonn, just as Hirzebruch would have it. He believed that science should not take place behind closed doors. Last year, the "doyen of German postwar mathematics" passed away at the age of 84.