Opening Ceremony

The opening ceremony of the Congress was held at the International Congress Center on Tuesday, August 18, 1988, starting at 10:00. Some of the talks were given in German, with an English translation on slides. Here we reproduce the English versions.

David Mumford

President of the International Mathematical Union

Minister Rüttgers,
State Secretaries Staudacher and Hauser,
Governing Mayor Diepgen,
Professors Hoffmann, Hirzebruch and Grötschel,
fellow mathematicians,
ladies and gentlemen:

Let me welcome you to the ICM'98, the 23rd International Congress of Mathematicians. It is a great honor and a great pleasure to open this Congress.

First I would like to congratulate the Organizing Committee for the superb job they have done in bringing to life this Congress. I have always been aware that the ICMs were major undertakings but only in the last four years, watching from the sidelines the huge number of decisions, negotiations and problems and the vast array of details that the Organizers have dealt with, did I appreciate all that this means. It has been a truly monumental task to which dozens of Professors and hundreds of assistants have devoted the major part of their lives for the last several years. But they have put together what we call in the U.S. a blockbuster of a Congress. Secondly, I want to say that I also did not appreciate how large and how crucial was the financial assistance from the host country in keeping these Congresses affordable to all researchers in mathematics. So I would like to especially thank our German hosts for their truly remarkable financial support. We will see in a few minutes the extent and the many sources, private and public, of this magnanimous contribution.

Thirdly, I want to say that I am accustomed, as a mathematician, to being in a nearly invisible field of work. Mathematics is neither a hard Science whose discoveries are widely broadcast nor an Art, which delights a major part of the public. So I am especially pleased that our Congress here in Berlin has attracted the attention of the Federal Minister of Education and Science, the State Secretaries of the German President and the Ministry of Finance and the Governing Mayor of Berlin. I am further delighted that there is a stronger public awareness here in Berlin of mathematics and of our Congress than I can recall at any previous Congresses. During this Congress we have an opportunity to present mathematics to people engaged in other professions and the organizing committee has put together an exciting program to accomplish this, as you will hear shortly. Let me do my part by saying a few words about how mathematics relates to the broader cultural world.

Mathematics is usually explained and justified to the world at large by giving examples of important inventions that could not have been made without its help. This is embodied in the myth that we mathematicians concern ourselves with eternal truths, which we hand on to physicists, who pass them on to chemists and engineers, etc. who finally pass them on to mankind as a whole. There are definitely important examples of ideas passing along this chain (in fact in both directions!) but I also think it is a rather narrow view to isolate mathematics on such a pedestal. There is a more socially grounded view, which says that mathematics and mathematicians are deeply embedded in human culture and are tied to the Arts in particular where the love of abstraction also flourishes. Let me illustrate this.

At the beginning of this century, the great German mathematician David Hilbert carried out his extremely influential dissection of the axioms of Euclidean geometry into their logical components. Was it a coincidence that at the same time, the French impressionists were dissecting the light and color of painting into their basic components? In the 20's and 30's, the Bauhaus school of architecture was building in Germany human habitations along minimalist lines. And Bourbaki in France was rebuilding mathematics in its most abstract possible setting. It is

Opening Ceremony

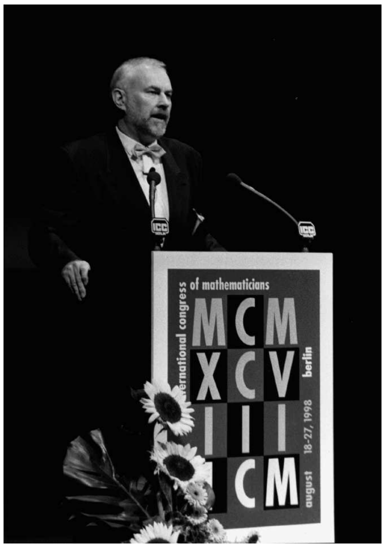
amusing to work out more parallels between mathematics and the broad trends in human culture, such as the discovery that randomness could be more effective than precise planning, by the artist Jackson Pollock and the mathematician N. C. Metropolis at roughly the same time. But I will content myself with the assertion that the most widely renowned mathematical achievement of the last four years, the solution of Fermat's 300-year-old problem, is the quintessential post-modern theorem. The basic qualities of what is known as post-modern art and architecture are their conscious combination of idioms from every era in the past. And, indeed, Wiles' proof combines ideas from almost every branch of classical mathematics - number theory proper, algebraic geometry, Lie group theory and analysis; and its roots go back to Kronecker's famous vision, his 'Jugendtraum', in the 19th century.

Although the links are sometimes hidden, mathematics is tightly woven with all of art and science. I wish the Congress success as a forum for the exchange of ideas between mathematicians and the citizens of this remarkable city as well as between mathematicians themselves. Welcome to this celebration of the best of mathematics at the close of the 20th century!

I propose that we elect by acclamation, here and now, Professor Martin Grötschel as President of the 1998 International Congress of Mathematicians and I call him to the stage.

Martin Grötschel

President of the ICM'98



Herr Minister,
Herr Regierender Bürgermeister,
verehrte Staatssekretäre,
ladies and gentlemen:

I am very grateful for your vote. It is truly an honor to preside over ICM'98, the 23rd International Congress of Mathematicians.

On behalf of the Local Organizing Committee I would like to welcome you all to ICM'98, in particular, to this opening ceremony at the International Congress Center (ICC) of Berlin.

An international congress such as this is, in the language of marketing, a very "complex product." Many groups, distributed all over the world, take part in the planning and preparation. I would like to reveal a few.

The General Assembly of the International Mathematical Union chose Berlin as the site of ICM'98 at its meeting in Luzern in 1994.

One of the first efforts of the Organizing Committee was to find a suitable logo. We were fortunate that a flash of genius of our designer team Ott & Stein produced a beautiful arrangement of the number 1998, the year of our congress, written in Roman numerals. Please watch the short video on my left to see how ICM and ICC, the abbreviation of the name of the building we currently occupy, show up magically.

During the last four years the preparation of ICM'98 proceeded in close contact with the IMU Executive Committee, in particular, with IMU President David Mumford and IMU Secretary Jacob Palis. This was and still is an outstanding cooperation. I would like to thank both, David and Jacob, for their excellent and continuing support.

The IMU appointed the Fields Medal and the Nevanlinna Prize Committee. Their achievements will be unveiled in about 90 minutes.

The committee that is most important for the scientific success of the congress is the Program Committee. It was chaired by Phillip Griffiths, its members are shown on the slide above me.

The Program Committee has chosen 21 plenary speakers and 169 invited speakers in 19 sections. Their selection was based on 19 international panels, that also received support from other scientific societies.

I believe that this choice of leading experts, who are going to report on the mathematical achievements of the last years in their field of interest, is why most of the about 3500 members of this congress have gathered.

Some statistics: The ICM'98 participants come from 98 countries; 1 % are from Australia, 2 % from Africa, 12 % from Asia, 20 % from America, and 65 % from Europe. About 12 % of the members are female, 10 % of the participants are students.

Staudacher, Ziegler, Diepgen, Aigner, Rüttgers, Hirzebruch, Hoffmann

Whatever scientific committees do and plan, it is impossible to launch an event such as this one without substantial financial support. The Organizing Committee is greatly indebted to many public and academic bodies, private corporations and foundations, and a large number of individuals for monetary contributions and the donation of goods and services. The slides above me show the major donors. Representatives of most of our benefactors are present at this moment. Thank you very much!

Thanking individuals in speeches like this is always a sensitive matter. Nevertheless, I would like to make an exception here and mention one person specifically. Our sincere thanks go to Hermann Schunck of the Federal Ministry of Education, Science, Research, and Technology, who was a mainstay and backed the organization politically wherever he could. For the group theoretists among you: he is the person after whom *Schunck classes* are named, an outgrowth of his PhD thesis, written in 1967 in his "former life."

One outcome of our fund drives and those of IMU makes us very proud. The donation of more than DM 900 000 enabled us to financially support the participation of about 460 mathematicians from developing countries and Eastern Europe. The sponsored colleagues have been selected from 1500 excellent applications and strengthened our scientific program considerably. They particularly contribute to the more than 1200 short communications and poster presentations that will, in addition to the invited lectures, be given at this meeting.

Everything I have reported so far was similar at former congresses. I believe that three features distinguish ICM'98 from previous ICMs.

First, it is the first time that extensive use of electronic communication, information, and organization was made. Almost everybody in this room has received e-mail from me. Many of you have corresponded with my colleagues and me by electronic means. This way we were able to stay in touch with our "customers." We have taken up various suggestions, avoided some mistakes and were able to repair others quickly. Quite a few "thank you letters" indicate that many of you felt well informed about the progress of the planning.

Some statistics may highlight the "electronic revolution": two thirds of the ICM'98 participants registered electronically, 95 % mailed their abstracts electronically, and only one of all plenary and invited papers was not submitted electronically. This made it possible to produce the proceedings before the congress and make them available in the Internet, except, of course, for the part that deals with the present Opening Ceremony.

Second, the Local Organizing Committee, in cooperation with IMU, has added an additional section, called the *Section of Special Activities*, where topics are covered that are of mathematical relevance but do not fit into the traditional scientific program. There will be talks, presentations, and round table discussions on electronic publishing, mathematical software, activities related to women, international comparison of mathematical studies, and a series on Berlin as a centre of mathematical activity.

Third, the International Congress was extended to the general non-mathematical public. This was considered a matter of utmost importance by all members of the Organizing Committee. The activities going on these days are too numerous to be mentioned here in detail. We have rented the Urania building to attract the Berliners to listen to mathematical talks. There will be several exhibitions, music performances etc. related to mathematics. We hope that these activities will not only be of interest for the general public but also for the ICM members and their accompanying persons.

To give you an idea of what to expect, let us watch a preview of the VideoMath Festival film that will be shown several times during the congress at the Urania.

I invite you all to this festival and the other activities at the Urania.

At the end of my words of welcome, I would like to thank my colleagues in the Organizing Committee. They are all volunteers and have done the organizational work in addition to their usual duties. They have joined forces enthusiastically and have given their best to make ICM'98 an exceptional event. Let's hope that our dreams come true.

Welcome to ICM'98, welcome to Berlin. We wish you a successful conference and a pleasant stay, thank you very much!

KARL-HEINZ HOFFMANN

President of the German Mathematical Society

Dear Mr. President Mumford,
ladies and gentlemen,
dear guests:

For the first time in 94 years the International Congress of Mathematicians returns to Germany. In the name of the German Mathematical Society I welcome you to Berlin.

My special greetings go to the State Secretary, Wilhelm Staudacher, who is representing the President of the Federal Republic of Germany today, as well as to the Minister of Education, Science, Research and Technology, Dr. Jürgen Rüttgers. I also extend a warm welcome to the Governing Mayor Eberhard Diepgen, representing the Land of Berlin.

Ladies and Gentlemen! In 1912, that is eight years after the ICM held in Heidelberg, we read in an essay of the Austrian-Bohemian writer Robert Musil:

Mathematics (as a science) is the bravery of pure reason, one of the few we have today. ... It can be said that we live entirely on the results. ... This whole being that runs ... and stands around us not only depends on mathematics for its comprehensibility, but has effectively been created by her, rests in its ... existence upon her.

A look at the program of the ICM'98 supports this assessment in an impressive way.

The broad spectrum of talks on pure and applied mathematics is supplemented by sections like Mathematical Software and by events for a non-professional audience as, for example, the VideoMath Festival and various exhibitions.

Mathematics is art and culture, but it is also the foundation of our technology based world. The Enquete Commission of the American Academy of Science has concluded:

High Technology is essentially mathematical technology.

Mathematics has not only given birth to her extremely successful daughter, computer science, but mathematical methods are also used in their own rights and thus have become the backbone of modern technology. Let me mention in this connection computer tomography, robotics, aeronautics and space science, semiconductor technology, and material sciences.

Contrary to a general belief, well trained mathematicians are not only wanted in the academic field, but also in business, banks, and insurance companies. The Federal Institute for Employment in Nürnberg has recently reported that there are as many vacant positions for mathematicians as there are mathematicians seeking employment. The broad education that mathematicians receive provides them with the flexibility which is a characteristic of modern working environments. In view of all this, the support which mathematics receives in Germany from the German Research Council DFG, the Max Planck Society, private foundations, industry and from the Federal Ministry for Education, Science, Research and Technology is an investment for the future. We are grateful for that. These measures of support have led to the creation of research centers, exemplified in the foundation if institutions, as well as the Research Networks, the SFBs (Sonderforschungsbereiche), Programs of the DFG, and Joint Projects of the BMBF (Ministry of Science and Technology):

- 2 Max Planck Institutes: the MPI for Mathematics in Bonn and the MPI for Mathematics in the Sciences in Leipzig.

- The Institute for Applied Analysis and Stochastics of the Leibniz Society in Berlin.

- The “Konrad-Zuse-Zentrum für Informationstechnik” in Berlin.

- 7 SFBs of the DFG in the fields of Algebraic Geometry, Partial Differential Equations, Differential Geometry, Discrete Mathematics, Scientific Computing, and Mathematical Modelling with a total budget of DM 13 Million per year.

- 4 Programs of the DFG in the fields of Dynamical Systems, Optimization, Stochastic Systems, and Conservation Equations with a total budget of DM 11 Million.

- A Program of the BMBF for the advancement of joint projects between universities and industry.

Students as well as academics from Germany and abroad will find a rich vein of mathematicial research in our universities. Although the media often deplore the lack of international collaboration in science in Germany, this criticism does not apply to mathematics.

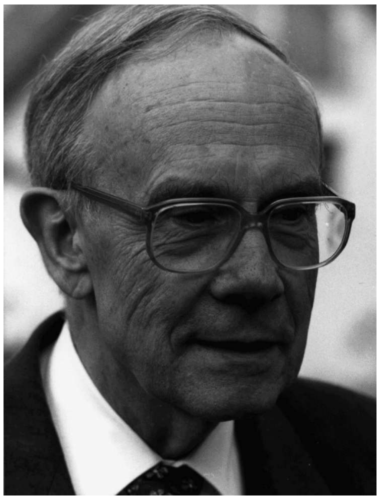
We are happy to demonstrate this fact by having the International Congress of Mathematicians in Berlin.

We are especially grateful to Professor Friedrich Hirzebruch, who, by his reputation and his personal integrity, has helped decisively to restore the position of German mathematicians within the international community. As President of the German Mathematical Society I ask you to elect by acclamation Professor Friedrich Hirzebruch as Honorary President of the ICM'98. Let me again welcome you and wish you all an interesting scientific program and exciting days in the reunited Berlin.

View over Berlin from the Technical University

Friedrich Hirzebruch

Honorary President of the ICM'98



Many thanks for the honour just bestowed on me. At the closing session in Zürich, I invited the congress to Berlin on behalf of the German Mathematical Society (DMV). The Organizing Committee in Berlin under Professor Martin Grötschel has worked hard and very efficiently using the most modern developments of electronic communication. As honorary president of this committee I had to do very little, but I had ample chance to admire their work. I wish to thank Professor Grötschel and all members of his committee very much, especially for making the honorary presidency so easy for me. In 1904 the Congress was in Heidelberg, supported by Kaiser Wilhelm and the Grand Duke of Baden. This time our support comes from the Federal Republic of Germany and the Land Berlin. We are grateful for the generous support. I welcome Staatssekretär Wilhelm Staudacher, who will read a message of the President of Germany, who agreed to be the protector of this Congress. The Federal support comes through the Minister of Education, Science, Research, and Technology. I welcome the Minister Dr. Jürgen Rüttgers. The Land Berlin is represented by its Governing Mayor Eberhard Diepgen. We thank the Technical University and its president Professor Hans-Jürgen Ewers for letting us use the University as venue of the Congress. In 1990 the German Mathematical Society (DMV) celebrated its 100th anniversary. Our application to issue a special postage stamp on this event was turned down. We are all the happier that for this congress a special stamp will be issued and Staatssekretär Hansgeorg Hauser will present it to us.

I mentioned the 100th anniversary of the DMV. Its first president was Georg Cantor, the founder of set theory. He was an ardent fighter for the establishment of the International Mathematical Congress. From the founding years of the DMV up to Nazi times, mathematics in Germany was leading internationally. Among the presidents of the Society in this period were Felix Klein, Alexander Wilhelm von Brill, Max Noether, David Hilbert, Alfred Pringsheim, Friedrich Engel, Kurt Hensel, Edmund Landau, Erich Hecke, Otto Blumenthal, and Hermann Weyl.

Alfred Pringsheim died in Zürich in 1941 at the age of 90 after having escaped from Germany. Edmund Landau lost his chair in Göttingen in 1934. Otto Blumenthal was deported to the concentration camp Theresienstadt, where he died in 1944. Hermann Weyl, president of our society in 1932, emigrated to the United States in 1933. He worked at the Institute for Advanced Study in Princeton together with Albert Einstein, Kurt Gödel, John von Neumann, who were all members of our society.

David Hilbert died in Göttingen in 1943. Hermann Weyl wrote an obituary published in the middle of the war in Great Britain and the United States. I quote: "Not until many years after the first world war, after Felix Klein had gone and Richard Courant had succeeded him, towards the end of the sadly brief period of the German Republic, did Klein's dream of the Mathematical Institute at Göttingen come true. But soon the Nazi storm broke and those who had laid the plans and who taught there besides Hilbert where scattered over the earth, and the years after 1933 became for Hilbert years of ever deepening tragic loneliness."

To those "scattered over the earth" belongs Emmy Noether, the famous Göttingen mathematician, daughter of Max Noether, president of the German Mathematical Society in 1899.

It is not possible for me here to analyse the behaviour of the DMV and its members during the Nazi time, or its reaction to the Nazi time after the war. When we began to prepare the present congress, it was clear for us that we "must not forget." My generation should be unable to forget. Many of my age have good friends all over the world where parents or other family members were killed in Auschwitz. We must teach the next generation "not to forget." The German Mathematical Society has announced a special activity during this congress to honour the memory of the victims of the Nazi terror. I read from this announcement and ask you to participate:

In 1998, the ICM returns to Germany after an intermission of 94 years. This long interval covers the darkest period in German history. Therefore, the DMV wants to honour the memory of all those who suffered under the Nazi terror. We shall do this in the form of an exhibition presenting the biographies of 53 mathematicians from Berlin who were victims of the Nazi regime between 1933 and 1945. The fate of this small group illustrates painfully well the personal sufferings and the destruction of scientific and cultural life; it also sheds some light on the instruments of suppression and the mechanism of collaboration.

In addition, there will be a special session entitled "Mathematics in the Third Reich and Racial and Political Persecution" with two talks given by Joel Lebowitz (Rutgers University), "Victims, Oppressors, Activists, and Bystanders: Scientists' Response to Racial and Political Persecution," and Herbert Mehrtens (Technische Hochschule Braunschweig), "Mathematics and Mathematicians in Nazi Germany. History and Memory."

Of the 53 mathematicians from Berlin honoured in the exhibition, three are here with us as guests of the Senate of Berlin and the German Mathematical Society. I greet them with pleasure and thanks. They are

Michael Golomb, United States,

Walter Ledermann, Great Britain,

Bernhard Neumann, Australia.

The last student of the famous Berlin mathematician Issai Schur is Feodor Theilheimer who lives in the United States. It is a pleasure to welcome his daughter Rachel Theilheimer. Schur and Theilheimer both belong to the 53 mathematicians honoured in the exhibition.

In addition, I welcome

Franz Alt,

driven away from Vienna, who emigrated to the United States and is with us today as a guest of the DMV.

In 1961 I became president of the DMV as successor of Ott-Heinrich Keller from Halle in the German Democratic Republic (DDR). The wall had just been built. The Mathematical Society of the DDR was founded. In 1990 I was president again and had to work for the reintegration of the DDR society into the DMV.

We look hopefully into the future and are happy as the reunited DMV to host the congress.

Progress and future of mathematics are represented by the laureates of the Fields medal and the Nevanlinna prize. It will be a great honour and pleasure for me to hand over the Fields medals to the winners.

Musical Break

Greetings from Federal President Roman Herzog

(read by State Secretary Wilhelm Staudacher, Director of the Office of the Federal President)

As patron of the congress, I have the pleasure of welcoming to Berlin the participants from all over the world who have come here for the 23rd International Congress of Mathematicians. Unfortunately, I cannot be with you in person today and have therefore asked State Secretary Wilhelm Staudacher to convey my greetings to you.

For us Germans it is a source of great pleasure that the International Mathematical Congress is being held in Germany, the first time since 1904. It is hard to conceive of a more appropriate setting for this congress than the capital of our reunified country. As mathematicians, you will likely focus more on the furtherance of science rather than on historical retrospect. Nevertheless, all of you will be aware that Berlin symbolizes the division of Germany, for the city was itself divided by a wall, but it also symbolizes the reunification of Germany as a democratic state with scientific freedom.

Here in Berlin we also remember that this city, along with Göttingen, was once a leading international center of mathematics, until the Nazi regime forced many scientists into exile or even murdered them. Mathematics in Germany was not able to recover from this terrible loss for a long time. It required the work of an entire generation - as represented by you, Professor Hirzebruch - to put mathematics in Germany back to the world map. Often the very scientists who had been driven into exile were the ones who helped in this process.

Our good progress is demonstrated by the award of the Fields Medal to Professor Faltings in 1986. And a current sign is the recognition expressed in the decision to let Berlin host this congress. For this I am most grateful.

The significance of mathematics is impossible to overestimate. For mathematics, often regarded as an ivory-tower subject, has in recent decades developed into a field of scholarship cutting across disciplinary boundaries, with increasing importance for the economy and society at large. This applies not just to the ever-more-powerful computers, but also to the direct penetration of mathematics into new domains.

The connection between physics and mathematics has always been of fundamental importance. In their origins hardly distinguishable from one another, these two disciplines have once again become especially closely linked. New mathematical theories emerge from ideas in physics, and the communication of physical results is impossible without mathematics.

One outstanding offspring of mathematics is computer science, without which life in the modern world is unimaginable. Materials science, chemistry, biology, and medicine cannot manage without mathematical methods. This congress will illustrate all of these fields of application. It will no doubt once again become clear that the solution of each problem throws up new questions, whose solution, in turn, often requires the development of new theories. One very pleasing outcome of this congress can thus already now be predicted: Mathematicians will never be without something to work on.

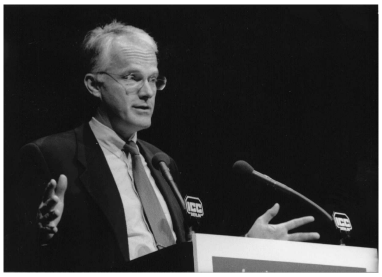
I also hope that the accompanying program will be a great success, a program in which you attempt to make the significance of mathematics clear to a broad public, especially through a series of evening lectures. The recently released results of the TIMMS Study have shown us that the mathematics performance of German pupils could certainly be better. For the knowledge-based society of the future, a solid grounding in mathematics is vitally important. So much remains to be done in this respect.

The Fields Medal and Nevanlinna Prize are awarded in recognition of outstanding accomplishment in research. I congratulate the young mathematicians who will be so honored. To be among those who have received this distinction is a great achievement within the international mathematical community.

I wish you all stimulating, productive, and enjoyable days in Berlin.

Jürgen Rüttgers

Federal Minister of Education, Science, Research, and Technology



Herr Präsident Mumford,
Herr Professor Grötschel,
Herr Regierender Bürgermeister,
dear ladies and gentlemen:

101 years after their first international congress, and two years before the turn of the millennium, mathematicians from all over the world have gathered here in Berlin.

In the name of the Federal Government I wish to welcome you to the old and new capital of Germany.

A few years ago the two parts of the city and the two parts of Germany were reunified. I invite you to experience with us how a new spirit of openness and of universality has inspired Berlin. We view your holding the congress here as an acknowledgement of this spirit. At the same time this Congress underlines the importance of Berlin as a center of science.

We can look back to a century of grand scientific achievements and progress. Especially in the last few years several problems have been solved which mathematicians had struggled with for a long time. As one example, let me mention the proof of Fermat's conjecture – an event where the level of public attention was in remarkable contrast to that of the public understanding, which did not diminish the excitement! Less spectacular signs of progress in mathematics, however, hardly get to the attention of the public. Because of this, the vitality of your science is often wrongfully considered to be quite low by uninformed contemporaries. In spite of this perception, mathematics is a vital, an extremely vital science. In manifold ways it reaches into our modern life. The importance of mathematics reaches far beyond its own speciality: Mathematics is something like a *common language*. It creates the possibility of precise communication between the natural sciences and the engineering sciences and more and more also the social and economic sciences. Mathematics is – beyond this – a *key technology of our times*. A country that wants to survive the global race for knowledge and its uses needs mathematics of the scientifically highest quality. It also needs a mathematically well-educated public. Because of this I have set for myself a goal: Together with the state ministers of science and culture I want to press for a strenghtening of basic mathematical education in Germany. For this, three points are necessary:

- We have to redefine the curriculum.
- We have to change the education of teachers.
- Finally, we have to reach standards of quality control that secure a uniformly high level of mathematical education in the different Federal states.

We should achieve also something else, which in practice is reached by committed teachers in particular cases, but is far away from being widespread: the enjoyment of mathematics. I had the opinion research institute EMNID ask young Germans what kind of knowledge they felt to be important for their future life, in particular for their working life. Here mathematics came in third place, immediately after the disciplines "computer skills" and "foreign languages." 84% of the young German women and men up to age 29 think that it is important to start life with a solid knowledge of mathematics. When pupils are asked their opinion about the school subject of mathematics, however, then the results are a disaster: Most of them think that math is dreadful. Now those who know me know that one of my basic theses is the following: It is not the main task of school to provide amusement to pupils; real learning may also be strenuous. By the way, this politically quite contested thesis has also been tested in our youth opinion poll and received the clear consent of 67% of the young people – this has been a surprise to many education liberals! In so far the educational challenge is how to create curricula and methods of teaching that do not cut out effort or circumvent it, but that would motivate the effort. I want to work on this together with my colleagues from the Federal states. We will have achieved our goal only when in a school yard we find "Math is cool!" as a graffiti on the wall.

Mathematical knowledge is important, in particular, in view of information and communication technologies. These technologies are the motor of our development from an industrial to a knowledge-based society. In the opposite direction, the development of computers has also provided a new tool to mathematics, not only as a machine for computing, but also as an instrument for the investigation and modelling of complex interactions. Thus equipped, mathematicians nowadays work on problems in economics, transportation, and society that not long ago were thought to be insolvable. One just has to tell it to the people out there: It is mathematicians who are dealing with traffic jams, health insurance, and other problems for whose solution there is a very high public interest. Let me tell you about one example here in Berlin: Not long ago the complete public transport system of Berlin was carefully analyzed and mathematically modelled. The result was that there is a potential for savings of more than 100 million Marks every year. Or equivalently: there is a chance to drastically improve the quality of the transportation system, while keeping the old budget. If you note that the German Science Foundation supports mathematics in Germany with an annual total of about 20 million Marks, then this seems to be well-invested money! I assume that the 5% increase of the funds for the German Science Foundation, as just approved by the Federal cabinet, will also benefit mathematics.

My ministry and the German Science Foundation have recently demonstrated that money is not the only way to show support for science. We have initiated a prize for excellent junior scientists whom we want to give a special opportunity to do independent scientific work. We have named the prize after Emmy Noether, as we wanted to honor this great scientist who has substantially influenced mathematics in this century. Emmy Noether had to leave Germany in 1933, without receiving the scientific recognition she would have deserved. Her name is essentially unknown to the public. I hope that this will change with the new Emmy Noether Prize. Mathematics depends on free, basic, theoretical research like hardly any other science. Mathematics is based on scientific curiosity. As probably the oldest science it is a basic part of our culture. Because of this I want to assure you today that I consider it as a part of my duty to see to it that basic research in mathematics and top-notch mathematical research receive a high priority in scientific politics.

We stand at the beginning of the knowledge-based society of the 21st century. We experience change that is as drastic as the industrial revolution 200 years ago. Of course, knowledge has always played a decisive role in the development of society. But in the future, knowledge will gain in importance as never before. While in an agrarian society land and labor decided about agricultural success, in a knowledge-based society the information about genetical codes of plants will be decisive for success of a harvest and the return it generates. While in an industrial society machines and steel defined the value of a car, already today it is the knowledge that is stored in the micro-electronics of the car controls that matters. Politically, for me, the development of a knowledge-based society is connected with the chance to replace the technocracy of the machine age by a truly "human" organization of life and work. Since only humans themselves can be the producers, transmitters and consumers of knowledge, they themselves – for the first time in history – move completely into the center. More than with any other achievement of our civilization, because of this we have reason for optimism! The knowledge society is no utopia. It is the name for changes in our society that can already today be seen and experienced. Mathematics and its offspring, computer science, have initiated this change. In the future, mathematics can also, beyond its manifold technical functions, give direction as a means of communication, as a form of rational argument and discussion, and as a means for the solution of the problems of society.

I wish the last International Congress of Mathematicians in this century a good and successful program!

EBERHARD DIEPGEN

Governing Mayor of Berlin

Sehr geehrter Herr Rüttgers,
Herr Staudacher,
Herr Ewers,
Herr Mumford,
dear ladies and gentlemen:

It is a great honor for me to welcome you to Berlin. The city does not see such a convention of high-power scientists every day, and it is a pleasure to host this congress of mathematicians from all over the world.

Of course, we in Berlin have not invented computing. This was not necessary thanks to the earlier work of the Babylonians and Greeks. But we have learned how to compute over the course of the centuries, even if one has to admit that mathematicians in Prussia were at first not very well-liked. In the kings "Tabakskollegium" they sometimes had to bear the brunt of rude jokes. But don't worry, today none of you will be soaked in beer. We also do not necessarily follow Goethe, who said about an acquaintance: "He is a mathematician and therefore stubborn." For stubbornness can also be a virtue.

Such rude manners directed towards the purest of all sciences have changed long ago. Gottfried Wilhelm Leibniz, Pierre de Maupertuis and Leonhard Euler are the persons who testify to this, scientists who have brought brilliance to our region. And they are not the only ones. We can also name Albert Einstein, Max Planck, and, of course, Karl Weierstraß and Konrad Zuse, the great pioneer of computer technology. Of course these are names of the past. The terrible drain caused by emigration and war recall wistfully nostalgic memories. And yet: Berlin has once again become a mecca of mathematics and not only of this. The city is a first-rate center of science.

Besides the three universities, three large research centers, five Max Planck, three Fraunhofer, and thirteen "Blue List"-institutes are all devoted to research. The extra-university institutions have a budget of roughly 750 million Marks per year. Last year four of the thirteen renowned Leibniz Prizes of the German Science Foundation went to Berlin. Beyond this we are making great strides in connecting research, high technology and the economy. Remarkable achievements have been reached at the science and business center in Adlershof and also at the life-sciences campus in Berlin-Buch.

There would be much more to talk about such as the interdisciplinary research groups with an emphasis in material sciences, information, communication, and transportation technology were there more time. Even this brief mention should point out to you that the place for your international congress is well-chosen, because the more than three thousand participants will find in Berlin a science and research climate which can inspire and which is intended to inspire.

"Numbers are the heart of all things," said Pythagoras, and he was probably right. But you will certainly not protest if I add to the great Greek: Numbers are not everything.

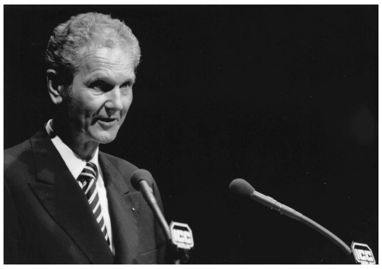
You have come to a city which is in the midst of a radical transition. Berlin is experiencing changes that you can witness in hardly any other metropolis on this continent. In a few months Berlin will again be the seat of the German government. Already now you can admire many buildings of the government center. You will realize at the same time how international the city has become – although Berlin had acquired an international flair long before, not only due to the presence of the Allies. More and more Berlin is becoming a congress, conference and exhibition city. The world is often a guest on the Spree River, a fact of which we are proud.

Use your congress-free time to also get to know the changing and changed Berlin. Look around in the city and discover its diversity. This, without doubt, is also one aspect of taking part in a congress in Berlin.

I wish you a meeting that is successful and valuable in many ways, and I hope you will often come back to Berlin.

Hans-Jürgen Ewers

President of the Technische Universität Berlin



Ladies and gentlemen,
meine Damen und Herren:

I am proud and happy to welcome all of you not only to Berlin, but also, beginning tomorrow, to the Technical University of Berlin, for a great ten-day celebration of mathematics. My hope and my wish is that you recognize this not only as "just" a congress, but that you view it as a festival, a big celebration, an "event." Mathematics itself will be the center and the object of this celebration: What is called pure mathematics will be celebrated because of its inherent beauty, and the Fields Medals will be given in recognition of spectacular contributions to its progress. I am happy and proud that the largest part of this celebration of mathematics will take place at my university.

Certainly you have heard many talks before that start with the words "I am not a mathematician, but ...." In my case, this half-sentence has a lot of possible continuations. As a president of a technical university, the Technische Universität Berlin, I can certainly refer to the engineering perspective of mathematics. Even if they don't like it, engineers speak of mathematics and use mathematics with great respect. They also recognize that there is an enormous trend for the further mathematization of the engineering sciences: in public transport and scheduling, in the planning and control of factory halls, in medical and biomedical technology. There is math in it, there is a lot of math in it, and in some cases (mathematicians might claim) there is hardly anything but math in it! At my university and elsewhere all over the world, mathematicians are putting their momentum and their energy into this trend with great success!

It is true that the public usually does not recognize the power of mathematics. This is only partially because mathematical research typically takes place in libraries or at the Oberwolfach Institute much more than in the streets or on TV. But if mathematics is to live and to flourish, then in the long run it will have to be visible in the streets or at least on TV. In that respect, it is quite remarkable that at this International Congress of Mathematicians, perhaps for the first time, an extensive series of lectures and events is directed towards the general public. There are posters in the subways, as you may have seen, and there are lectures at the URANIA Public Lecture Institute on topics ranging from the mathematics of detecting cancer to the mathematics of the CD-player. So at this ICM, mathematics goes public – and this is good and necessary!

This Congress moves to the TU Berlin tomorrow. I hope that you will feel welcome and that you will regard the TU Berlin as a nice environment for a great congress. You may notice signs of deterioration, of buildings not being quite kept up to their standards – take this as a mark of the typical Berlin charm, or more seriously as a sign of the massive budget cuts at all Berlin Universities, which make it even hard to maintain the buildings. Nevertheless, we haven't stepped back to the times of Konrad Zuse, who built the first electronic computer at home, in his parents' living room, rather than at a university research lab.

After all, it's not the buildings that count but the people who live and work in them. From the mathematics building at TU, you have a great view to East Berlin. But we have more than just the view: our math department is proud to play an active role in research efforts, travel, and exchange that bridges East and West. Intensive collaboration between West Berlin and East Berlin has become common place, as in the joint research project "Geometry and Physics" between the Technical University and the Humboldt University. The mathematicians in Berlin see themselves positioned at a central place, where the relations and exchange to Warsaw, Moscow and Prague are as important as the contacts and collaboration with Paris, Oxford, and the United States. And now, for these two weeks, we are happy and proud to assume the role of the "center of the Mathematical world" here in Berlin.

Mathematics may make the world go round. But I am an economist, and I am also a university president. In both functions I dearly know that money makes the world go round, as well. This implies, "as a corollary," that without money, and without a lot of public and private support, this great mathematical party would not have been possible. Speaking on behalf of the host institution for all those at the party, let me thank all the private and public sponsors of the event who made and will make this celebration of mathematics possible.

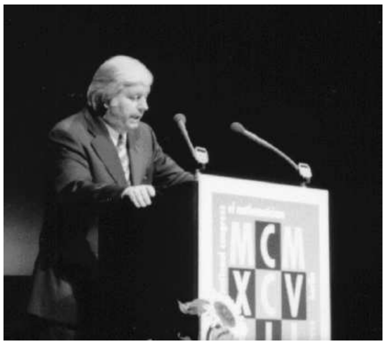
And to all of you, let me now say: Welcome to Berlin! Welcome to the Technical University of Berlin!

Mathematics Building of the Technical University

HANSGEORG HAUSER

Parliamentary State Secretary at the Federal Ministry of Finance

PRESENTATION OF THE SPECIAL STAMP
ON THE OCCASION OF ICM'98



Dear Prof. Mumford,
Prof. Hirzebruch,
Prof. Grötschel,
ladies and gentlemen:

The International Congress of Mathematicians is taking place this year for the 23rd time. The first congress was held in Zürich in 1897.

It surely has not happened very often that the finance minister of the country hosting the congress has participated in the opening ceremony. To explain *my* presence today, I could say that even representatives of the finance ministry must know how to add.

Now, I expect that mathematicians would surely object to this last remark, noting that – while they must also occasionally add – thinking is much more important. But let me assure you that even the representatives of the finance ministry have to be able to think, too!

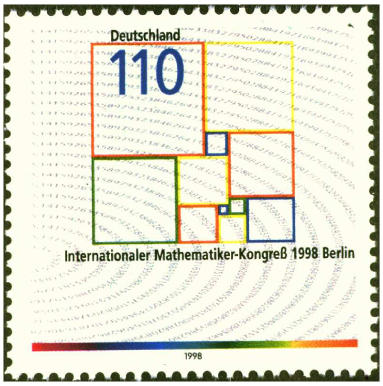
Well, at any rate, I am here: For although the federal postal service has been privatized and the postal ministry eliminated, responsibility for the issuance of stamps has remained under state control and has been delegated to the finance ministry.

Following the good example of the congresses in Moscow in 1966, Helsinki in 1978, Warsaw in 1982, Kyoto in 1990, and Zürich in 1994, a commemorative stamp is being issued to mark this mathematical congress. Ladies and gentlemen, I have the pleasure today of presenting this stamp to you.

As you can see, the most prominent feature of the stamp is the number 110. I asked a mathematician about the special properties of this number and his answer was the following: "This is the number that resulted from the perfect square 100 after the cost of sending a letter was recently increased by 10%." He continued, "It's more interesting to note that this number can be represented as the sum of three squares in exactly three ways:

$$\begin{aligned} 1 + 9 + 100 \\ 25 + 36 + 49 \\ 4 + 25 + 81. \end{aligned}$$"

The graphic artist Norbert Höchtlen from Munich, designer of the stamp, has also chosen to represent the decimal expansion of π in a sequence of concentric rings; if you look closely, you will see that the expansion becomes more precise as the rings become larger.



More than 4000 years ago the Babylonians recognized that the ratio of the circumference of a circle to its diameter is always a certain constant, the value of which is approximately equal to 3. They held the value, more exactly, to be $3\frac{1}{8} = 3.125$. Although the Babylonians did not use a decimal system of notation, in the system we use, their value is correct up to the first decimal place.

In the Old Testament account of the construction of the Temple (as commissioned by King Solomon), π has the value 3. Let me quote the relevant verse:

> *And he made the molten sea of ten cubits from brim to brim, round in compass, and the height thereof was five cubits; and a line of thirty cubits did compass it round about.* (I Kings 7:23 and II Chronicles 4:2)

Owing to the special use of Hebrew letters in the two places where this text appears, experts believe it is possible to conclude that the value of $333/106 = 3.141509\ldots$ for π was then known. As our commemorative stamp shows, this value is correct up to the first four decimal places.

The approximate value of $22/7 = 3.1428\ldots$ is due to Archimedes (ca. 287–212 B.C.). Mentioning his name gives me the opportunity to congratulate the new recipients of the Fields Medal, upon which the portrait of Archimedes is depicted. I also congratulate the recipient of the Nevanlinna Prize.

I should note that, with the help of computers, it has recently become possible to determine several thousand million decimal places in the expansion of π.

Over the centuries, many people have tried in vain to square the circle, that is, beginning with a circle, to use compass-and-straightedge constructions to construct a square of equal area. These efforts continued even after Lindemann showed in 1881 that π is transcendental, so that squaring the circle is impossible. Having to square the circle is nonetheless a task which is all-too-familiar to politicians.

This brings me to the large square on the stamp. If you measure its sides carefully, you will discover that it is nearly a square, as the sides have lengths 177 and 176, in appropriate units. This "near-square" has been decomposed into various perfect squares, the sides of which are all whole numbers; for example, the red squares have sides of length 99, 57, and 34.

Ladies and gentlemen, I must express my admiration for the field of mathematics. Not only because it can find such square partitions, but also because such discoveries have found application in the construction of networks.

Please allow me to note one further point about the design. As you can see, the small squares are all colored. Though there are many squares, it suffices to use only four colors, which calls to mind the famous Four Color Theorem. In this form the "near-square" on the new stamp was already used as the logo for the 1987 annual conference of the German Mathematical Society, a logo designed by the Berlin graphic artist Johanne Nalbach.

I would like to ask you to think back for a moment to the year 1987 in Berlin. At that time, the conference took place at the Technical University, where you will be gathering beginning tomorrow for the sessions of this international congress.

In 1987, Berlin was still divided. The mathematicians from East Berlin could not take part. But some participants crossed the border into East Berlin in order to meet colleagues there.

Only a few years later, in 1992, another annual conference of the German Mathematical Society took place in Berlin—this time, in a newly re-united city. The conference was held at the Humboldt University, in what had been East Berlin. To me, as well as to many others, the re-unification of Germany still seems today to be nothing short of a miracle. Yet without this miracle, the current congress could not now be taking place in Berlin.

I thus hope that, in addition to savoring the mathematical program, you will take a bit of time to enjoy the sites of this unified city of Berlin.

I now have the pleasure to present the first issue of the stamp commemorating the International Congress of Mathematicians in Berlin to

- the President of the International Mathematical Union, Prof. David Mumford, of Brown University in Providence, Rhode Island, in the United States,
- the Honorary President of ICM'98, Prof. Friedrich Hirzebruch, of the Max Planck Institute for Mathematics in Bonn,
- and to the President of ICM'98, Prof. Martin Grötschel, of the Technical University and the Konrad-Zuse-Zentrum in Berlin.

Thank you.

Hauser presenting ICM'98 commemorative stamp to Hirzebruch, Mumford, Grötschel (from left)

Presentation of the Fields Medals and a Special Tribute

by

Yuri I. Manin

Chairman of the Fields Medal Committee

I would like to thank our hosts for their hospitality and the efforts they invested in the organization of this Congress.

The international community of mathematicians, amply represented here, never bothered much about self-definitions. If pressed, I would choose as such Georg Cantor's famous motto:

Das Wesen der Mathematik liegt in ihrer Freiheit
–The essence of mathematics is its freedom–
–Суть математики – свобода–

Fields Medal and Prize

Now we turn to the award of Fields Medals and a special tribute.

The history of the Fields Prize goes back to 1924, when the President of the International Congress of Mathematicians in Toronto, Professor John Charles Fields, suggested to establish two gold medals, to be awarded for outstanding discoveries in mathematics. His proposal was accepted by the Zürich Congress in 1932, and the first medals were given at the Oslo Congress 1936. Starting with the Harvard Congress in 1950, two, and after 1966 two to four medals were awarded at every successive ICM.

When Fields expounded his vision of the prize, he brought up two important issues. He wanted it to be "of a character as purely international and impersonal as possible." And he wished it to be given "in recognition of work already done" and also as "an encouragement for further achievement on the part of recipients and a stimulus to renewed efforts on the part of others."

The designer of the medal did his best in order to express symbolically Professor Fields' first wish. You can see the result of his efforts, complete with Latin inscriptions and their translation. In particular, Fields' name does not appear on the medal.

As for the second point, the words "encouragement for further achievement" were taken to mean that the recipients must be reasonably young.

Fields Medal

COMMITTEE '98

The Fields Medal Committee '98 appointed by the Executive Committee of the International Mathematical Union consisted of Professors John Ball, John Coates, J. J. Duistermaat, Michael Freedman, Jürg Fröhlich, Robert MacPherson, Kyoji Saito, Steve Smale, and myself as chairman. Since this was to be the last International Congress of Mathematicians before the year 2000, we felt somewhat like a collective Santa Claus of the swiftly expiring millennium.

As all the Committees before us, we tried to select the most daring, profound, and stimulating research done by young mathematicians.

As all the Committees before us, we agreed, not without hesitations and doubts, to follow the established tradition and to interpret the word "young" as "at most forty in the year of the Congress."

PRIZE WINNERS

The selection process involved long deliberations and difficult choices. We acknowledge with gratitude the assistance of many colleagues who helped us to reach the unanimous decision to award four Fields Medals to the following mathematicians (in alphabetical order):

RICHARD BORCHERDS,

WILLIAM TIMOTHY GOWERS,

MAXIM KONTSEVICH,

CURTIS MCMULLEN.

A special tribute of the Executive Committee of the IMU is awarded to

ANDREW WILES.

Shor, Wiles, McMullen, Kontsevich, Gowers, Borcherds

On behalf of the Committee, I offer to all of them our warmest congratulations. The work of the Prize winners which won the international recognition will be described in more detail at the afternoon session.

Before we start the awarding ceremony, I would like to invoke a personal recollection. Many years ago a friend of mine was going abroad to receive his first international prize. He was excited, delighted, and worried about the proper behavior on such occasion. So we decided to consult the great book by the great wise Miss Manners, treating all sorts of good manners in difficult situations.

With initial surprise turning to admiration, we learned that Miss Manners reserved her most enlightening suggestion not for the award winners, but for all of us present at the ceremony, who don't get any prizes this time.

Her advice was: "Take it easy, have fun and enjoy your life!"

Richard Borcherds

For his contributions to algebra, the theory of authomorphic forms, and mathematical physics, including the introduction of vertex algebras and Borcherds' Lie algebras, the proof of the Conway-Norton moonshine conjecture and the discovery of a new class of automorphic infinite products.

WILLIAM TIMOTHY GOWERS
For his contributions to functional analysis and combinatorics, developing a new vision of infinite-dimensional geometry, including the solution of two of Banach's problems and the discovery of the so called Gowers' dichotomy: every infinite dimensional Banach space contains either a subspace with many symmetries (technically, with an unconditional basis) or a subspace every operator on which is Fredholm of index zero.

MAXIM KONTSEVICH
For his contributions to algebraic geometry, topology, and mathematical physics, including the proof of Witten's conjecture of intersection numbers in moduli spaces of stable curves, construction of the universal Vassiliev invariant of knots, and formal quantization of Poisson manifolds.

CURTIS MCMULLEN
For his contributions to the theory of holomorphic dynamics and geometrization of three-manifolds, including proofs of Bers' conjecture on the density of cusp points in the boundary of the Teichmüller space, and Kra's theta-function conjecture.

ANDREW WILES
I am happy to announce that the Executive Committee of the IMU decided to produce a commemorative silver plaque as a special tribute given to Andrew Wiles on the occasion of his sensational achievement.

Everybody knows what Andrew Wiles proved. I will say it in Pierre Fermat's own words:

> *"[...] nullam in infinitium ultra quadratum potestatem in duas ejusdem nominis fas est dividere."*

Unfortunately this plaque is too small to write Wiles' proof down.

Presentation of the Rolf Nevanlinna Prize

by

David Mumford

Chairman of the Rolf Nevanlinna Prize Committee

The Rolf Nevanlinna Prize was established by the International Mathematical Union with funds donated by the University of Helsinki for the most outstanding work in "Mathematical Aspects of Information Science" and has been awarded four times in 1983, 1986, 1990 and 1994. It is given at the ICM's with the belief that Information Science – including here theoretical computer science, analysis of algorithms, scientific computing, optimization and related fields – are all in essence part of the umbrella of mathematics. A Committee consisting of Bjorn Engquist, F. Thomas Leighton, Alexander Razborov and myself as chairman decided on this year's prize. We solicited a wide variety of opinions and, after much deliberation, are awarding this prize to:

Peter Shor.

He found many deep and remarkable results prior to 1994 in the analysis of combinatorial algorithms, many with a geometric flavor such as his discovery with Lagarias of a tiling of 10-dimensional Euclidean space by cubes with no common faces. Since 1994, he has been the principal driving force behind the development of quantum computing. First he put it on the map, so to speak, by factoring numbers fast (thus breaking the RSA encryption scheme) by a quantum computer. And second he has led a major assault on error correction and fault tolerance in this new situation, the main obstacles to the realization of quantum computing. Let me invite Professor Olli Lehto to present the award on behalf of the University of Helsinki.

Rolf Nevanlinna Medal

Prof. Dr. Friedrich Hirzebruch
Honorary President ICM 98

Max Planck-Institut
für Mathematik
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ICM
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III
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LIN

International
Congress
of
Mathematicians
August 18-27, 1998
Berlin

An den Herrn Bundespräsidenten
Professor Dr. Roman Herzog

Berlin

Fax: 39084717

Berlin, den 18. August 1998

Sehr verehrter Herr Bundespräsident!

Am Dienstag, dem 9. August 1904, fand in Heidelberg ein Bankett statt, von dem folgendes Huldigungstelegramm abgesandt wurde:

An des Kaisers Majestät, Berlin.

Dem machtvollen Herrscher des Deutschen Reiches, dem unermüdlichen Schirmer des Friedens sendet der zum erstenmal auf deutschem Boden versammelte Internationale Mathematiker-Kongreß ehrerbietigste Huldigung.

Im Auftrage: Prof. Weber. Prof. Krazer.

Heute am Dienstag, dem 18. August 1998, schreiben wir Ihnen von unserem Bankett aus wie folgt:

An den Bundespräsidenten, Berlin.

Dem höchsten Repräsentanten der Bundesrepublik Deutschland, der für die Bemühungen seines Landes um Frieden und Freundschaft in der Welt steht, sendet der zum zweitenmal auf deutschem Boden versammelte Internationale Mathematiker-Kongreß ergebenste Grüße und Dank für das Grußwort bei der heutigen Eröffnung.

M. Grötschel F. Hirzebruch K.-H. Hoffmann D. Mumford

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ICM MCM XCV III BER LIN

International Congress of Mathematicians
August 18-27, 1998
Berlin

An den Regierenden Bürgermeister
Herrn Eberhard Diepgen

Berlin
Fax: 24013019

Berlin, den 18. August 1998

Sehr verehrter Herr Regierender Bürgermeister!

Am Dienstag, dem 9. August 1904, fand in Heidelberg ein Bankett statt, von dem folgendes Huldigungstelegramm abgesandt wurde:

> An seine Königliche Hoheit den Großherzog von Baden, St. Moritz-Bad.
>
> Dem allverehrten Fürsten und Herrn des schönen Landes, dessen Gastfreundschaft wir genießen, dem warmherzigen Beschützer von Kunst und Wissenschaft huldigen wir in Verehrung und Dankbarkeit.
>
> Die zum III. Internationalen Kongreß in Heidelberg versammelten Mathematiker.
>
> Im Auftrage: Prof. Weber. Prof. Krazer.

Heute am Dienstag, dem 18. August 1998, schreiben wir Ihnen von unserem Bankett aus wie folgt:

> An den Regierenden Bürgermeister von Berlin.
>
> Dem verehrten Bürgermeister des schönen Landes, dessen Gastfreundschaft wir genießen, dem warmherzigen Beschützer von Kunst und Wissenschaft, danken wir von Herzen, insbesondere für die Ansprache bei der heutigen Eröffnung.
>
> Die zum XXIII. Internationalen Kongreß in Berlin versammelten Mathematiker und Mathematikerinnen.

M. Grötschel F. Hirzebruch K.-H. Hoffmann D. Mumford

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Opening Reception during the lunch break