The International Congress of Mathematicians: a human endeavour

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What is an ICM?

FOR more than 110 years, mathematicians have been gathering together in these particular reunions known as International Congress of Mathematicians. They are unique among any other scientific or intellectual meetings. What is the peculiar feature which explains their singularity?

Oswald Veblen hinted an explanation at the opening of Amsterdam's 1954 International Congress:

'The series of International Congresses are very loosely held together. They are not congresses of mathematics, that highly organized body of knowledge, but of mathematicians, those rather chaotic individuals who create and conserve it.'

Adolf Hurwitz, when addressing the participants in the first International Congress held in Zurich in 1897, searching more into the mathematician soul explained:

'It is true that most of the great ideas of our science have raised and matured in the silence of the working studio; no other science, but possibly for Philosophy, presents a character so eremitic and secluded as mathematics. And yet, in the heart of a mathematician lives the necessity for communicating and expressing himself to his colleagues. And each of us certainly knows by personal experience how stimulating personal scientific intercourse can be.'

A bird-eye's view at the series of the International Congress of Mathematicians reveals, in stark contrast to the public image of our science, that deep in the heart of mathematics there is a strong impulse towards communication and an intense sentiment of constituting a community. The international congresses are the highest example of this community identity.

The origins

How did these international congresses came to be and why did they arise at the end of the 19th century and not earlier or later?

The international congresses were the last step of a long process. Up to the 17th century, science was a passionate but secondary dedication for its practitioners. By the end of the century the first scientific academies were created in London and Paris, and later in Berlin and in St Petersburg. The French Revolution provoked many profound changes: science moved to the universities and its development joined with higher education. University professors assumed the additional (and imperative) role of researchers. The 19th century witnessed the creation of academic positions for science, specialized journals (the first, the *Annales des Mathématiques Pures et Appliquées* in 1810), national mathematical societies (firstly, in 1864, the Moscow Mathematical Society) and review journals.

Georg Cantor and Felix Klein were instrumental in the last steps towards the internationalization of mathematics. Cantor promoted the celebration of an international meeting; he needed an international arena where to defend his mathematical ideas, free from censure and unfair criticism. Klein was interested in expanding his standards for the teaching, research and organization of mathematics. On the occasion of the World's Columbian Exposition in Chicago in 1893, a mathematical meeting was arranged at the University of Chicago. The main figure was Felix Klein. In the opening address, entitled 'The present state of Mathematics', he presented an internationalist programme:

'A distinction between the present and the earlier period lies evidently in this: that what formerly begun by a single master-mind, we now must seek to accomplish by united efforts and cooperation. A movement in this direction was started in France some time since by the powerful influence of Poincaré. (...) But our mathematicians must go further still. They must form international unions, and I trust that this present World's Congress at Chicago will be a step in that direction.'

By the end of the 19th century, mathematicians were more professionalized and specialized and mathematical research had become a highly structured activity. This new shape made mathematics more international. The time was ripe for the First International Congress.

Early times

The First International Congress met in Zurich in 1897. It will be remembered for having established some 'Regulations for the Congress' whose spirit remains in today's ICM. The first article established the objectives of the

congress, the first two were: (i) To foster personal relations between mathematicians of different countries; (ii) To present in the lectures of the plenary sessions and the different sections an overview of the current state of the different areas of mathematical sciences and their applications, and to discuss specific problems of particular importance.

The order in which these two aims appear reveals the importance assigned to the personal relations between mathematicians (the joy that marked the social activity of the congress reflects also this desire). Hurwitz' address to the participants has become a symbol of the scientific and the human intentions of the congresses;

'May the inspiring force of personal communication rise during these days, providing plenty of occasions for scientific discussions. May we together enjoy the relaxed and cheerful comradeship, enhanced by the feeling that here representatives of many different countries feel united by the most ideal interests in peace and friendship.'

The scientific part of the congress was organized into four plenary lectures, by Henri Poincaré, Adolf Hurwitz, Giuseppe Peano and Felix Klein. Other lectures were organized into five scientific sections, viz.: Section I: Arithmetic and algebra; Section II: Analysis and function theory; Section III: Geometry; Section IV: Mechanics and mathematical physics; Section V: History and bibliography.

The congress was a success and the general feeling of the participants was expressed by Émile Picard at the closing banquet:

'*The success of our first meeting is a warrant for the future of the institutions just founded.*'

The idea of reuniting mathematicians from countries all around the world was exciting and full with expectations for future success. The following congresses were held in Paris in 1900, Heidelberg in 1904, Rome in 1908 and Cambridge in 1912.

The Paris 1900 Congress will be remembered by David Hilbert's renowned lecture (Who of us would not be glad to lift the veil behind which the future lies hidden. . .) where he presented 10 of the famous list of 23 problems with the intention of illuminating (and perhaps also determining) the future of mathematics in the 20th century. Let us point out that, among side issues, the congress recommended to '*study the proper means to remedy the harms coming from the increasing diversity of languages employed in the scientific literature*'.

The congresses of Heidelberg in 1904, Rome in 1908 and Cambridge in 1912 continued a similar path. A noteworthy difference was the more relevant role given to applied mathematics. In Heidelberg there was a superb exhibition of mathematical model and apparatus; in Rome there was a new section, on 'Various applications of mathematics'; in Cambridge a technological company, the Cambridge Scientific Instrument Company, was visited. All these congresses devoted time to honour past glories of mathematics: Jacobi in Heidelberg; Italian mathematicians of the Renascence in Rome and Cayley in Cambridge.

These congresses followed each other at an ever quickening pace. The scope, aims and goals of the congresses expanded; the number of mathematicians attending, the number of countries represented, the number of lectures delivered increased.

	Participants	Countries	Lectures	Communications
Zurich, 1897	208	16	4	30
Paris, 1900	250	26	4	33
Heidelberg, 1904	336	20	4	78
Rome, 1908	535	22	10	127
Cambridge, 1912	574	28	8	122

The general excitement and commitment to the idea of an international congress of mathematicians grew tremendously. All the expectations were fulfilled. At that moment, the future of the ICM as the wellspring of international cooperation in mathematics seemed sure and clear.

Crisis in the interwar period

The Great War of 1914–1918 and its aftermath had a tremendous impact on all aspects of social life; science was not immune to it. In the case of mathematics, the pressure from the 'outside world' was too strong and tainted the course of the congresses. The Allied Powers forced to overturned the decision adopted in Cambridge in 1912 to celebrate the next international congress in Stockholm. An option more along the lines of the Treaty of Versailles was taken: the congress was held in Strasbourg, capital of Alsace, a region just regained by France from Germany.

The Strasbourg Congress illustrates very well the difficulties and problems that occurred for the international mathematical cooperation in the period between the two World Wars. Although there were no scientific objections (the congress was presided over by Émile Picard and the Honorary President was Camille Jordan), the number of mathematicians attending was only 200. This is the least number of participants in the history of the ICM. What could have happened? Had the war crushed the enthusiasm of the pre-war ICMs? The explanation is the exclusion of mathematicians from the former Central Powers (Germany, the Austro-Hungarian Empire, Bulgaria and Turkey) imposed by the Allied Powers, who had the almost publicly declared objective of eliminating the preeminence that German science had in many fields.

This caused, as is described in the proceedings, the tone of the congress to be startling postwar. There were many differences with the previous congresses. In contrast with what had been previously done, the procedure for choosing the participants was not open:

'The Congress has been convened by not collective but individual invitations, sent by the own French national committee, who also centralized the proposals for lectures or communications.'

The traditional ceremony of deciding the venue of the next congress at the closing ceremony by open discussion did not take place this time. The decision, 1924 in New York and 1928 in Belgium, was taken some days before the congress started by an Allied supported scientific organization.

The peak of this harsh atmosphere came in the closing speeches, Émile Picard said:

'In respect to certain relations broken by the tragedy of these last years, our successors will determine if a sufficiently long lapse of time and a sincere repentance could allow them to resume some day, and if the ones who excluded themselves from the civilized nations deserve to reenter again. For us, too close to the events, still assume the fine words said by Cardinal Mercier during the war: to pardon certain crimes is to become accomplice with them.'

The celebration of the international congress had depended before on purely consensual grounds, but now was subjected to a high level of political interference. By 1922, it was clear that an international congress could not be organized in the United States excluding the mathematicians from the former Central Powers (take into account that US mathematicians still had strong links with the German academic world, and that the war had less dramatic effects in the US than in Europe). The continuity of the series of the ICM was in danger; it was saved by the offer of John Charles Fields to hold the international congress, not questioning the exclusion policy, in the University of Toronto. The photograph of Charles de la Vallée Poussin presenting a commemorative wreath at the foot of the Soldier's Memorial Tower of the University of Toronto as homage to the students of the university who laid down their lives in the war symbolizes the Toronto 1924 Congress. Fields was careful not to confront the exclusion policy openly but pointed out the need for its end. Indeed, he was careful to call the Congress as the International Mathematical Congress, avoiding the controversial issue of its character as a true international congress of (all) mathematicians, and hence whether or not it was one more in the series of previous ICMs.

Despite the unfavourable conditions, Fields was able to organize a successful congress, where participation rose to 444. As had happened in some of the previous congresses, there was a strong presence of the applications of mathematics. This can be seen in the list of sections: Section I: Algebra, number theory, analysis; Section II: Geometry; Section III (A): Mechanics, physics; Section III (B): Astronomy, geophysics; Section IV (A): Electrical, mechanical, civil and mining engineering; Section IV (B): Aeronautics, naval architecture, ballistics, radiotelegraphy; Section V: Statistics, actuarial science, economics; Section VI: History, philosophy, didactics.

This applied trend of the congress is also seen in list of participants (with participants from Eastman Kodak, General Electric, American Telephone and Telegraph, Marconi, from banks and insurance companies, and military personnel from the War Department of the United States and the French Ministries of War and Navy), and is also seen in one of the congress' excursions, as is explained in the proceedings of the Congress:

'The members of the Congress crossed to Niagara, where, on the invitation of the Hydro-Electric Power Commission of Ontario, they inspected the generating station at Queenston. They then proceeded to Niagara Falls, where they were entertained at Luncheon in the Clifton Inn as guests of the Power Commission. After viewing the Falls, and taking the trip along the Gorge Route, the party returned by boat to Toronto.'

The story has a happy ending. Mathematicians revolted against the exclusion policy, the will for collaboration overcame all difficulties, and the 1928 Congress, held in Bologna, was open to all mathematicians of the world. David Hilbert was a living incarnation of the spirit of cooperation of the ICMs. His entrance to the opening ceremony of the congress is legendary. Constance Reid in her book on Hilbert, recreates those emotive moments:

'For a few minutes there was not a sound in the hall. Then, spontaneously, every person present rose and applauded.'

Then, Hilbert spoke saying what still today symbolizes the universality of mathematics:

'It makes me very happy that after a long, hard time all the mathematicians of the world are represented here. That is as it should be and as it must be for the prosperity of our beloved science.'

The congresses of Bologna in 1928, Zurich in 1932 and Oslo in 1936 returned to the original spirit of the international congresses as conceived in Zurich in 1897. The only threat was the deep economic crisis that followed the Depression of 1929, which affected the congresses but did not stop them.

	Partici-pants	Count-ries	Lectures	Commu-nications
Strasbourg, 1920	200	27	5	79
Toronto, 1924	444	28	8	241
Bologna, 1928	836	36	14	419
Zurich, 1932	853	35	21	247
Oslo, 1936	487	36	19	205

The Fields Medal

One of the highlights of the 1932 Zurich Congress was the acceptance of the proposal of John Charles Fields to create an award for young mathematicians:

'The International Congress of Mathematicians held in Zurich accepts with thanks the offer made by the late professor Fields of two medals to be awarded to two mathematicians at intervals of four years by the International Congresses.'

Élie Cartan at the opening ceremony of the Oslo 1936 Congress inaugurated a new feature of the congresses' protocol, the awarding of the Fields Medals:

'The commission has come to this agreement of designating Mr. Lars Ahlfors from the University of Helsinki and Mr. Jesse Douglas from the Massachusetts Institute of Technology as the two first awardees of the Fields Medals.'

Creating an international award in recognition of 'Outstanding Achievements in Mathematics' was an idea of John Charles Fields, using the balance left over of the Toronto 1924 Congress. The medal is struck in gold by the Royal Canadian Mint; in the obverse side it shows the head of Archimedes, whereas the reverse side shows a sphere inscribed in a cylinder, following Plutarch's and Cicero's account of the drawing that Archimedes requested to be engraved over his tomb.

The most original of the clauses of the award which distinguishes the Fields Medal from other scientific awards is a peculiar prescription of the memorandum that Fields wrote when creating the award:

'In making the awards while it was in recognition of work already done it was at the same time intended to be an encouragement for further achievement on the part of the recipients.'

It was interpreted by the first Fields Committees that the award should be given to 'two young mathematicians'. The settlement of the age issue came in the 1966 International Congress held in Moscow where the tradition was specified and put into writing:

'On the basis of this text [Fields' memorandum], and following precedents, we confine our choice to candidates under forty.'

This rule has been applied strictly ever since. But, there are always cases which confront the rules. This occurred with the proof of Fermat's Last Theorem. Andrew Wiles had a complete proof right after the 1994 International Congress. The theorem, which had resisted solution from the most preeminent mathematicians for more than 350 years, had been finally proved. At the next congress, in Berlin in 1998, Wiles was 45 so he could not receive the Fields Medal.

The golden years

The invasion of Poland on 1 September 1939, by Hitler's Third Reich caused the outbreak of World War II and also the suspension of the international congress which was going to be held at Cambridge, Massachusetts, in September 1940. After the war, plans for the holding of the congress were resumed. A crucial issue was who could participate in the congress. Fortunately, memories of the disastrous aftermath of World War I were still present and prevented further errors of the same sort.

The first international congress after World War II was held at Harvard University. There was an effort to resume the traditions of previous congresses. Veblen in his presidential address explained that:

'We are approaching the end of another epoch. I mean the period during which North America has absorbed so many powerful mathematicians from all over the world that the indigenous traditions and tendencies of mathematical thought have been radically changed as well as enriched. These American gains have seemed to be at the cost of great losses to European mathematics. But there are so many signs of vitality in Europe that it is now possible to hope the losses will be only temporary while American gains will be permanent.'

The Fields Medals were awarded for the second time, 14 years after the first medals were awarded in Oslo, in this case to Laurent Schwartz (for the theory of distributions) and Atle Selberg (for his results on number theory). An interesting complement to the scientific programme of the Congress was the lecture on computing machines by Howard Aiken, the designer of the series of electromechanical devices known as the Harvard Mark computing machines.

The Congress was full of activities aimed at entertaining the participants. There were receptions at the Fog Art Museum of Harvard University, and in Wellesley College at tea; there was the choice of an informal dance in Lowell House or a beer party in Memorial Hall; the Congress banquet was held in the Sever Quadrangle; and there was a farewell party at Gardner Museum. The musical programme had also such an ample and diverse character that is worth mentioning a concert by the Busch

String Quartet in the Sanders Theatre; an organ recital in the Daniel L. Marsh Chapel of Boston University; a concert of ballads of various nations by the folk-singer and guitarist Richard Dyer-Bennet in the Sanders Theatre; and a concert by the soprano Helen Traubel in the Symphony Hall.

Amsterdam in 1954, Edinburgh in 1958 and Stockholm in 1962 were the subsequent international congresses. They displayed, as did the Cambridge 1950 Congress, a classical and magnificent style and laid out the foundations of the current international congresses.

Regarding participation, countries represented and lectures delivered, the figures were impressive, more than double of the highest figure from before World War II.

	Participants	Countries	Lectures	Communications
Cambridge, Mass., 1950	1700	40	22 + 20	374
Amsterdam, 1954	1553	51	20 + 42	496
Edinburgh, 1958	1658	–	19 + 37	604
Stockholm, 1962	2107	57	16 + 57	745

What about the Soviet participation in ICM during this period? Soviet mathematicians had been absent from the international congresses since 1932. There had been no answer from the Soviet Union to the first invitation to the 1950 Congress, and Kolmogorov did not participate in the deliberations of the Fields Medal Committee. However, just before the opening of the 1950 Congress, a cablegram from Moscow was received and read at the opening:

'*USSR Academy of Sciences appreciated receiving kind invitation for Soviet scientists take part in International Congress of Mathematicians to be held in Cambridge. Soviet Mathematicians being very much occupied with their regular work unable to attend the Congress. Hope that impending Congress will be significant event in mathematical science. Wish success in Congress activities.*'

This friendly message opened the hope for future attendance at the international congresses of mathematicians from behind the Iron Curtain. Stalin's death in 1953 surely facilitated these hopes coming true. In 1957 the Soviet Union, and other socialist European countries joined the International Mathematical Union and for the Edinburgh 1958 Congress, the Soviet delegation was the largest to date. Attendance from socialist countries to the Stockholm 1962 Congress was close to normal. Finally, Soviet attendance at the ICMs was normalized. The decision to hold the 1966 Congress in the Soviet Union was definite proof of the Soviet interest in the international congresses.

The Moscow Congress and beyond

The Moscow Congress of 1966 marked a turning point in the trajectory of the international congresses. There were several reason for this.

In the record breaking pace of ICM attendance, the Moscow Congress signifies a huge jump: there were around 4280 mathematicians attending (and almost 5600 pre-registered!). Attendance had doubled that of the Stockholm Congress, which was the highest to date, and it was twenty times that of the first congress in Zurich in 1897. (Among the thousands of participants, there was an unexpected one, holding registration number 4397: Nicolas Bourbaki. The question continuously circulating around the congress was: 'Has Bourbaki already arrived to Moscow?'.)

Apart from its size, the congress had an important impact which can be gauged by looking at the number of Soviet mathematicians who attended: 1470. For a scientific community which had been very much isolated since the 1930s, being able to meet, discuss and chat with over 2000 mathematicians from the West was quite an important occasion.

The congress marked the guidelines for the scientific programme of today's ICMs. For the first time four, instead of two, Fields Medals were awarded (to Atiyah, Cohen, Grothendieck and Smale); there were 17 plenary addresses (of which five by US mathematicians and five by Soviet mathematicians); there were 64 invited addresses related to the sections; the list of sections was refined and expanded (find in brackets the number of invited addresses within each section): Mathematical logic and foundations of mathematics (2); Algebra (4); Theory of numbers (2); Classical analysis (5); Functional analysis (3); Ordinary differential equations (3); Partial differential equations (4); Topology (4); Geometry (1); Algebraic geometry and complex manifolds (7); Probability theory and statistics (2); Applied mathematics and mathematical physics (4); Mathematical problems of control theory (3); Numerical mathematics (4); History and pedagogical questions (1).

The congress made newspaper headlines; not for matters of a scientific nature but for political matters. First, because Grothendieck's refusal to attend the congress where he was going to be awarded the Fields Medal; second, because of the so-called Smale incident. Smale was under scrutiny in the US because of his activities against the Vietnam War. At the request of a North Vietnamese reporter, Smale gave a press conference on the steps of Moscow University where he said:

'I believe the American Military Intervention in Vietnam is horrible and becomes more horrible every day. I have great sympathy for the victims of this intervention, the Vietnamese people. However, in Moscow today, one cannot help but remember that it was only 10 years ago that

Russian troops were brutally intervening in Hungary and that many courageous Hungarians died fighting for their independence.'

Next, as in a John Le Carre's novel, he was led into a car accompanied by two Soviet individuals; the car drove off at high speed and disappeared. He was returned some time later, after having toured through the Moscow museums!

The large scale contact between mathematical communities which had been previously separated was one of the most valuable achievements of the congress. The atmosphere was casual and friendly (there was a soccer game, the USSR team against the rest of the World; the USSR won 5 to 2). However, with this congress it began a period in which the ICMs again suffered from international tension, in this case through the Cold War.

The 1970 Congress was held in Nice; it exhibited a peculiar scientific programme, grounded in Bourbaki's viewpoint of the architecture of mathematics. Vancouver's Congress in 1974 will be remembered for the awarding of only two Fields Medals (to Bombieri and Mumford) and its unique hippie atmosphere. Helsinki in 1978 held a massive but perfectly organized congress. The Warsaw 1982 Congress had to be postponed due to the martial law decreed in Poland by General Jaruzelski. It was finally held in 1983 under difficult conditions; it hosted the first awarding of the Nevanlinna Medal for 'Mathematical Aspects of Information Sciences'. The Berkeley Congress in 1986 ended the series of ICM of this period where the Cold War tension marked attendance figures, lists of plenary speakers and even Fields Medals (Novikov in 1970 and Margulis in 1978 could not receive their awards at the ICM).

The ICM in the global world

By the end of the 20th century, new features appear in the ICM marking the starting point of a new era for international cooperation in mathematics. First, the ICM opened to the East: in 1990 the congress took place in Kyoto, Japan; in 2002 in Beijing, China and in 2010 in Hyderabad, India. This shows that mathematics exhibits a similar behaviour as the rest of the world activities: an increasing weight of the East. Secondly, after the isolated case of Emmy Noether, who gave a plenary talk at the Zurich ICM in 1932, women were present in the ICMs as plenary speakers; the first were Karen Uhlenbeck in Kyoto in 1990, and Ingrid Daubechies and Marina Ratner in Zurich in 1994. Thirdly, with the surplus of the Berlin 1998 Congress, a new international award was established: the Gauss Prize, aimed at highlighting the role of the applications of mathematics; it was awarded for the first time in the Madrid 2006 Congress. The Madrid 2006 Congress will also be remembered by the refusal of Grigori Perelman to accept the Fields Medal that he was awarded for the final solution of Poincaré's conjecture.

Coda: the future of the ICM

It is instructive to consider the opinion of relevant mathematicians on the future of the ICM. William V. D. Hodge, at the closing of the Edinburgh 1958 International Congress, said:

'Through the choice of the invited speakers and through the large number of communications of other members the congress has presented a picture of mathematics today and its trends. But the international congresses have another purpose, which I believe is just as important, that of promoting fellowship between mathematicians of all countries. This fellowship has its roots in our common love for our science, to whose growth we all try to contribute. It is the responsibility of each generation to take care that this fellowship is maintained and strengthened, and extended to the new generation.'

Lennart Carleson, in the Foreword of the book *Mathematicians of the World, Unite!*, wrote:

'The ICM, however, still provide the unique possibility for the young to see to-day's icons, to learn and respect other areas of the fields than their own specialty. We often talk about the unity of mathematics and the ICM give us the possibility to get new impulses from areas that we otherwise don't see.'

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