

ICM 2022: The first virtual ICM

Background and reflections

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The first ever virtual International Congress of Mathematicians (ICM) took place over 6–14 July 2022. It is without doubt unique in the series of ICMs thus far. I would therefore like to describe what happened, and – with the benefit of several months having passed since the event – add some reflections.

Let me first set out the background to the ICM. The ICM is the flagship event of the IMU, dating back to 1897, which represents a showcase of the best of contemporary mathematics by many of the best mathematicians worldwide. At the opening ceremony, some of the most coveted prizes in mathematics are awarded, most notably the Fields Medals. The format has developed over a long time into a particular structure, with over 200 invited lectures organized across roughly 20 sections. The sections run in parallel. In addition, the program includes about 20 plenary lectures and a number of prize lectures. The invitation to give an ICM lecture is itself considered a distinction. The selection of speakers is of course merit based, but the pool of suitable candidates is relatively broad, meaning that – in addition to the circa 200 happy invitees – there are many more who might expect to be invited but are disappointed



Fields Medalist Maryna Viazovska

Photo: Jussi Rekiaro/Unigrafia

Courtesy: International Mathematical Union

in the end. The responsibility for the selection of speakers rests with the Program Committee (PC), where the chair, appointed by the IMU President, is the only publicly known committee member until the opening of the ICM. The composition of the PC is decided by the IMU Executive Committee (IMU EC), and it has become increasingly important that its membership reflects the full diversity of the global mathematical community (gender, geography, area, age, etc.). It is a fact that the format of the ICM has remained rather static over the years. Indeed, it is not easy to identify natural subdisciplines of mathematics. Furthermore, the use of mathematics has spread into most other sciences, and in many cases, in non-trivial ways. In addition, we have the important areas of mathematics education and the history of mathematics. Thus, it is a very difficult task to find the right way to define what should properly be considered as part of an ICM.

To address this problem, the 18th General Assembly (GA) in 2018 introduced the ICM Structure Committee, charged with the task of considering the structure of the ICM, and suggesting natural sections of mathematical subdisciplines and their relative sizes. There is a natural fluctuation in mathematical disciplines – new areas are introduced, other areas suffer a decline in interest, while some areas blossom. A task for the Structure Committee is to assess these developments, and suggest relevant changes. In addition, the Structure Committee can propose other activities as an integral part of the scientific program. The final decision about the structure of the scientific program is then taken by the IMU EC. For ICM 2022, the Structure Committee suggested 19 sections, each with a target number of lectures. In addition, the Structure Committee proposed introducing “Special Plenary Lectures” on assigned topics. The Program Committee made a call for possible topics on *MathOverflow*, which received a massive response. After further discussions, the PC decided on one lecture on formal proof verification, another on gravitational waves, and, finally, one on developments following the proof by Taylor and Wiles of Fermat’s Last Theorem. Furthermore, about 20 lectures were designated as special sectional talks, which were very well received by the community. Topics include “Lecture on the Ricci flow after Perelman”, “Survey lecture on billiards”, and “Survey lecture on motivic cohomology”, to mention but a few.



The General Assembly in Helsinki
 Photo: Rajupaja Oy | Courtesy: International Mathematical Union

The Program Committee is then left with the task of selecting speakers for the given scientific program. Sectional talks can be shared, and fractions of talks can be assigned to different sections. With the program complete and the speakers selected and invited, mathematicians from all countries around the world can assemble at the chosen venue of the ICM, meeting with friends and colleagues, as well as listening to interesting and stimulating talks during a fully packed nine-day congress. Another nice feature of the ICM is that several countries host receptions in the evenings. However, for reasons well known to all, this year turned out to be different.

The 18th General Assembly in 2018 decided to award ICM 2022 and the 19th General Assembly to Russia with Saint Petersburg as the venue. The concrete planning of the congress started with full speed on the Russian side immediately after this decision. Similarly, the ICM and GA were discussed in depth by the IMU EC at every one of its annual meetings, with further discussions held between meetings as necessary. The collaboration with the Russian organizers went well, and as it should. This happened against a backdrop of the COVID-19 pandemic, which at any given moment threatened to overturn all plans by, e.g., imposing severe travel restrictions or disallowing indoor meetings with large audiences.

However, with the aggressive Russian invasion of Ukraine on 24 February 2022, it was clear the we could not proceed with the GA and the ICM in Saint Petersburg. By coincidence, the IMU EC had its scheduled annual meeting starting 24 February. Following discussions, the IMU EC unanimously issued the following public statements:

- The General Assembly will be organized outside Russia on 3–4 July.

- The ICM will be organized as a fully virtual congress on 6–14 July.
- There will be an IMU Award Ceremony outside Russia on 5 July.
- The ICM will be open to all participants.
- The General Assembly and the ICM will be conducted without any financial contribution from the Russian Government.
- No official or representative of the Russian Government will be part of the organization or activities of the ICM.

At that point, there were no additional financial or human resources available to us, and we only had four months to plan and execute our decisions. For the ICM we contacted several providers of platforms that could host a virtual ICM. Fortunately, the pandemic has resulted in a rapid development of the technology and a surge in the number of high-level providers. After some consultation, we contracted the services of the K.I.T. Group, whose platform would allow for 7,000 participants¹ – twice the number of participants of any previous ICM – and the possibility of Q&A sessions with speakers. All lectures would be recorded and uploaded on the IMU YouTube channel afterwards for posterity. Participation would be free of charge and open to all. We were able to secure generous partial funding from the Klaus Tschira Foundation for the financial outlay of the virtual platform.

We decided to organize a compact and tight ICM, with lectures from morning until evening over 6–14 July according to the CEST

¹ Server capacity scales with the number of participants, and so does the financial cost. While the platform could provide a higher number of participants, we capped the number at 7,000 for budgetary reasons.



Delegates and guests attending the 2022 General Assembly
 Photo: International Mathematical Union

time zone, based largely on the schedule from the planned ICM in Saint Petersburg.

Next was the task of finding a host for the in-person GA. We received many generous offers from our member states, and we also solicited a number of offers ourselves. After carefully reviewing several options, we accepted the generous offer from the Council of Finnish Academies to host the GA in Helsinki, Finland. With its historical and important position between East and West, we found Helsinki² to be the ideal venue.

Regular invitations to all member states were sent out, and the IMU offered full coverage of accommodation expenses for all delegates. In addition, we offered to cover the travel expenses of one delegate from each member. Thus, the GA represents a substantial burden on the IMU budget. We were uncertain if delegates would be willing to attend the meeting in person – the pandemic having had a strong impact on all of us³ – but thankfully, a very high number of delegates registered for in-person attendance. During the previous winter, we had thoroughly tested a system for electronic voting that we were prepared to use in case we had to go for a fully virtual GA. While a few delegates could not travel in the end – having tested positive prior to their departure to Helsinki – and a number preferred to attend virtually, at the opening we

had around 165 persons on site, with a further 30 participating remotely. The GA went very smoothly, and the electronic voting system worked without a hitch with voting delegates both present in Helsinki and participating remotely.

As usual, many important decisions are taken by the GA – budgets are decided, important elections are carried out, and delegates hear reports about the various activities of the IMU and its commissions and committees. We will not report on the outcome of the elections here, but rather focus on some other important decisions.

The IMU Statutes have essentially remained unchanged since the resurrection of the IMU after World War II. Recently, there has been an increase in the interest in and focus on the freedom of science. The IMU has been a member of the International Science Council (ISC)⁴ since its inception, and through that, subscribes to the ISC's mission to "Defend the free and responsible practice of science". In Article 7 of the ISC Statutes, the ISC clearly outlines its aim to support the principle of freedom and responsibility in science. The GA expressed the view that an amendment to the IMU Statutes to incorporate this aim would underscore its importance to the mathematical community. Thus, the GA unanimously added a new Article 3 which reads:

The Union adheres to the International Science Council's principle of embodying the free and responsible practice of science, freedom of movement, association, expression and communication for scientists, as well as equitable opportunities for access to science, its production and benefits,

⁴ Including its predecessors, the International Council of Scientific Unions (ICSU) and the International Research Council (IRC).

² Helsinki is of course also historically relevant to the IMU, having previously hosted the ICM in 1978 and housed the IMU Archive until it was moved to its present location at the IMU Secretariat in Berlin in 2011.

³ In many countries the pandemic was still rather prevalent, not to mention the increased risk of infection through travel and attendance at large-scale meetings. On top of that, Europe was experiencing significant problems with air traffic at the time.

access to data, information and research material; and actively upholds this principle, by opposing any discrimination on the basis of such factors as ethnic origin, religion, citizenship, language, political or other opinion, gender, gender identity and sexual orientation, disability or age.⁵

The GA also passed a resolution expressing support for all mathematicians affected by the war in Ukraine, and in particular the IMU calls upon its members and other scientific organizations to do everything they can to assist Ukrainian colleagues in these difficult times.

Given the dire situation in Ukraine, the GA was asked to waive Ukraine's membership dues for two years by the Ukraine delegation. The GA resolved to waive the dues in case these were not settled by a third party. In the end, many member states generously offered to support Ukraine directly by paying the relevant dues. Moreover, since several members encounter temporary problems in paying their IMU membership dues, the GA decided in addition to create a more universal way to assist countries in dire situations. The GA decided to introduce the IMU Reserve Fund, with the task of assisting member states experiencing a temporary adverse situation outside their control that makes it impossible for them to cover their IMU dues. The reasons can be varied, e.g., deterioration of the financial situation in a country, hyperinflation, collapse of government, various natural catastrophes, and civil unrest or military conflict. In addition, some countries are subject to international sanctions that prohibit international money transfers. The IMU EC was charged with the task of writing precise regulations, and these have now been distributed to IMU members.

The IMU received one bid for the ICM in 2026 from the US delegation. The GA enthusiastically supported the bid and the next ICM will be held over

22–29 July 2026 in Philadelphia, USA

preceded by the 20th General Assembly on

19–20 July 2026 in New York City, USA.

On 5 July, the day between the end of the GA and the opening of the virtual ICM, the IMU decided to host the first ever IMU Award Ceremony. In the magnificent Aula of Aalto University, Mr Sauli Niinistö, the President of Finland, welcomed an enthusiastic and fully-packed audience. Here the four Fields Medalists, Hugo Duminil-Copin, June Huh, James Maynard, and Maryna Viazovska, received their gold medals. Appropriately, the first IMU Abacus Medal, partly sponsored by the University of Helsinki, was presented to Mark Braverman. The Leelavati Prize was awarded to Nikolai Andreev. In addition, the Gauss Prize and the Chern Medal were awarded to Elliott H. Lieb and Barry Mazur, respectively, both of whom participated remotely. In addition to the prize ceremony itself, we watched

superb short videos on the laureates, and a separate laudatio was given for each recipient on their excellent accomplishment.

On the first day of the ICM on 6 July, proceedings were opened by IMU President Carlos E. Kenig in the old lecture hall of Aalto University. Following this, each of the Fields Medalists and the IMU Abacus Medalists delivered their live prize lectures. The whole event was streamed live and freely accessible worldwide. After the first day, the ICM switched to a fully virtual mode. Every speaker had been given the option of either delivering a live talk (with a recorded back-up), or providing a prerecorded lecture. In many ways, we were utilizing the know-how garnered during the pandemic. Indeed, we have all learned a lot from two years of remote lecturing! Overall, our experience from attending many lectures is that speakers often put in extra effort to give a livelier talk in front of an audience, so this was a welcome element wherever possible, and there were in fact several such efforts coordinated and facilitated by the ICM Satellite Coordination Group.

However, in the last few days before the virtual ICM launched, the K.I.T. Group encountered serious technical problems, which necessitated the restructuring of the format for the virtual ICM at very short notice. This was an exceptionally stressful period for all involved. To cut a long story short, we ended up with a simplified platform that posted all talks on the IMU YouTube channel but eliminated the possibility of a Q&A with the lecturers. This was of course disappointing, but the upside was that, in this format, no registration was necessary, and thus the ICM was truly open to all.

Circumstances outside our control forced us to organize the ICM as a fully virtual event. On the positive side, this gave the IMU the chance to test a dramatic change in the format of an ICM. Some elements of the virtual ICM represented a big step forward – to



The 2022 Fields Medalists (left to right) Maryna Viazovska, James Maynard, June Huh, and Hugo Duminil-Copin
Photo: Jussi Rekiaro/Unigrafia
Courtesy: International Mathematical Union

⁵ Other unions have similarly adopted such a text, see, e.g., the International Union of Psychological Science, from whose statutes the text for the IMU's new Article 3 is taken.



The 2022 IMU Award Ceremony in Helsinki
Photo: Jussi Rekiaro/Unigrafia | Courtesy: International Mathematical Union

make all lectures freely available to all shortly after the lectures were given, was clearly exceptionally well received by the community – and more than 500,000 have watched the videos to date. It is clear that this is of lasting value and will be an integral part of future ICMs. Unfortunately, as explained, we were not able to test the possibility of having a remote Q&A with the speakers for technical reasons. At a regular ICM, there are normally few questions, but the virtual format may well invite more questions and direct participation. Finally, regarding participants, for financial reasons we had capped the number at 7,000, but registration was free of charge. The latter was decided for two reasons, one being that truly anyone could participate in this way, and the other being the fact that collecting a small amount from thousands of participants worldwide would be expensive and difficult. However, making the event free of charge does have its drawbacks – signing up thereby has no consequences, and one might feel less committed to participating. With a cap on participants, this could easily mean sacrificing valuable places that could otherwise be made available to those interested in participating.

But one aspect of the Congress that no virtual ICM can replace is the human one – the happy encounter with old friends and colleagues, and the possibility of sharing a dinner and exchanging views on the latest developments in mathematics. The importance and value of this cannot be overestimated. Yet the question of how to best reconcile this in the future with the natural temptation to watch a lecture from your favorite spot at home – especially given the hassles and environmental concerns around modern

travel – remains unanswered. Perhaps a happy middle ground can be found? We shall see!

Acknowledgements. The author is very grateful to the IMU Manager Scott Jung for extensive help and improvements in this text. The above recollections are mine and do not necessarily represent those of the IMU.

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