

Report of the External Review of the Research Institute for Mathematical Sciences Kyoto University

February 2018
submitted on behalf of the Review Committee
by its Chair Jean-Pierre BOURGUIGNON

Introduction

The Research Institute for Mathematical Sciences (RIMS) is a research institution well known throughout the world as a major infrastructure for mathematics.

It was founded in 1963 with the purpose of developing a global research facility for mathematics in Japan with an international dimension in line with the position occupied by the country in mathematics worldwide.

RIMS has now a triple mission: conducting research in the mathematical Sciences at the highest possible level; training graduate students and offering a stimulating environment for postdoctoral fellows; hosting regular weekly workshop in all areas of mathematics.

RIMS' structure has evolved over time. Due to the new organisation of higher education and research in Japan, it is now a division of Kyoto University located on the main campus.

At the initiative of Professor Michio YAMADA, Director of RIMS, a Review Committee, whose composition is detailed in Appendix A, was commissioned with the duty of assessing the performance of the Institute taking its remit as a basis, identifying the current challenges faced by the Institute. The Committee also tried to foresee how the Institute can contribute to enhancing new developments of mathematics. In recent years approaches involving advanced mathematics have proved relevant in more and more domains of importance to society, from the many developments of artificial intelligence to the new horizons of personalised medicine.

The management of the Institute produced an 81-page self-evaluation document containing detailed information on many aspects of the Institute's life: structure, scientific personnel and staff, financing, events organised at RIMS, etc. Members of the Review Committee members received it before their visit.

The agenda of the visit by the Review Committee is given in Appendix B. Being on site, the members of the Review Committee were able to interact with the Director and the Deputy Director, as well as with a number of mathematicians present at RIMS, to get a better idea of the present situation of the facilities. Members of the Committee prepared a first draft of the report while in Kyoto. They were received by Professor Nagahiro MINATO, Provost of the University of Kyoto, just before finishing the visit as described in Appendix B.

The members of the Review Committee want to thank Professor Michio YAMADA and Professor Takashi KUMAGAI for their warm hospitality and for providing all the information requested by the Review Committee, and also the Institute's staff for its support, and in particular Ms Fumiko ONITSUKA for the remarkable care she took of the members of the Review Committee.

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Executive Summary

A. General Comment

In recent years, more than ever, research in mathematics has shown its relevance to a broad spectrum of issues, some scientific with new interactions with the Physical Sciences, the Life Sciences and in particular with Medicine, and some in direct contact with societal issues through the generalised use of “big data” and machine learning in a number of economically significant activities.

One should not be led to believe that this was possible just through routine applications of long-established mathematics that one can take off the shelf. To the contrary, it is striking to see how the most abstract branches of fundamental mathematics, resulting from a purely curiosity-driven process, impact a number of recent developments in a completely unpredictable way. This leads to transforming society as a whole and gives an enhanced value both to mathematical knowledge, in particular to recently developed theories, and to people with a solid mathematical training.

B. Findings

1. Research conducted at RIMS cover several of the most active branches of mathematics, and has even broadened further in recent years. Professors at RIMS are leaders in their fields and recent appointments have strengthened further the Institute. RIMS remains a key asset for Japanese mathematical research.
2. RIMS continues to enjoy a high international recognition and this can be used as the basis for further steps in the internationalisation efforts presently made in Japan in higher education and research.
3. The recruitment of graduate students at RIMS remains selective, especially at the doctoral level. They seem conscious of the high level environment they are exposed to. RIMS also hosts a number of post-docs, some international. To attract more international students would require finding a solution to their funding problem.
4. RIMS operates as a Joint Usage/Research Centre (JU/RC) for the organisation of numerous workshops which are increasingly international. This action, which takes considerable resources, is very much appreciated by the Japanese mathematical community.
5. The 10-year tenure given to assistant professors now in place at RIMS guarantees a flow of junior appointments, which is a very valuable asset. Nonetheless, the Committee noticed that about half of people recruited were already at Kyoto University.
6. The office facilities at the disposal of RIMS remain very inadequate by lack of space and fragmentation. This is unfortunately a long standing problem which, because of its impact on the development of the Institute, was already considered to be a serious impediment in previous evaluation reports.
7. The administrative and technical staff working at RIMS are competent and efficient, and their service is highly valued by the mathematicians at the Institute and visitors.

C. Recommendations

1. Kyoto University bidding for a new building for RIMS should be reactivated. In the mean time, rationalising the space made available to RIMS to reduce fragmentation between different sites should be addressed as a matter of urgency.
2. RIMS should seek new avenues of funding to support its international mission on the basis of the know how it has accumulated.
3. In its effort for internationalisation, RIMS should bid also for the organisation of international conferences.
4. RIMS should continue to pursue intensively its international search for very high potential mathematicians when posts are vacant.
5. It is advisable for RIMS to continue the diversification of topics, gender and origins represented in its faculty.

I. Assessment of the Remits of RIMS

1.1 RIMS as International Centre

RIMS has functioned for many decades as a successful centre for international collaboration, and in recent years hosts around 300 foreign visitors each year. Many science centres across Japan benefit from RIMS' international visitor programme, and RIMS' track record could serve as an outstanding model for building up the internationalisation of Japanese science. We believe that it is highly desirable that RIMS is included in the International JUCR programme that is currently in planning.

In addition to numerous international mathematicians coming to Japan for one-off activities of RIMS or of its JU/RC, RIMS together with the Mathematics Department of the Kyoto Graduate School of Science has led Kyoto University's government-funded Japan Gateway project KTGU (Kyoto University Top Global Programme) since 2014.

Within this project, RIMS has hosted more than 20 extended visits by world leading researchers. As Distinguished Visiting Professors of Kyoto University, these have taught intensive high-level lecture courses, supervised and collaborated with Kyoto graduate students, and helped them make return visits to universities in the USA, Germany, the UK, and elsewhere.

Around 20 students have benefitted from this exposure every year since 2014. Thanks to this programme, many students have completed their PhDs, and several of them have published in prestigious journals. This is just the initial segment of what promises to be a very successful programme.

1.2 Research conducted at RIMS

RIMS' twelve Professors are among the best mathematicians in Japan, and each is world-leading in their field. Four Japanese prizes for outstanding work have been awarded to some of them each year in the period 2014–2016, and close to 10 Japanese and international prizes in 2017. The ten Associate Professors and three Lecturers, while at a more junior level, are nevertheless prominent mathematicians with a strong track record in research and excellent future career prospects. RIMS also has a number of Assistant Professors, mostly on 7 year contracts, who are doing serious work. These are joined by a considerable population of postdocs, both Japanese and some international. The RIMS mathematicians teach a population of around 30 MSc and PhD students, providing them with a vibrant and creative environment.

RIMS researchers publish on average around 80 papers per year, more than half of which are joint with a foreign co-author. Many of these are published in top quality journals (in 2017, about one third appeared in top 10% journals).

The RIMS researchers cover a wide spectrum of modern mathematics. These include traditional strengths in algebraic geometry, representation theory and number theory, but also areas of analysis, differential geometry, symplectic geometry, topology, operator algebras, probability, fluid dynamics, discrete mathematics, logic and computer science, theoretical physics and Quantum Field Theory.

We should possibly make particular mention of the research of Shinichi MOCHIZUKI, which has achieved a lot of attention around the world. While off-beat, this is a wide-ranging and imaginative programme of study, components of which are currently providing PhD problems for a number of graduate students. If successful, it will have a large impact on the development of number theory and related areas of geometry.

As reported by several of the researchers we interviewed, including Shinichi MOCHIZUKI himself, a great virtue of RIMS is that it is able to give the time and freedom for them to follow their own research path.

1.3 Graduate Training Programme

A second remit of RIMS is to act as a graduate school, training students to the Master's or Doctoral level. Around twenty students are currently registered in the Master's programme, and more than 40 graduated with Master's degrees in the years 2012 – 2016. The RIMS PhD programme currently has 21 students among which 3 students from abroad. A total of 19 students graduated with PhDs in the years 2012–2016, and a similar number is currently in the pipeline.

It would of course be extremely desirable to find some source of funding to some of these students. In particular, advertising scholarships to students from neighbouring countries would raise the international profile of the RIMS graduate school and of the Kyoto University Mathematics Department. It would put their outstanding expertise in research and graduate training to work and contribute to the objective of internationalisation of Japan science. The RIMS Graduate School must put itself in a position to expand.

It is to be noted that very few of the students are female. Having more international students could help address this extreme situation.

1.4 Cooperative Research Institute

As a service to all Japanese mathematicians RIMS runs about 80 activities per year on a variety of research topics. These are funded primarily by a government initiative called Joint Usage Research Centre (JU/RC), that is currently in its second funding round lasting 6 years from 2016. They break down into large scale RIMS projects (usually lasting 6 months or one year), that have run since 1991, symposia and workshops (usually lasting one week), and "Camp-style seminars" that are closed meetings held usually outside Kyoto University. These activities play an important role for Japanese researchers across the country and are extremely appreciated as an opportunity to hear and communicate new research results, and to keep in touch with specialists in their subject. They attract in total around 4000 participants every year, including around 400 from abroad, a proportion which is slowly growing. The track record of running these series of conferences puts RIMS in a strong position to run further international activities within the scope of the forthcoming International JU/RC programmes that are expected to be announced soon, and for which RIMS would be a natural candidate.

RIMS hosts around 300 visits by foreign mathematicians every year, around 20 of whom stay for longer than one month and 2 or 3 stay from six months up to one year.

2. Facilities and Resources

2.1 Facilities

Getting more space has been an urgent issue for RIMS for many years. With its three missions RIMS needs lecture halls, offices for faculty, short and long term visitors, postdoctoral fellows and Ph.D. students. It also needs seminar rooms, and meeting/discussion rooms. The first problem is the total area of the available rooms, which is quite insufficient.

The Review Committee found members of RIMS happy with their research environment from many points of view, but heard complaints about the shortage of space: small discussion spaces, seminar rooms for young researchers in particular, to facilitate interaction with each other. For mathematical research, face-to-face discussions are of paramount importance. Offices for long term visitors are also in need. Since RIMS has established its renown in the international community, a number of mathematicians around the world would like to visit it. Due to the shortage of space, some of them had to be turned down even when there is budget to invite visitors.

A second problem is that RIMS offices are presently split into four distinct buildings, some at considerable distances from the others. This is very inconvenient, and causes a fragmentation of RIMS' cohesion. It reduces opportunities for members and visitors to meet and discuss outside their own research groups, which is of essential importance to produce unexpected encounters of knowledge and ideas. Such an inappropriate situation tends to cause isolation of researchers, and postdoctoral fellows.

2.2 Administrative Staff

The administrative and technical staff of RIMS are efficient and helpful. Through the JU/RC activities (hosting numerous workshops) together with many other activities, RIMS takes care of around 4000 participants and more than 300 foreign visitors each year. The staff need to coordinate the schedules of parallel conferences, prepare for visas and travel and housing for foreign visitors, and process the large volume of paperwork corresponding to all the services rendered. In addition the IT staff need to maintain the computer system and organise computer access for visitors. The support of the administrative staff is indispensable to maintain the RIMS reputation and to provide an excellent research environment to all. The good quality support is appreciated highly by not only faculty members but also visitors.

2.3 Financial Resources

The budget of RIMS is fairly stable as compared with other institutes/universities in Japan. The source of revenue consists of three items: Kyoto University money, JU/RC funds, and competitive external grants (Grant-in-aid of JSPS) won by individual members. The budget of national universities has been continuously reduced by the government by 1% annually for more than 10 years. Kyoto University has reduced the budget and the number of academic members of RIMS accordingly. The budget for JU/RC is stable but not adequate; the deficit is covered by RIMS's management money. A further problem is that, after 2014, a substantial part of the JU/RC funds

became open to competition. RIMS has to organise its programme of meetings before the outcome of the competition is known, and, though RIMS has had a high success rate so far, some skilful management is needed to reduce the financial risks. A strategy to use indirect income should be introduced because the Japanese government started discussing how the indirect income of various competitive funds can be used efficiently.

Considering the role RIMS could have in challenging the frontier of mathematics and open new research areas, in view of the severe constraint of the imposed decrease of the number of faculty, a clear vision must be introduced in order to keep the research highly dynamic with a long view, although the current members are of outstanding scientific quality.

2.4 Computing Facilities

Most researchers at RIMS have relatively modest computing needs, which are met by desktop and laptop computers purchased using the individual researchers' Grants-in-Aid. However, some groups, such as the numerical analysis group, have much greater needs; some of these are supplied by a vector processor in the RIMS basement, and in addition RIMS researchers have access to university supercomputing facilities. RIMS also has a terminal room for the use of visitors and students. While researchers usually purchase their own computers, these need software updates, and network connections. The visitors laptops also need to be connected to the RIMS network. Thus RIMS needs versatile computer support staff; from what we were told, it is clear that the current staff are efficient and helpful.

2.5 Library and Publications

The library of RIMS is an important national resource, since many smaller universities do not subscribe to a full range of journals. The escalation in prices of electronic journals can no longer be addressed by an individual university but should be achieved nationwide. RIMS may take the leadership for such an action.

RIMS also supports research by its publication activities. It issues three kinds of publications. The first of these is the journal "Publications of the Research Institute for Mathematical Sciences", founded in 1964. From 2010 on, this journal has been published by the European Mathematical Society, and is available on-line as well as in printed form.

Next is the series *Kôkyûroku*, mainly proceedings of the various conferences supported by RIMS. These are now published online, but a small number (about 6 per year) are selected to be printed as part of the "RIMS *Kôkyûroku Bessatsu*" series; papers in volumes of this series are refereed.

3. Helping RIMS to grow internationally / Challenges for the future

3.1 Research

As reported above, the general level of research at RIMS is very high. The key factor is making sure that RIMS continues to appoint outstanding researchers to its positions. In general, professors are appointed following an informal search, while positions at the associate professor, lecturer and assistant professor levels are advertised with an open search.

While the three senior grades are all tenured, assistant professors are appointed for a period of 7+3 years. Some members of the Review Committee think that a shorter period might be more beneficial for the career development of the assistant professors at RIMS, and allow more young researchers to benefit from the opportunity of an extended period at RIMS.

About half of the junior researchers at RIMS are from Kyoto University. In part this is the result of the very high level of the graduate school in Kyoto, but the Review Committee considers it important that RIMS' new appointments be made on the basis of an open and wide search.

All the researchers we spoke with were very pleased with their position at RIMS, and had few or no issues in terms of their research being impeded by lack of resources except more possibilities of meeting people through less dispersed offices.

3.2 Graduate and Postgraduate centre

It is a continuing challenge for RIMS to attract strong graduate students. Undergraduates in Japan tend to continue for graduate study at the same University, so there is little circulation of students between Japanese universities. As RIMS researchers do not usually teach, they do not have this standard avenue to recruit students; it requires an individual initiative on the part of researchers.

As far as international students are concerned, there is an additional structural problem due to the mechanism of graduate student funding in Japan. Many of the international competitors to Kyoto/RIMS (e.g. in the USA or UK) offer graduate students a full financial support package, either via a scholarship or via a teaching assistant type position. In contrast most international graduate students in Japan will need to be supported by their families. It is not easy for RIMS to deal with this problem on its own. In the longer run the possibility of seeking alternative sources of funds to support international students at RIMS should be investigated, and avenues for that purpose explored.

In order to enhance the student experience at RIMS, we see room for more joint seminars with the Mathematics Department at the University of Kyoto. In addition, we would like to see more networking between students, and recommend that they be encouraged to run their own seminars to create opportunities to learn from the work of others.

RIMS is an attractive place for postdocs, but shortage of positions provides an obstacle for growth in this direction. RIMS does have a small number of its own post-doctoral fellow positions, for which competition is very intense. In addition RIMS can attract a number of postdocs with JSPS funding, as well as some funded from International sources.

Some past programmes, such as the GCOE programme, provided funds for postdocs, but the Kyoto University Top Global Programme (KTGU) does not provide such funds.

It would be beneficial for RIMS to secure more funding for post-doctoral fellows, in particular to diversify their profiles and to make it easier for international researchers to apply and spend time at RIMS.

3.3. Workshops and Conferences

As a Joint Usage/Research Centre (JU/RC) RIMS runs regular weekly workshops. About 1/4 of the meetings are International in character, similar to those at BIRS in Canada, CIRM in Luminy, France, or the Mathematisches Forschungsinstitut in Oberwolfach, Germany. The remaining 3/4 of these workshops are 'domestic', that is intended for researchers in Japan. These workshops are very much valued by the Japanese mathematical community, and are particularly useful for researchers at smaller Japanese universities. In many cases the talks are in Japanese, so these meetings may be rather inaccessible to international researchers.

In spite of these difficulties, we would consider it valuable to attempt to include an international component to these workshops. Whether domestic or international, this kind of meeting is one of the most valuable resource for research in the mathematical sciences, since it allows experts in a particular area to really focus on their research topic and exchange with other experts.

The proportion of international researchers at these meetings has been increasing in the last few years; it rose by about 22% from 2012 to 2016. We encourage the organisers of the JU/RC programme to continue to support this trend.

3.4 National and International Networking, and International Visitors

RIMS has agreements with other research institutes, in Japan and also internationally. These include agreements with institutes in Canada, Italy, Germany, Korea and Pakistan. These agreements may facilitate visits by researchers. We would encourage RIMS to continue to explore possibilities here, and in particular to look for further links with research institutes in Asian countries; in many of these the research strength is growing rapidly.

RIMS currently has 3 Visiting Professor positions, which are used to attract strong international researchers to RIMS for periods of 3 to 12 months. We encourage RIMS to look for funding sources to strengthen its visitors programme.

3.5 Outreach Activities

At present these activities go in two main directions: first, towards freshmen at Kyoto University, there is a regular programme of introductory lectures on different areas of mathematics – 13 in 2016 –, that covered topics from quantum information to cubic surfaces; second are the 'RIMS lectures to the public', in which three speakers each give four lectures (over a period of four days) on a specific topic. It is encouraging to see that, in spite of the quite demanding nature of these courses, they are well attended, with about 120 people attending each of the last three years.

RIMS could consider having an annual public lecture on some topic in mathematics by a nationally or internationally renowned speaker.

A handwritten signature in black ink, reading "J.P. Bourguignon". The signature is written in a cursive style with a large initial "J.P." and a long, flowing "Bourguignon".

Submitted by Jean-Pierre BOURGUIGNON
Chair of the Review Committee.

APPENDIX A

List of Members of the Review Committee

- **Martin BARLOW, FRS**
Professor, University of British Columbia, Vancouver, Canada
- **Jean-Pierre BOURGUIGNON (Chair)**
Directeur de recherche émérite, Centre National de la Recherche Scientifique;
Professeur honoraire, Institut des Hautes Études Scientifiques, France
- **Motoko KOTANI**
Professor, Tohoku University, Japan
- **Miles REID, FRS**
Professor, The University of Warwick, United Kingdom
Former Director of Warwick Mathematics Research Centre
- **Mohamed SAÏDI**
Professor, The University of Exeter, United Kingdom
(Professor SAÏDI could not participate in the site visit but provided a technical report on Professor Shinichi MOCHIZUKI's Inter Universal Teichmüller Theory)

APPENDIX B

Description of the Evaluation Process

Members of the Review Committee received the self-evaluation report produced by the RIMS Executive Board ahead of the visit.

On the morning of Thursday 22 February, an extended presentation of the self-evaluation report was made by Professor Michio YAMADA, Director of RIMS, accompanied by members of the RIMS Executive Board, followed by a questions and answers session.

The rest of the day was dedicated to several sessions of exchanges with faculty members, post-doctoral fellows and graduate students.

Members of the Review Committee interviewed in groups or individually the following professors, associate professor and lecturers: Ryoki FUKUSHIMA, Kazuo HABIRO, Yuichiro HOSHI, Masayuki KAWAKITA, Nobu KISHIMOTO, Shinichi MOCHIZUKI, Shigeru MUKAI, Noboru NAKAYAMA, Kaoru ONO, Shinichi TAKEHIRO, Kazushige TERUI.

The Review Committee interviewed the following assistant professors: Kento FUJITA, Stefan HELMKE, Tatsuyuki HIKITA, Naohiko HOSHINO, Hiraku KAWANOUE, Teruhisa KOSHIKAWA, Takuya OOURA.

The Review Committee interviewed the following graduate students and post-docs: Naotake TAKAO, Kazuki TOKIMOTO, Arata MINAMIDE, Yu YANG, Takuya TAKEISHI, Kenta OKAZAKI, Takao MATSUMOTO, Alexander VAN BRUNT, Hisashi ARATAKE, Toshio ISHIKAWA, Akira SARASHINA, Naoki GENRA, Suguru ISHIKAWA, Shuta NAKAJIMA.

On Friday 23 February, after a session between members of the Review Committee, a tour of the facilities in the Masukawa building and the main RIMS building was organised. In the early afternoon, the members of the Review Committee made a tour of the offices in other parts of the campus.

Later in the afternoon, the Review Committee was received by Professor Nagahiro MINATO, Provost of the University of Kyoto, in presence of the RIMS Director, Professor Michio YAMADA, the RIMS Deputy Director, Professor Takashi KUMAGAI, and the past RIMS Director, Professor Shigefumi MORI. This exchange made it possible for the members of the Review Committee to share their first conclusions, namely the confirmation of the very high quality of the research conducted at RIMS and unfortunately the persistence of the space problem for the Institute. Further support to accompany the RIMS in its effort for more internationalisation, a legitimate goal in view of its history and its potential was argued for.

Later in the day, the Review Committee had the opportunity to interact one more time with Professor Michio YAMADA and Professor Takashi KUMAGAI.