

RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program

Advisory Council Report 2019

July 24-26, 2019

iTHEM.S

理化学研究所 数理創造プログラム

RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program

August 28, 2019

Report of the 2019 RIKEN iTHEMS Advisory Council

Meeting of the Advisory Council of the RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS), July 24 – July 26, 2019, Wako, Japan

I. Preliminary Information

● Members of the RIKEN iTHEMS-Advisory Council (AC)

Dr. Masato Wakayama (Chair, Mathematics)
Executive Vice President, Kyushu University, Japan

Dr. Roger Blandford (Astrophysics)
Professor, Stanford University, Particle Physics and Astrophysics, USA

Dr. Satoshi Iso (Particle Physics)
Director, KEK Theory Center, High Energy Accelerator Research Organization, Japan

Dr. Namiko Mitarai (Mathematical Biology)
Associate Professor, Niels Bohr Institute, the University of Copenhagen, Denmark

Dr. Masaki Sano (Soft Matter)
Professor, The University of Tokyo, Japan

Dr. Akira Takada (Industry)
Specially Appointed Professor, University College London, UK

Dr. Michio Yamada (Computational Science)
Director, Research Institute for Mathematical Sciences, Kyoto University, Japan

● Information provided to the iTHEMS-AC

- Meeting Program of iTHEMS-AC 2019
- Introduction to RIKEN Slides (Presented for RIKEN by Dr. Shigeo Koyasu, RIKEN Executive)
- iTHEMS Overview Slides (Presented by Dr. Hatsuda, Program Director of iTHEMS)
- White paper of iTHEMS-AC 2019: Review Material (Main Part)
- Review Material (Appendix A & B)

- iTHEMS Newsletter compilation vol. 1-60
- Curriculum Vitae of the sole PI (Dr. Hatsuda)
- SWOT Analysis provided by the Program Director of iTHEMS
- Presentations (15 + 5 min.) by Senior Research Scientists
- Oral (1 min.) and Poster Presentations by Postdocs
- Report of the 10th RIKEN Advisory Council 2016
- Interviews with iTHEMS Program Director (Dr. Hatsuda)
- Interviews with iTHEMS Program Deputy Program Directors (Drs. Tsuboi, Nagataki, Miyoshi, Mochizuki) and Senior Research Scientists (Drs. Kurosawa, Taki, Y.Inoue, Fawcett, Ozawa, Okada, Yokokura)
- Interviews with iTHEMS Research Scientists (Drs. Kubota, Warren, Chang, S.Inoue, Iritani, Mikami) and Postdocs (Drs. Gibo, Sugiura, Hiroshima, Yokota, Ouchi, Nozaki, Miyazaki, Goto, Konno, Sato)

● **Tasks of the iTHEMS-AC**

The iTHEMS-AC is tasked with reviewing the activities of iTHEMS planned from 2018 to 2024 and giving a reply to the Terms of Reference (ToR), from the Center Advisory Council for review as laid out by the President of RIKEN. The ToR is included in the White Paper of the 2019 iTHEMS-AC and summarized as

[ToR1] *Evaluation of the research conformance from the international standard, social contributions and consistency with mid-to long-term plan (7-year plan).*

[ToR2] *Evaluation of the suitability for the SWOT on center management provided by the Director.*

[ToR3] *Evaluation and further recommendations on Collaborations and Internationalization.*

[ToR4] *Evaluation of the (sole) PI on the status of fulfillment of duties based on the 7-year plan, research performance and suitability of the management capability, including efforts to support early-career researchers.*

● **Information and recommendations from previous reviews**

Since the RIKEN iTHEMS was founded in November 2016, no previous review of the iTHEMS by the Advisory Council (AC) under the RIKEN Advisory Council (RAC) framework has been performed. Hence, this report is the first review. As the predecessor of iTHEMS, the Interdisciplinary Theoretical Science Research Group (iTHES) operated from FY2013 through FY2017, where researchers from different fields were engaged in cooperative intensive interactions and achieved a number of interdisciplinary research

outcomes. From that, iTHEMS aimed to accomplish the full-scale utilization of modern mathematics to actively promote interdisciplinary research. Thus, the reason and/or focus of the establishment of iTHEMS is summarized in the 10th RIKEN (RAC) Report (2016.12.16), on page 5 as follows: “The expanded program in theoretical and mathematical sciences shows real potential for bridging existing scientific fields and giving rise to new avenues of understanding of physical phenomena and information.”.

II. Introduction

The meeting of the Advisory Council of the RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS-AC) took place from July 24 to July 26, 2019, in Wako, Japan. Over three days and through fruitful meetings and examinations of various supporting documents, the iTHEMS-AC reviewed the organization and management directed by the PI and supported by the senior members, research activities, various interdisciplinary activities developed by theoreticians working in mathematics, theoretical physics, theoretical biology and informatics (computer science). The iTHEMS-AC also reviewed the ongoing science projects and visions for future research directions including the fostering of earlier career researchers from the viewpoint of the fourth mid-to-long-term plan (7-year plan). Overall, during those three days, the AC was impressed with the present excellent activities of iTHEMS and its vision for a bright future.

In this report, no evaluation was made of individual achievements of researchers other than those of Dr. Hatsuda, the sole PI in iTHEMS. In addition, the iTHEMS-AC listed the corresponding recommendation along with each individual item, but there are some important issues that straddle each item in the ToR; thus, in some cases, recommendations are collected and listed in the final chapter “Concluding remarks and recommendations” as well. In the following, iTHEMS-AC is simply referred by AC.

III. Findings and Recommendation

In this report, the evaluation of iTHEMS by the AC is described in the order of the ToR of the President of RIKEN through the evaluation comments.

1. “Whether the center’s research meets international standards, whether its research results have contributed to society, and whether it fulfills the center’s up-to-date activities and its strategies meet the aims of the fourth mid- to long-term plan (7-year plan). [ToR1]”

Findings:

[Research]

Research in iTHEMS is conducted at a high level; notably, the motivation and achievements of early career researchers are impressive.

[Contributions to society]

iTHEMS’ activity supports cross-disciplinary communications for young researchers, planting seeds for new research fields. Training through generic and cross-disciplinary theoretical research prepares the young scientists to find a broad range of careers by providing problem solving skills in new areas, especially when the problem under consideration requires novel solutions. In general, theoretical and mathematical advances impact the entire field of science and technology in unscripted manners. However, it seems to be very early for such advances to have occurred in a major way, especially in mathematics, but this phenomenon is likely to occur because a satisfactory research foundation is being established. In addition, there is an indirect impact on the general culture, education, and welfare of the human beings.

[Consistency with the 7-year plan]

Excellent examples are available of developing interdisciplinary research with significant advances in the supported fields. To investigate the consistency of iTHEMS performance with the 7-year plan, it should be quoted as follows.

Translation of RIKEN mid-term and long-term goals for FY2018-FY2024: From pages 7 to 8:

In natural and social sciences, interdisciplinary approaches are becoming increasingly important, so that there is great demand to share and combine scientific methods studied independently in different fields, and to develop new mathematical methods for extracting information from big data and controlling highly complex systems. By developing mathematical sciences which can integrate theoretical and computational methods in physics, chemistry, biology, etc., we attack not only the fundamental problems in nature but also key issues related to social needs. In addition, we nurture human resources to lead such activities in the future.”

Translation of RIKEN mid-term and long-term plans for FY2018-FY2024: From page 11:

“One of the most fundamental challenges in natural sciences in the 21st century is an unified understanding of the Universe, Matter and Life. Toward this goal, we plan to integrate different fields through theoretical and mathematical methods. Such an attempt will also help to solve key problems in modern society. Specific directions to be explored are the following; (1) new concepts of geometry through coevolution of mathematics and natural sciences, (2) complex biological networks and the evolution of life, (3) origin of spacetime and matter from extreme astrophysical phenomena, (4) mathematical understanding of the deep learning to go beyond, and (5) encouraging junior scientists to cross the boundaries between different fields by creating a brain circulation network involving domestic and international institutions.”

The AC confirmed that activities, progress and achievement of iTHEMS are truly along with the direction of the goal in natural sciences described in the RIKEN mid-term and long-term goals for FY2018-FY2024. Additionally, the AC observed that some research activity in social science such as econophysics has been initiated in iTHEMS.

Recommendations:

The members of iTHEMS are well-selected promising young researchers. To contribute to society, they are expected to advertise their interdisciplinary activities not only to researchers and companies but also to non-scientists using, for example public lectures. In this manner, it is hoped to change the common view of theoretical and mathematical science in Japan.

The AC recommends that iTHEMS (and RIKEN) endeavor to increase their impact by making more specific choices between subfields, and by building stronger connections with other selected Japanese academic groups. In addition, iTHEMS (and RIKEN) should strengthen international and industrial ties as well.

2. “Describe the SWOT on center management provided by the Director to AC and evaluate whether these observations are suitable. [ToR2]”

- [S] Strengths (Internal origin, Helpful) presented by the Director:
 - New research platform of theoretical, mathematical and computational sciences under one roof
 - Hiring bright junior researchers over relatively long-terms (3 to 7 years)

- Flexible structures without rigid teams and group structures
- Broad range of research networks with domestic and overseas institutions

Findings (Suitability):

The AC agreed that the long term (5-7 years) position is essential for young researchers to explore interdisciplinary research themes. The AC could distinguish general broadening of researchers who remain in the same subfield but embark on cross-disciplinary research from career changes where more patience should be exercised. Notably, different types of transitions have been found. The AC observed that some mathematicians and theoretical physicists changed to biology but observed no examples of the inverse transition. Nevertheless, it is clearly appropriate for biologists to pursue research based on thoughts and ideas of physicists.

Research networks with overseas institutions play a critical role for young scientists as a gateway to the world. iTHEMS succeeded in creating a supportive atmosphere for cross-disciplinary collaborations. The AC also confirmed that the current platform bears a flexible structure designed to facilitate interaction. In summary, iTHEMS provides a vibrant and integrated research program for theoretical, mathematical, and computational sciences along with excellent opportunities to discern when and how interdisciplinary research is productive. Room remains, however, for a discussion on certain flexibility in contract durations, as it will be described several times in this report.

Recommendations:

Collaboration among researchers within different disciplines is a challenging task. Sometimes the technical terms used in a field may sound like a foreign language to researchers in other fields, creating a barrier to effective communication. The AC observed that the unique research framework/platform “Research CELL” accelerates cross-disciplinary collaborations in iTHEMS. Currently, iTHEMS has four CELLS: “Extreme Universe”, “Life and Evolution”, “Mathematics and AI”, and “Future Geometry”. Researchers can join any of the CELLS they are interested in and interact with each other amalgamating different disciplines. Additionally, CELLS can be created, divided, or fused together. The most notable element of iTHEMS is the ideas of the individual researchers who drive the evolution of CELLS, iTHEMS, and the future of science. The AC recommends that iTHEMS maintains this unique idea. Additionally, daily interactions are stimulated by various efforts, including the “coffee meeting” where iTHEMS members give 15-minute talks, followed by lunch and discussion. Such daily

interactions are particularly important for the development of interdisciplinary research, for which the language barrier has to be overcome. The AC found out that presently RIKEN does not allow financial support for daily coffee or related cost. Since the actual cost is quite small and yet it will significantly encourage daily interaction, the AC recommends that RIKEN be flexible in supporting such activities.

- [O]Opportunities (External, Helpful) provided by the Director:
 - Growing expectation of mathematical science from governmental agencies
 - Growing recognition of the iTHEMS brain circulation system by the scientific community
 - Growing expectation of mathematical science from industry inspired by data science and AI

Findings (Suitability):

Collaborations with industry have already started in some areas. In addition, some researchers moved to industry as a result of being inspired by the iTHEMS activities and mission.

Recommendations:

More collaborations with nearby universities are encouraged to strengthen the research by addressing many research fields necessary for interdisciplinary research and to make iTHEMS visible to outside graduate students, who could potentially be future members of iTHEMS. Additionally, for instance, from the viewpoint of traditional but very big data science, an expectation is that in the area of astrophysics a strong relationship between various international institutes and major Japanese research centers be forged. iTHEMS is encouraged to make a critical contribution from the theoretical standpoint.

Consideration of fixed-term employment of researchers by cross-appointments between industry (not only from the domestically but internationally) and RIKEN-iTHEMS, and/or temporary acceptance for a certain medium period, might be useful. In this manner, iTHEMS (and RIKEN) are expected to promote cross-disciplinary research and build a nonacademic career plan for young researchers, furthermore hire additional senior researchers who can support young individuals.

- [W]Weakness (Internal, Harmful) provided by the Director:
 - Vulnerability in management and support because of budget limitations
 - An insufficient number of tenured positions
 - Serious shortage of the office space
 - Inflexible RIKEN system of receiving nongovernmental funds for mathematical sciences
 - (In the closed session, the director also mentioned the lack of diversity in both gender-wise and nationality-wise.)

Findings (Suitability):

In addition to the listed weaknesses, the AC observed that substantial support from senior staff is essential for young researchers when they want to pursue cross-disciplinary research. Internal communication within RIKEN can be improved. For example, a variety of information on RIKEN researchers' expertise should be shared more effectively outside the iTHEMS and beyond seminars. Another notable issue is the serious gender imbalance and the proper actions to mitigate the situation needs to be taken. Engagement of female research scientists is limited. Graduate student engagement is also limited, in general. Moreover, the AC observed that there may be insufficient attention to career planning for younger scientists, although presently all the alumni have obtained their new posts uneventfully.

The research area in iTHEMS has been successfully expanded under the leadership of the PI with excellent coordination by the support staff, and iTHEMS is now an active organization encouraging young scientists to explore interdisciplinary research. iTHEMS is also expected to foster important theoretical and mathematical research areas which are relatively weakly supported in Japan, for example, theoretical computer science.

Recommendations:

For iTHEMS to increase in size in the future, strategic organization is necessary. iTHEMS has great potential and sufficient financial support should be provided. To strengthen the activity of iTHEMS, it would be important to increase the number of tenured positions of eminent senior leaders (not of normal researchers) who are excellent in producing and advancing grand plans of iTHEMS. Such action would support long-term research, thus reducing the risk of challenging cross-disciplinary research. From another perspective, the insufficient diversity in gender and nationality is a serious concern. The AC would like to recommend that iTHEMS actively search for talented young women and non-native Japanese men and women, and encourage them to join iTHEMS. Although all

researchers receive support for research from iTHEMS (1.5 million yen per researcher), the AC observed that young researchers proposed and most of the cases succeeded in obtaining external funding in their original research fields, particularly, the JSPS-Grant. The researchers are highly encouraged to continue this excellent situation. Young researchers are also encouraged to apply for external funds to advance interdisciplinary research if possible. In addition, leading discussions on a better general career structure for more than merely the researchers who will land tenured academic positions is desirable. For instance, the introduction of a counseling system might also be helpful.

The size of iTHEMS organization is much smaller than those of other centers in RIKEN. Although the AC passed on a discussion of whether iTHEMS should be the same size as other centers, the lab tour arranged during the AC meeting suggested a shortage of office space. In the next phase, creation of an independent administrative section is also desirable.

Today, only one young female scientist is affiliated with iTHEMS. Notably, the number of female undergraduate students in science and engineering, especially in departments relevant to physics and mathematics, is very limited in Japan, so that the AC understands that it is very challenging to change the situation. From an international perspective, however, iTHEMS must understand that this severe gender imbalance is disadvantageous to its mission; for example, various experiences and outlooks are particularly vital to an interdisciplinary program. To increase the number of female researchers, one of the most effective measures might be to hire senior female leaders (in a tenured positions) from Japan and abroad, thereby encouraging more female research scientists to join iTHEMS. Another effective measure for iTHEMS might be to emulate Kavli IPMU and OIST which have grown roughly contemporaneously by adopting different approaches to diversity.

- [T] Threats (External, Harmful) presented by the Director:
 - Insufficient financial and moral support from the government for basic science
 - Nationwide shortage of tenured positions for junior researchers
 - Insufficient consistency of government policy on education and research

Findings (Suitability):

The nationwide shortage of tenured positions in Japan is a serious problem for junior researchers and makes them hesitate to take the risk out of embarking on new research fields. Under the circumstance of declining government support for basic science, obtaining the necessary funding for iTHEMS may be difficult.

The only PI is Dr. Hatsuda himself, while the two Program Deputy Directors from outside RIKEN is employed part time, and the other two Deputy Directors are from other RIKEN centers; thus the operation of iTHEMS is crucially dependent on Dr. Hatsuda. The AC asserts that iTHEMS may be disrupted if Dr. Hatsuda resigns. Much of the funding is appropriated for the salaries of younger researchers, and with the support from only four assistants alone, the agenda of the PI is already extremely overloaded. At least one other iTHEMS full-time coordinator connecting science with management is absolutely necessary, but hiring such a coordinator may be impossible because of insufficient financial resources. This situation creates operational vulnerabilities, and will become a serious problem if iTHEMS attempts to increase the number of researchers after the next fiscal year.

Recommendations:

Interdisciplinary research is sometimes highly risky and is not always as successful as expected. Simple encouragement cannot always produce the anticipated results. Thus, concerted and strong support is necessary. RIKEN should properly invest in developing this unique opportunity and place in the context of declining government support for basic science. For example, if a young researcher risks of investing her or his time in a new research area that may temporarily reduce their research output, RIKEN should consider contract extensions to facilitate such career changes. Such systematic and thoughtful support is necessary to steer interdisciplinary research.

iTHEMS now provides young researchers with an excellent and privileged research environment which is difficult to find elsewhere in Japan. The young researchers therefore naturally want to earn tenure positions in iTHEMS. The present privileged environment of iTHEMS appears having good chemistry with the non-tenured positions for young researchers, who should prepare themselves for future positions outside iTHEMS. Additionally, from the viewpoint of interdisciplinary research, the allocation of tenure positions to scientists should be performed carefully and with caution, because interdisciplinary research at present, if it is successful, will produce established research

areas; hence, the tenure positions may obstruct further interdisciplinary activity in future. Tenure positions should be reserved only for up-and-coming and/or eminent leaders, who are excellent at formulating grand plans for iTHEMS. Alternatively, a prudent and flexible extension of contract terms facilitates the continuity of research not only of the individual researchers but of iTHEMS's cross-disciplinary research. From this viewpoint the introduction of a new evaluation system that allows young researchers in iTHEMS to submit a proposal (e.g., by themselves or by recommendation by director or deputy directors) for a one-to-two-year extension of their stay in iTHEMS, approximately two years before the end of their contract, should be considered.

3. “[ToR3] Evaluation and further recommendations on:”

3.1 Collaborations, including those in the Science and Technology Hub program

Findings:

Collaborations with academic institutes, companies and professional societies, have begun. Collaborations with five domestic and five overseas sites are ongoing.

Recommendations:

The AC recommends a robust expansion of these collaborations because they would create more opportunities for the future careers of young researchers, and at the same time influence the development of interdisciplinary research in Japan. As previously recommended in this report several times, it is also recommended that senior researchers who have an understanding of and experience in interdisciplinary research for some period from universities that have the RIKEN Science and Technology Hubs should be recruited. Possible methods and approaches include cross-appointments and using the university's sabbatical system.

3.2 Internationalization

Findings:

iTHEMS has started joint programs with five overseas partner institutions.

Recommendations:

The AC recommends an increase in the number of hires at iTHEMS who are international researchers in the early stages of their careers. Additionally, the present international

program could be expanded, but caution must be used to ensure that the stipends for iTHEMS personnel working abroad are sufficient to cover living expenses.

iTHEMS has SUURI-COOL Satellite Offices in Japan and the United States. iTHEMS is working as a training center for young researchers towards interdisciplinary research. This function is essential for the future of science and technology, and it is expected and important that more young individuals, including students, could spend time at iTHEMS, even a short time (e.g. for a few months), upon their application.

4. “[ToR4] For the unique Principal Investigator”

4.1 Whether the PIs fulfill their duties in accordance with the mission of the center, in consideration of the 7-year plan.

Findings:

The AC confirmed that the PI has been pursuing activities by using best practices to achieve the mission of the 7-year plan with great effort.

Recommendations:

The AC encourages the PI to continue his wise and visionary leadership.

4.2 Whether the PIs’ performance meet international standards.

Findings:

Dr. Hatsuda is one of the most prominent leaders in the community of theoretical nuclear physics all over the world. He is famous for his work on the derivation of nuclear force from QCD based on the lattice gauge theory (HAL QCD collaboration), and his expertise is widely extended across the field of nuclear physics, from low energy nuclear physics to the properties of quark matter in extreme conditions in the high energy accelerator experiments and neutron stars. All his work has been quite influential. He published almost 200 papers, and the related citations exceed 10,000. These numbers are substantial in Dr. Hatsuda’s field. He has also been invited to many prestigious conferences and to lead international scientific activity in nuclear physics. He has a pivotal role in the community of theoretical nuclear physics, and indeed he is the leader in his field in Japan. After the inception of iTHES/iTHEMS, he became involved in a research topic in mathematical biology, demonstrating his serious interest in interdisciplinary collaborations.

Recommendations:

The AC appreciates the performance of the PI and hopes the performance would continue at the same high level.

4.3 Whether the PI has suitable laboratory management capability, including efforts to support early-career researchers.**Findings:**

Early-career researchers are encouraged to perform independent research activities regarding their interests and to communicate actively with researchers with different backgrounds, thereby enabling them to widen their interest beyond what they could accomplish alone. Interdisciplinary research is encouraged but not forced. This goal is reasonable because the researchers' terms are temporal; hence, they must continue to publish, and investing time in research topics vastly different from their current expertise could be risky. Thus, iTHEMS provides individual research funding for each postdoc researcher. For theoretical researchers in the early stage of their career, 1,500,000 JPY/year is a larger sum than is offered by comparable institutions such as Kavli IPMU, OIST, and comparable with the JSPS Grant. This default budget is essential for young researchers starting interdisciplinary research which is usually difficult to obtain independently at such an early stage. At the same time, it would be important for young researchers not engaged in interdisciplinary research to be encouraged to continue applying for competitive external funding. It is highly appreciated that young researchers have enough freedom to collaborate with scientists outside iTHEMS, and propose organization of workshops and conferences.

Recommendations:

The AC would like the PI to work on new proposals for the future of iTHEMS, taking advantage of his valuable experience.

IV. Concluding remarks and recommendations (Encouragements):

iTHEMS is a unique organization, where the majority of researchers are in their early career stage and pursuing their own research interests. This structure quite differs from a traditional research group structure, where a senior established researcher leads the direction of the projects in the group. The AC observed a great potential in iTHEMS. The freedom of the young researchers and the active cooperative interactions between them

is likely to lead to various new research directions that would otherwise be difficult to explore.

At the same time, under the present organization, the early-career researchers have to take risks by themselves to launch new interdisciplinary research projects. If they succeed, it is their own achievement, but if they, for example, could not publish a significant paper despite the time spent to make great efforts, their career may be negatively affected. This may make young iTHEMS members somewhat hesitant to start up their new interdisciplinary research projects, although such new research initiation may thereafter increase their opportunities to get to know researchers of the same generation but in different fields and thus broaden their horizons. In other words, embarking on interdisciplinary projects will, in the long term, increase the chance of interdisciplinary collaboration, even after leaving iTHEMS.

Initiation of interdisciplinary research could be accelerated and made less risky if senior researchers can support the young scientists. To carry out interdisciplinary research, much time must be spent learning about the new field before coming up with promising ideas. It will be great if senior researchers with their own scientific discipline and some experience in interdisciplinary research can support young scientists to accelerate the learning process toward challenging interdisciplinary projects.

The support by senior researchers in terms of organizational operation is also necessary for iTHEMS to increase its number of researchers in the future. Today, the number of the researchers in each scientific discipline is relatively small, just about the critical number required so that they are not too isolated, while iTHEMS intends to grow further. The present organization, which relies on a single PI, is not sustainable in the long term or in a bigger organization. It is a real challenge to maintain the present interdisciplinary activity so that a compartmentalized organization will not disturb the freedom and positive atmosphere. Organizational help by senior researchers who have a good understanding of interdisciplinary research activities is crucially needed.

In the AC meeting, it became apparent that data science can be a sort of glue, connecting different fields. Different scientific disciplines produce data, while mathematics definitely contributes to analyzing them and even exploring new research themes or fields. Of course, these days, big-data is a buzzword, and especially its application is studied

worldwide. Nevertheless, by having a unique mixture of researchers in basic sciences, iTHEMS may be able to promote fundamental progress in this direction.

Given that most of the positions at RIKEN are temporary, the career paths of the young researchers after leaving iTHEMS should be seriously monitored. The AC believes that training through generic and cross-disciplinary theoretical research prepares individuals for finding a broad range of careers by providing problem solving skills in new areas. Indeed, career switches to industry have occurred, demonstrating that the effect iTHEMS is not only academic. The AC looks forward to the iTHEMS young researchers' success in various careers and fields. Moreover, the AC considers that iTHEMS needs plural tenured positions for researchers who are excellent at producing and managing the grand plans of iTHEMS. In other words, these tenured posts should be used for experienced researchers who can create and practice iTHEMS' grand vision while supporting the program director. The AC recognizes, however, that a simple increase of human resources may cause conflicts with the current excellent organization led by the program director.

Obviously, the most important asset of iTHEMS is its diverse talented human resources. Although the AC did not provide a suggestion regarding how much iTHEMS should be enlarged in the short term, recruitment of additional foreign, young research scientists is critical. Hence, the international visibility of the iTHEMS activities should be enhanced for that purpose. Moreover, as described in the section on the weakness in the SWOT analysis, female recruitment should be pursued aggressively.

The AC observed that the role of each deputy director in iTHEMS is commendable. They support and encourage early career researchers in reasonable manners from the viewpoint of their original discipline and interdisciplinary work. In this sense, a management system with four deputy directors and one coordinator is helping the program director to exercise strong and appropriate leadership. The research environment offered to young scientists by iTHEMS is privileged and unique aforementioned. The AC agrees with the idea that the activities and opportunities offered by iTHEMS should be expanded. Actually, in order to sustain and even to extend this research environment, the AC encourages RIKEN to increase the number of PIs and posts for younger researchers. At present, the sole PI can ensure that the steering of iTHEMS to such a direction is smooth and offers necessary advice to all young researchers. However, if iTHEMS expands further, this method cannot be sustained under the present framework. To promote interdisciplinary research based on a long-term vision and nurture young theoretical researchers in Japan, RIKEN

and RIKEN-iTHEMS should start discussions on the future of iTHEMS, including its operation. In other words, establishment of a new vision for the advancement of interdisciplinary and theoretical research sustainably in RIKEN is necessary and should be provided as early as possible in the second phase of the current mid-term and long-term goal periods.

V. Acknowledgement

The Interdisciplinary Theoretical and Mathematical Science Program Advisory Council (iTHEMS-AC) thanks the RIKEN President Hiroshi Matsumoto, Dr. S. Koyasu and Dr. M. Kotani, and the Program Director of iTHEMS Tetsuo Hatsuta, as well as all the members and staff of the RIKEN iTHEMS for their hospitality during this Advisory Council meeting. The iTHEMS-AC also appreciates the efforts made to present the scope of the activities of the iTHEMS carried out by the Research CELLS, with emphasis on the interdisciplinarity, domestic and international collaborations, as well as to outline the mid-term management and scientific strategy for future development. All members of the iTHEMS-AC thank the RIKEN iTHEMS team for the excellent preparations for this meeting. Specifically, the quality of the supporting documents and the clarity of the presentation including the poster session by the young researchers were instrumental in facilitating this iTHEMS-AC review. The Program Director of iTHEMS also provided the AC members with the opportunity to carry out a direct unbiased discussion with staff, including especially early-career researchers. The AC has appreciated these opportunities, because they were very helpful for the discussion among members of the AC.

As a final acknowledgement, the AC members would like to thank RIKEN for having established iTHEMS for early career theoreticians with special emphasis on cross-disciplinary fields to spearhead the improvement of the research environment of Japan.

Fukuoka, August 28, 2019



Prof. Masato Wakayama
on behalf of the iTHEMS Advisory Council.

Epilogue

The existence of iTHEMS and its activities are very encouraging for the future, because the research environment in Japan tends to embody a short-term vision that makes research planning and activities too uniform, as a Kintaro-ame* is, that is, the strength of diversity may be lost. In short, under the present situation of government funding of only a few unexplored areas, we expect iTHEMS to lead the exploration of new and fundamental directions from a theoretical standpoint for the future of humankind.

* Cylindrical candy made so that Kintaro's face appears wherever it is sliced. Kintaro (the childhood name of late-Heian warrior Sakata no Kintoki) is a boy who is a hero of Japanese folklore, who befriended animals and had supernatural strength.