平成 30 年 3 月

国立研究開発法人理化学研究所
理事　松本 洋一郎

平成 29 年度実施 主任研究員の研究業績レビュー（中間）の結果について

研究開発等評価実施規程（平成 15 年 10 月 1 日規程第 74 号）及び主任研究員及び上席研究員研究業績評価実施細則(平成 27 年 10 月 23 日細則第 84 号)に基づき主任研究員の研究レビュー（中間）を実施し、レビューアーから事務局に送られた評価結果を取りまとめ下記のとおりです。

1．評価対象：古崎物性理論研究室古崎 昭 主任研究員

1）評価体制

実施日：平成 29 年 12 月 22 日（金曜日）

4 名の所外有識者を評価委員とするヒアリングレビューを実施。

評価者：

Eduardo FRADKIN, Professor
University of Illinois, U.S.A

Norio KAWAKAMI, Professor
Kyoto University, Japan

Hidenori TAKAGI, Director
Max Planck Institute for Solid State Research, Germany

Kazuo UEDA, Editor in Chief
Journal of the Physical Society of Japan, Japan

2）評価結果の概要等

General comments:

【Reviewer 1】

Dr. Akira Furusaki was appointed as the chief scientist of the Condensed Matter Theory Laboratory in October 2002. Dr. Furusaki has his expertise in theoretical physics with mathematical rigor. However research activities of the theory group are broad and various important subjects have been investigated in the group, for example (1) topological states of matter, (2) quantum magnetism of frustrated spin systems, and (3) strongly correlated electron systems.

In 2010, after seven years from the start, the condensed matter theory group was evaluated by an external review committee. The conclusion of the review was that the introduction of this group into RIKEN as the first theory group in the field of condensed matter physics was very successful. It was shown explicitly by number of outstanding research papers published by the group. In particular, the seminal papers on the classification of topological insulators, the microscopic theory of iron pnictide superconductors, and the frustrated quantum magnets were published during the first seven year term. The theory group was successful also to attract the best and brightest researchers in condensed matter theory. The chief scientist has consistently provided

those young researchers with freedom to choose their research subjects by themselves. As a result two former staff members and 11 postdocs have obtained academic positions in universities in the first seven years.

In the second seven year period the tradition of the group formed in the first seven years has continued naturally and extended to some extent. One significant difference in circumstance is that in RIKEN there are now several theory groups in condensed matter physics, instead of the only one in the first term. It is now possible to have various collaborations not only between theory and experimental groups but also among theory groups by themselves. The condensed matter theory group continues to be active and its presence in the physics community is visible not only inside RIKEN but worldwide. In the second seven year term 11 former postdocs have been promoted. The present three staff members are active in their fields and qualified well to be promoted in academic positions to form their own research groups.

In conclusion I am very much impressed by the strong activities in the last fourteen years by the condensed matter theory group on various current important problems in condensed matter physics and we may say that it has been established as a leading theory group in the world. For this accomplishment I am convinced that the chief scientist laboratory system in RIKEN have played an essential roll.

【Reviewer 2】

During his second seven years (2010-2017), Dr. Furusaki and his Condensed Matter Theory Laboratory (CMTL) worked on a broad range of attractive topics in condensed matter science, from topological state of matter, quantum magnetism to correlated electron physics. The research output during this period was impressive. At the end of the first seven years of CMTL (2002-2010), Dr. Furusaki together with his colleagues published the first report on a classification of topological insulators. This seminal work provided the community of topological matter with a firm theoretical basis and was cited more than 1000 times up to date. In his second year, Dr Furusaki upgraded beautifully his classification by incorporating interaction effects and by introducing Clifford algebra, which made him distinct in the field of topological matters. Members of CMTL proposed theoretically novel state of matters, notably in close connection with experiments, including a “quantum” spin ice and a spin nematic phase. Those works were well received in the community of quantum magnetism.

CMTL currently consists of Dr. Furusaki, three staff scientists (permanent) and seven postdocs. Dr. Furusaki offers his young colleagues the scientific freedom of conducting their own project of interest. They work quite independently but, if necessary, can get good advice from Dr. Furusaki. All his young colleagues are satisfied with the scientific environment of CMTL. This style of management which Dr. Furusaki has been conducting since he started CMTL is perhaps quite unique in RIKEN but seems to be functioning very well for CMTL. This does make sense because Dr. Furusaki is recruiting only young scientists with the talent who can conduct independent research.

【Reviewer 3】

This is my review of the research done since 2010 by Dr. Akira Furusaki, PI of the Laboratory of Condensed Matter Theory of RIKEN. The Laboratory staff consists of the PI (Dr. Furusaki), three permanent staff members, and seven postdoctoral researchers. Research in the Furusaki Laboratory covers essentially several frontier areas of Condensed Matter Physics: Topological Insulators and Superconductors, Low Dimensional Systems, Frustrated Spin Systems and Molecular Conductors and Insulators.

Dr. Furusaki's Lab is one of the stronger Condensed Matter Theory groups in Japan and a strong asset for RIKEN and I would say it ranks with the leading groups worldwide. The program that Dr. Furusaki has developed in his Laboratory is really impressive. His research program is both deep and ambitious. Dr. Furusaki himself is a leading condensed matter theorist who has made fundamental and long standing contributions to this field. This is reflected in the many prizes and awards that he has received, in the many invited talks at key conferences, and in the impact of his publications (including the large number of citations). In the past decade he has authored and coauthored some of the most influential papers in the field. In one series of papers, published between 2008 and 2010, Furusaki coauthored with Shinsei Ryu, Andreas Ludwig and Andreas Schnyder on the classification of topological insulators and superconductors ("the tenfold way") has played a key role in organizing our understanding of topological systems both from the conceptual point of view and as a tool for experimentalists. Some of these papers have over one thousand citations, a remarkable accomplishment for what at first reading is fairly abstract work. In particular, the work that Dr. Furusaki and his group have done since 2010 is truly impressive. Here I will focus on just a few significant ones.

In 2013 and 2015 Dr. Furusaki and Dr. Takahiro Morimoto (Furusaki's postdoc, now a postdoc at the University of California Berkeley, USA) published two important papers, one on the classification of topological insulators with reflection symmetry, and the other (coauthored also by Dr. Christopher Mudry, from the Paul Scherrer Institute in Switzerland) on the breakdown of the integer classification of topological insulators by local electron-electron interactions. This last paper is one of the few published papers addressing the changes that affect the free fermion classification when sufficiently strong interactions are taken into account. This is a very promising direction of research, which combines the physics of topology with strong correlations which is a key direction of research in the community. This line of research also informs on important problems with work done in high energy and quantum field theory groups. It would be important to strengthen these connections and foster collaborations at RIKEN (in particular). On the same vein the work done by this group on strongly frustrated antiferromagnets (both in 2D and in 3D) is truly impressive and has attracted a great deal of attention. In this respect I want to stress the relevance of the work by the three staff members. Much of the theoretical work done in this Laboratory falls within the general scope of Quantum Materials and the collaboration with experimental groups working in this developing field should be encouraged.

One aspect of Dr. Furusaki's Lab is the richness and originality of the research they do. This is largely due to his free style of management which allows the staff members to have independent lines of research and hence to succeed in their goals. This style does not detract in any way from this being an actual group. They clearly learn from each other and they influence each other's research. I also want to highlight the importance of the postdoctoral program. The group has been able to attract a significant number of highly qualified postdocs. These postdocs have been able to

secure long term positions elsewhere in Japan, as well as research positions in leading institutions in the USA. This is one of the great successes of Furusaki's lab.
In summary, Dr. Akira Furusaki has developed an exceptionally strong and successful program, by any measure. I strongly recommend that this program be renewed at the highest possible level of support. It is a key asset for the future development of Condensed Matter Physics in RIKEN and in Japan at large.

【Reviewer 4】

Furusaki laboratory started in 2002 is now recognized as one of the most outstanding groups in condensed matter theory in the world. In these seven years, his group has been keeping extremely high research activities at the forefront of condensed matter theory on a wide variety of topics such as topological states of matter, correlated electron systems including spin systems, low-dimensional systems, etc. The amazingly high activities in research can been seen e.g. from a number of influential papers published in top journals. Dr. Furusaki and his colleagues aim to develop a new research platform in condensed matter physics. In particular, topological classification and its generalization to various topological phases have been quite successful, which were indeed pioneered by Dr. Furusaki et al.
Concerning the management of the laboratory, a very good research atmosphere is provided. Three staff scientists as well as seven PD fellows are highly productive and enjoying their research in collaboration with Dr. Furusaki, or under his constructive suggestions. This excellent environment, I believe, enables them to produce highly qualified results. I would like to note that many of the young researchers who stayed in the laboratory have found their way to successful academic careers.
Summarizing, the scientific achievements of Furusaki's laboratory are excellent, and the lab's atmosphere is very good. In order to keep the high activities, I hope that RIKEN can continue to provide a steady support for his group in the future.

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