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Report on my stay at the Yukawa Institute for Theoretical Physics for the 2017-18 school year

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Abstract. This is a report on my last school year as an Advanced Future Studies Senior Lecturer at the Yukawa Institute for Theoretical Physics. I describe my scientific activities during this period.

Keywords: Fault tolerant quantum computing, topological quantum error correction

1. Scientific Activity

I started working at the Yukawa Institute for Theoretical Physics on January 2016 and finished on January 2018. What follows is an account of my scientific activities during the period extending from April 2017 to January 2018.

The most important development is that during this year I obtained a research grant as a principal investigator. In particular, a KAKENHI Wakate-B for a total of 3.200.000 JPY to be divided in 3 years. Its title is “Removing noise in quantum computers with topological methods” and its purpose, “To extend well-stablished methods in fault-tolerant quantum computation to (i) deal with qualitatively

different forms of noise and (ii) reduce the amount of control required on the physical system. To understand the physics of the quantum Hamiltonian systems derived from gauge color codes, stablishing if they are self-correcting or not. To generalize such systems."

During this year I have followed two main distinct lines of research:

Permanent failures on quantum computation components. Fault-tolerant quantum computation, the art of designing quantum computers that can function reliably despite being composed of individual unreliable components, is a core aspect of my research. During this period my main focus has been to investigate the properties of the most popular form of fault-tolerant computation in the presence of components that fail permanently.

Self-correcting quantum memories. It is not known whether a three-dimensional condensed matter system can have the ability to passively protect quantum information from decoherence. Recently I came up with a promising theoretical construct, gauge color codes, that has the potential to guide us in finding such exotic condensed matter systems. In order to understand better this problem, I have studied its connections with lattice gauge theories.

In terms of participation in conferences and workshops, there has been a big contrast between this year and the previous one. Whereas last year I felt overwhelmed by the invitations to international conferences, this year I did not receive any invitations.

2. Conclusion

During this year I obtained my first grant as a principal researcher. Also, I pursued two interesting lines of research, still to be culminated, that aim to bring closer the dream of a quantum computer. Incidentally, this period has continued to witness an increased amount of investment in what is now the nascent industry of quantum computation.