

変革を駆動する先端物理・数学プログラム (FoPM)

国外連携機関長期研修 報告書

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Overview

I participated in the workshop “BPS Dynamics and Quantum Mathematics” at Galileo Galilei Institute for Theoretical Physics (GGI) in Florence for two weeks. This workshop aims to provide a place of discussion and communication for researchers from all over the world to promote the interaction of quantum field theory and mathematics. The workshop also includes introductory lectures by leading researchers for students and young researchers in the first week, and talks on recent developments of each research topic of participants from the second week.

Through these lectures and talks, I obtained some new knowledge on supersymmetric quantum field theories, their spectrum and moduli spaces, and related mathematics. In addition, through discussion and communication with leading researchers in my current research interest, Mathieu moonshine, I got a lot of inspiration and clues to the next steps of my research.

Daily Life

After breakfast buffet, take a 15-20 min walk from my hotel to GGI, while looking down a great view of Florence city, since the hotel and the institute are both located at high altitudes.

In the first week, there were usually two 90 min lectures in the morning and one in the afternoon. In the second week, there was a 60 min talk in the morning, and occasionally another 60 min talk in the afternoon. Lunch was provided by a catering service, and participants had lunch while chatting and discussing.

At other times, we freely do our business or discussion in their assigned office rooms. My room was shared with a PhD student from SISSA in Trieste, and he kindly taught me some general things about Italy. Unfortunately, he left in the first week, so I monopolized the room in the second week.

All talks end no later than 4 pm. Leave GGI after 5 pm, get back to the hotel once, and take a bus to the city center for laundry, shopping, and dinner. The buses in Florence are not so punctual and often take more time than expected. The main means of transportation in the city is walking; you would become a good walker if you lived in Florence without any vehicles.

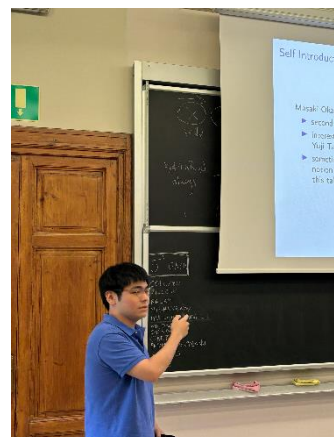
Experience at GGI**Lectures:**

There were four series of lectures: lectures on quivers and cohomological Hall algebras (CoHa) by Prof. Markus Reineke, the Seiberg-Witten theory and spectral networks by Prof. Lotte Hollands, vertex operator algebras and log-CFT by Prof. Terry Gannon, and BPS spectra and quantum invariants by Prof. Sergei Gukov.

I learned a lot of interesting aspects of supersymmetric quantum field theories through these lectures. One of my favorite topics was CoHa, an algebra mathematically formulated to describe the structure of BPS states. Prof. Reineke introduced it using representations of quivers as an example, and everything was clearly explained with relatively elementary linear algebra and combinatorial methods. Despite its simplicity, many problems remain unsolved even for quivers with easy structures.

Gong show presentation:

On Wednesday afternoon in the first week, there was a gong show for students to give 5-min talks. I decided to give a talk at this gong show on the day I arrived at GGI; I would like to thank the organizer Prof. Fabrizio Nieri for inviting me to do so. I prepared slides and a manuscript, and talked about our recent paper with Prof. Yuji Tachikawa, which shows that non-invertible symmetries act on local operators as quantum operations. The idea of this work was based on previous works by Bischoff and their collaborators in the context of operator algebra, more specifically, local conformal nets or axiomatic quantum field theory. I also mentioned that I am currently interested in Mathieu moonshine, which is a phenomenon where a certain sporadic finite simple group appears in the elliptic genus of conformal field theories with K3 surface targets, and its mechanism is not fully understood yet. As a result, Prof. Katrin Wendland and Prof. Terry Gannon, both renowned researchers of the topics I mentioned in my talk, kindly asked me questions, and it gave me opportunities for later discussion. (Photo by Prof. Masahito Yamazaki.)



Discussion:

Prof. Gannon gave me an interesting comment after the gong show: he showed that the results of Bischoff et. al. also hold in the language of vertex operator algebra. Since vertex operator algebras go better with physicists' understanding of conformal field theories, it could provide novel methods to study for example Mathieu moonshine. I could also ask him some questions on vertex operator algebras I had in my mind for a long time after his lectures and at lunchtime.

Prof. Wendland also gave me an opportunity to discuss my research on Mathieu moonshine with her. She told me about some recent developments of her famous idea, symmetry surfing. I also told some possibly new ideas recently I noticed on a certain analogous problem of Mathieu moonshine, and she gave me some advice and kindly encouraged me to keep on going.