

**The Global COE Program**

**“The Next Generation of Physics, Spun from Universality and Emergence”**

**Bilateral International Exchange Program (BIEP, invite) report**

**Send report to: Your responsible Professor in Kyoto University**

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(Year/Month/Day)\_\_\_\_2011/07/18

**Invited Student**

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**Responsible Researcher in Kyoto University**

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**Research Project**

Title	<b>Moduli Spaces in String Theory</b>
Duration	<b>11/04/29 – 11/07/15</b>

**Please summarize your activities and results during your stay in Kyoto University.**

**Also please describe how your stay has been beneficial to the graduate students in the host institute. You can add a sheet, if you need more space.**

**You can also write any comments and requests to the GCOE program.**

The visit to the Yukawa Institute for Theoretical Physics has been an exciting and productive experience, and I would like to thank above all my hosts Professor Kazuo Hosomichi as well as Professor Tohru Eguchi for their hospitality and efforts to make my stay comfortable and an unforgettable experience.

The visit has been themed under the title “Moduli Spaces in String Theory” during the application process, but the theme has been extended towards many interesting areas of research in String Theory during my stay. New ideas leading to ongoing projects and publications have been conceived during my stay in Kyoto.

As a second year Ph.D. student under the supervision of Professor Amihay Hanany at Imperial College London, I have been working on various aspects of understanding and classifying Calabi-Yau moduli spaces of supersymmetric gauge theories in 3+1 and 2+1 dimensions. A seminar on a particular work on a certain class of theories known as  $Y_{pq}$  theories has been the introductory seminar I have been asked to give in the first few weeks of my visit in Kyoto. The seminar contained a comprehensive introduction for the audience about the tools known as brane tilings and Hilbert series which have proven to be very effective in studying various aspects of moduli spaces of worldvolume gauge theories of D-branes probing Calabi-Yau singularities.

Another project, on which I have been able to make significant progress during my visit, was on the study of particular worldvolume theories of D-branes on non-compact Calabi-Yau manifolds where the involved toric geometry is described by reflexive polygons. In the past, Batyrev et. al. utilized reflexive polygons and in general polytopes in various dimensions to find and study mirror paired Calabi-Yau manifolds on which one could compactify superstring theory. Until today, this pioneering work led to advancements in heterotic string phenomenology and F-theory. The existence of only 16 reflexive polygons in two dimensions has appealing aspects for the study of 3+1 dimensional supersymmetric gauge theories – the apparent purely geometrical duality between reflexive polygons have interesting physical interpretations in the gauge theory context. Moreover, the fact that multiple supersymmetric gauge theories can refer to the same reflexive polygon under a correspondence known as Seiberg duality is indicative of the rich yet unexplored nature of the finite set of supersymmetric gauge theories corresponding to reflexive polygons. The results obtained during my visit at Kyoto led to a new discovery particular to this set of supersymmetric gauge theories, which soon will lead to a publication on the subject.

A long-term project during the first two years of my Ph.D. has been to study the combinatorial nature of classifying abelian orbifolds of toric Calabi-Yau manifolds. A study of the correspondence between torus coverings and abelian orbifolds led to a publication during my stay at the Yukawa Institute (JHEP09(2011)116, YITP-11-56).

A project initiated during my stay at Kyoto with my host Professor Hosomichi has been the study of the partition function on the 5-sphere. The 5 dimensional  $N=2$  supersymmetric Lagrangian has been studied intensively during my stay, and we were able to take first steps towards writing down the partition function using localization techniques. The project has the prospect of leading to a publication in the future.

Very interesting discussions regarding works on brane tilings have been conducted with Dr Masato Taki who is a post-doc at the Yukawa Institute. The discussions were enlightening, and new ideas have been conceived which in the future might lead to new projects.

Overall, the visit made also an impressive non-academic impact on me. The fact that it was the first time for me to visit Japan and I was not able to speak or understand Japanese was not a hindrance during my stay due to the very warm welcome I have received from the people at YITP. Especially, speaking to fellow graduate students about their research work as well as about life in Japan and in Europe led to interesting conversations and an exchange of ideas. I hope to meet again many graduate students from Kyoto University in the near future.

As a farewell event, the graduate students have invited me in the last weekend of my stay to go together to see the famous "Gion Matsuri" festival. It was an unforgettable experience to see and taste the atmosphere, and to spend the time with students and friends.

I think overall, my visit to the Yukawa Institute has been beneficial for my future career in theoretical physics. I also believe it benefited other graduate students at the institute academically and socially, and I would recommend the experience to every interested graduate student in the future.