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Research ares: Applied mathematics, Topology

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Research Area: I have worked on a number of different areas in mathematics (e.g. geometry, representation theory and integrable models), and most of my research can be categorized into mathematical physics. My research has been in theoretical physics, in particular high energy theory, quantum field theory and string theory. My research has also covered areas such as particle phenomenology, cosmology and statistical mechanics.

My main interest has been on mathematical structures in quantum field theories and string theory. A sample of research topics in the past includes (homological) mirror symmetry; Donaldson-Thomas invariants and wall crossing; quantum invariants of 3-manifolds and knots and the connection with three-dimensional complex Chern-Simons theory; quantum Teichmüller theory; cluster algebras; integrable models (lattice model and quantum field theories, and connection with four-dimensional Chern-Simons theory); Painlevé equation; high-dimensional conformal field theories and their representation theories. For more details, please have a look at my homepage http://member.ipmu.jp/masahito.yamazaki/index.shtml. Most of my research is motivated by high energy theory, however, I sometimes study purely mathematical problems and write papers in pure-mathematics in theorem/proof format. I have always made it a rule to pursue whatever research topic I am passionate about, and my research area evolves constantly as a consequence.

For students: While my research is at the interface between mathematics and physics, an advanced knowledge of physics is not needed if you are an undergraduate student in mathematics. What is more important is that you have a solid understanding of the basics of whatever areas of mathematics you are interested in. It also helps greatly if you familiarize yourself with basic undergraduate physics, such as quantum mechanics and statistical mechanics—they will be long useful in your later career.

I can also supervise very "physical" topics away from conventional mathematics. Physics undergraduate students are very welcome, and you are encouraged to write both mathematics as well as physics papers. Having said that, since you are a student in graduate school of mathematics, you are expected to write M.S./Ph.D. theses which contain solid mathematical results.

It is hard to know in advance which knowledge will be needed in your actual research. This is particularly the case in my research area, which often is located at the interface of several different areas in mathematics and physics. It is therefore crucial to have strong motivations and flexibility to quickly assimilate necessary material on whatever topics needed. It also helps tremendously if you could communicate effectively with researchers from other areas.

We will discuss research topics on a case-by-case basis. While there are many potential topics and my interest tends to be broad, (1) you yourself should be strongly interested in and committed to the subject, and (2) it would be desirable to have some connection with physics, either directly or indirectly. We can start with journal-club-type discussion of papers or textbooks on the topic. (To give one example, I have recently been interested in papers and textbooks by my collaborator Kevin Costello, e.g. "Factorization algebras in quantum field theory, Vol II".) Depending on the research topic, it might be possible to start research immediately after reading a couple of papers; in other cases it requires longer preparation.

I am located at Kavli IPMU, Kashiwa (in the suburb of Tokyo), while the math department is located in the Komaba campus in Tokyo. The idea is that in the first year of the graduate school you will concentrate on study and lectures in the Komaba campus (in addition to on-line discussions), and you will come to Kavli IPMU from the second year on. Kavli IPMU is an international research institution with daily interactions between mathematicians of different areas, and also between mathematicians and physicists; for this reason I believe it is an ideal environment for those interested in the interface between mathematics and physics.