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Research field: Lie groups, Lie algebras, Representation Theory, Algebraic Geometry, Differential Geometry

Key words: Geometric Representation Theory, Gauge Theory, Quiver varieties

Present Research:

My research topic is a mathematical study of gauge theories, which have their origin in mathematical physics. In particular, I study homology groups of various moduli spaces appearing in gauge theories, using a technique called geometric representation theory. Not only can this study be considered an analysis of gauge theories, it also sheds an interesting new light on representation theory, as I obtain familiar objects like Kac-Moody Lie algebras and their quantum analogue in a very different manner than usual. As examples of moduli spaces, I am interested in quiver varieties, which can be regarded also as spaces of representations of quivers (certain noncommutative algebras). They are closely related to representation theory of Kac-Moody Lie algebras. Recently I give a mathematically rigorous definition of Coulomb branches of 3d supersymmetric gauge theories using this method, and study their properties and representation theory of their noncommutative deformations (quantization).

Notice for students: In the master course, we require a student to learn basic knowledge in the specialized field, understand papers of earlier research, and write a paper including a new result or an originality as a master thesis.

When I was a student, I was specialized on nonlinear PDE on manifolds and studied differential geometry and analysis. However in order to pursue study of moduli spaces of solutions of PDE, I needed to learn algebraic geometry, Lie algebras and representation theory of noncommutative algebras, and various other topics. Based on these experiences, I recommend students not only focus on a particular field described as above, but also have interests on other areas.

The above is rather general advice. Let me give a practical matter. I am a member of Kavli IPMU, which is an institute studying mysteries of our universe by mathematics, physics, and astronomy. Therefore I welcome students who wish to study mathematics related to physics. There are research seminars held, but no course is taught at Kavli IPMU. Therefore I recommend students to stay at Komaba campus, at least while master course. We have studying seminars either at Komaba or Kavli IPMU, depending on convenience of students and myself.

I would ask students to learn what were taught in undergraduate lectures well. In particular, I will assume that you learn basics on manifolds, cohomology groups of topological spaces, Lie groups and Lie algebras.