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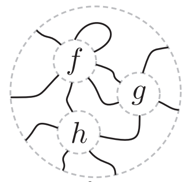
Research statement

I'm interested in the interplay between algebra and topology in low dimensions.

In practice this means that I study algebraic gadgets called planar algebras, as well as higher dimensional generalisations of these. 'One dimensional' algebra deals with events or processes that occur in linear succession, whereas in a planar algebra we can combine objects in more complicated ways. These operations are described by diagrams with explicit two-dimensional topology:

$$\{f, g, h\} \rightsquigarrow$$



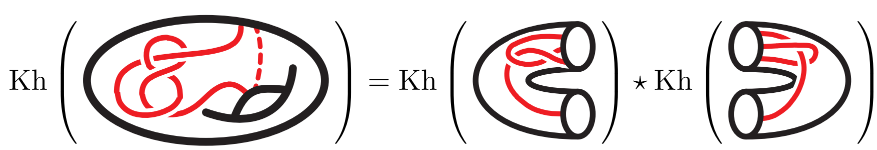
(The diagram on the right represents the output of an operation on f, g and h just as $f(x)$ represents the value of a function)

More generally, in higher dimensional generalisations the operations reflect natural topological operations on manifolds (e.g. 'cutting and pasting'). I'm mostly interested in the low dimensions, so these manifolds are 2, 3 or 4 dimensional. (A 2-manifold is a surface, and so on.) In some circumstances I investigate particular examples in detail, while in others I work to extend the general theory, or develop new constructions which allow either applications of algebra to topology, or of topology to algebra.

A Miller Research Fellowship would be wonderful — I'm looking forward to collaborating with Vaughan Jones, and also expecting to work with Professors Teichner, Kirby, and Reshetikhin. I plan to participate in the active research seminars in the department, and get lots of work done! Berkeley would certainly be my first choice for a next position. I'm excited about interacting with the many other postdocs in the mathematics department, as well as meeting other Miller Fellows at the legendary Tuesday lunches and learning about their work.

I've spent the past two years as a postdoctoral researcher at Microsoft's research group in Santa Barbara, where the eventual goal is to build a 'topological quantum computer'. This subject incredibly straddles topology, representation theory, conformal field theory, and condensed matter physics! Ideas that used to be toy models suitable only for mathematicians have found applications in physics, in particular in the study of the fractional quantum hall effect. Participating in this community has given me a real sense of the importance of 'applied' problems in even the most esoteric mathematics, and endless ideas for new projects. For example, through our group in Santa Barbara I've come across the work of Ashvin Vishwanath, a condensed matter physicist at Berkeley, and I look forward to talking with him.

In 4 dimensions, my work focuses on Khovanov homology. Khovanov homology associates a graded vector space to a knot. Moreover given a cobordism between two knots (i.e. a surface embedded in 4-space whose boundary is the two knots), it gives a recipe for a map between these vector spaces. Previously, I helped establish that this recipe is well-defined. I'm currently working to extend the definition of Khovanov homology to knots in arbitrary 3-manifolds, by finding operations that reflect topological gluing operations on balls and tangles.



In 2 dimensions, I've been thinking about the classification of planar algebras. There's already an excellent classification for small cases (and this classification in turn implies a classification result in analysis, about pairs of von Neumann algebras). I'm in the midst of implementing computer programs that make use of many of the currently known techniques for analysing planar algebras. I love to program, and think we should all spend more time teaching computers interesting mathematics! It should be possible to describe currently known examples in much more detail, as well as to push the classification results further.