

Although much of string theory is beyond the reach of even the most dedicated undergraduates, my specific interests in the field are surprisingly well suited for student participation. Such opportunities are an important part of the undergraduate curriculum. As I learned from my own Harvey Mudd College thesis, participation in research is the best way to learn to think like a physicist. While experimental research is the right choice for many students, those who are passionate about theory deserve the chance to pursue it.

I believe that I can successfully collaborate with students on cutting edge projects: while I handle the field theory and other aspects out of their reach, they can contribute the geometry or other accessible calculations. Below, I outline a few explicit examples of how I plan to put that into practice. Some of these would contribute to my main research programs as described in my research statement, while others are side projects interesting in their own right.

- It would be useful in my future work to know the proper gauged linear sigma model Lagrangian to describe two or more Kaluza-Klein monopoles together. The single monopole case can serve as a model and a warm up exercise: starting from its known Lagrangian one applies the Euler-Lagrange equations to eliminate auxiliary fields and check that it gives the desired target form (this is related to the monopole metric, though no detailed knowledge of relativity is required). I would then provide the desired multi-monopole metric, and the student would look for an appropriate Lagrangian as the new starting point.
- String dualities involve algebraic rules that transform the tensors defining the geometry into those of the dual configuration. In recent work on doubled geometry I have shown that some of these rules can apply to a broader range of configurations than previously believed. I used the Kaluza-Klein monopole as an example, but it would be very interesting to see what this can tell us about dualities involving D-branes. The procedure is not technically difficult, but the student would need to become familiar with several broad concepts from relativity and string theory to understand the starting point and interpret the results.
- The background field equations of string theory include Einstein's equation relating the geometry of space-time to the energy density of various fields, and this should extend to the doubled geometry formalism. Once that is established, checking that these equations hold for the Kaluza-Klein monopole/NS5-brane system will be an important test. A student familiar with the vector potential could easily learn to calculate the energy density of the related background fields in this case, and a knowledge of general relativity (perhaps from an independent study course) would enable them to compute the curvature as well. I often use a package like Mathematica or Maple for these calculations, and students would benefit from experience with such tools.
- In a project related to cosmology, I once studied possible origins of the "dark energy" causing the expansion of the universe to accelerate. The most common explanation is vacuum energy (a cosmological constant), but another possibility is a "quintessence" field. The string-related model that I used included both of these features, but only the vacuum energy was discussed in the literature. Working out the implications of the specific quintessence field that I found could serve as a good introduction to these topics.