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AMO Physicist – Simulation and Modeling

To whom it may concern,

I come to with a strong background in geometry and a deep affinity to mathematical physics. My thesis takes Clifford analysis (which is a higher dimensional analog of complex analysis) and applies it to electromagnetic problems, specifically a geometric version of the Electrical Impedance Tomography problem. Much of this work can actually be seen as a broad generalization of Fourier theory. One of my favorite quotes is that "physics is geometry" from Misner and Wheeler. By keeping this in mind, new physics topics come quickly to me since I am usually able to translate them to geometry. I love to view physically motivated problems using in a few ways. First, extract coarse qualitative features using topology and make these more fine grained and quantitative by invoking geometry. Then, when you actually need to compute, you move to the realm of algebra.

Aside from the above, I also have a long-term collaborative project with another group that develops new Data Assimilation (DA) techniques. Our group uses model and data dimension reduction methods to promote the effectiveness of particle filters in high dimensional nonlinear systems. The software we have built is model agnostic, but at the moment we are using it to explore the information exchanged between components of a coupled ocean-atmosphere model. This has given me the ability to write thousands of lines of MATLAB code. Over this time I have worked with a handful of numerical solvers and schemes. Fortunately, this has helped me develop strong programming abilities and an learn how to write useful, readable, and modular software. Other projects such as modeling COVID dynamics and building equity trading algorithms has had me using Python as well. Lastly, I will mention that I have an interest in software design motivated by category and type theory that is used in practice in an area referred to as formal methods.

Physics modeling would be a stellar way to synthesize all of my undergraduate and graduate work. Not to mention I have felt like a physicist in mathematician's clothing ever since stepping foot in graduate school. There are many topics I have learned in over the last few years that I have been wanting to apply to more physics problems. For instance, there is the Hodge (or Helmholtz) decomposition that has proven extremely useful in practice with electromagnetics via finite element methods and this is likely helpful in simulating some of the hardware designs that your company is interested in. Another useful and modern framework that I feel very comfortable with is discrete differential geometry. This has been growing in popularity due to its wide scope of applicability and methods to reduce the computational overhead.

This position grants me the ability to share research and collaborate. I come bearing a wealth of mathematics insight and I would be ecstatic to teach these to others and provide my intuition. Over the last five years as a gradute student, I have taught and developed many courses; that includes an open source textbook for the course I am currently teaching. Alongside my colleagues I have given many research presentations and feel very comfortable being put on the spot. On the flip side, I may be less of an expert on AMO physics, but I am eager to learn and use my skills to help the team achieve their goals. Please just tell me what I need to learn and I would be happy to do so!

Not only does this position give me a chance to combine the fields of study I concentrated on as graduate student, but it pairs me with an organization located in a beautiful part of the world. It also gets me back in a laboratory setting which I have really missed. While the research environment is important, the area I live in contributes to my mood and happiness in a huge way. I would enjoy getting to explore all the areas surrounding Boulder over the coming years. I am excited to hear back from you and see your company grow!

Sincerely,

Colin Roberts