

# Colin Roberts

PHD CANDIDATE · MATHEMATICS

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**CIRES / NOAA Search Committee**

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BOULDER, COLORADO

## Space Weather Geoelectric Research Scientist

To whom it may concern,

I am a Ph.D. candidate in mathematics at Colorado State University (CSU) and I expect to graduate in June 2022. The geoelectric research scientist position available at CIRES/NOAA is fascinating and would allow me to combine all of strengths as a researcher.

I have a background in mathematical physics, but focus on electromagnetism. My thesis uses Clifford algebras as a backbone for novel algebraic, topological, and geometric methods to study a generalized version of the Electrical Impedance Tomography problem. At its core, we replace physics with geometry and generalizes it further from there. Coarse features are extracted using algebra and topology. I will remark that Clifford algebras are not so esoteric. For example, they are widely used in robotics and computer vision.

Electromagnetic fields are wonderful since they are governed almost entirely by topological laws. Thinking this was has led the group I am working with at NASA to attempt to derive a coordinate free and topological set of equations for plasmas based off the Vlasov equation. At the moment, we are providing new proofs of classical results by using the universal framework using Clifford algebras. We have a handful of new results as well. We are stepping our way towards plasmas by first describing the electromagnetic material properties and measurements of fields in a topological manner.

All the above work is in line with my thesis, but I also collaborate 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.

Space weather systems seem to be a perfect synthesis of my graduate research. I believe that topological techniques such as the Hodge decomposition can be extremely useful in practice when combined with DA schemes and finite element methods. These could possibly be combined in the framework of discrete differential geometry. In that regime, it is easy to determine topological properties which and use these to reduce the size of the space of functions.

This position grants me the ability to share our research and collaborate. I come bearing pure mathematics techniques and I would be ecstatic to teach these to others and provide my intuition. Over the last five years as a graduate 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 have organized seminar and reading groups. On the flip side, I may be less of an expert on the specific models that NOAA/CIRES deal with every day, but I am eager to learn and use my skills to help the team achieve their goals.

I would also like to continue my companionship with NASA. Their interests in electromagnetics, plasmas, and heliophysics align well with NOAA/CIRES. This potential partnership could add breadth to your organization and give me the opportunity to expand my own network of collaborators. The more people with the same unified goals, the better.

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 that values work-life balance. I have found that I am more successful by orders of magnitude when I am happy and well rested. Furthermore, while the research environment is important, the area I live in contributes to my mood in a huge way. The town of Boulder is beautiful and I would enjoy getting to explore all the surrounding areas. I can guarantee that I would be beyond content with the complete package CIRES/NOAA has to offer.

Sincerely,

**Colin Roberts**