Draft version November 18, 2023
Typeset using LaTeX **modern** style in AASTeX631

Personal Research Statement and Statement of Objectives

Edward M. Berman[1]

[1]*Northeastern University*
100 Forsyth St
Boston, MA 02115, USA

1. CONSTRAINED OPTIMIZATION AND ASTRONOMY

I am interested in the shape and geometry of data, and applications in astronomy. For example, in (Berman & McCleary 2023), I leveraged the geometry of the manifold $B_2(r) \times \mathbb{R}_+$ to accelerate a common parameter estimation task for point spread function modeling. This approach was inspired by the SE-Sync algorithm, which uses manifold learning to solve the SLAM problem in robotics (Rosen et al. 2019). For a rigorous treatment of optimization problems on manifold valued data, I encourage you to read Absil et al. (2008) and Boumal (2023). I am also interested in constraints imposed by priors for measuring ΛCDM parameters (Corasaniti et al. 2021; Abbott et al. 2022; Abbott et al. 2020). The null hypothesis says that with every new survey, we shouldn't expect our parameters to be any different. In any case, large scale surveys such as COSMOS-Web (Casey et al. 2023) provide new and interesting prob-

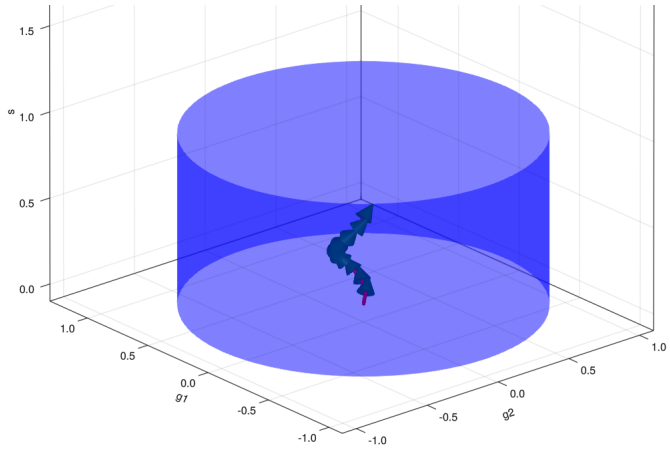

Figure 1. path to point through $B_2(r) \times \mathbb{R}_+$

Corresponding author: Edward Berman
berman.ed@northeastern.edu

lems for constrained parameter estimation and give us an oppurtunity to see if we can ***break*** existing physics

2. AI AND PROGRAMMING LANGUAGES, RELATED INTERESTS

My interests in AI are deeply intertwined with my interests in optimization. I am a coauthor of `Reflexion: Language Agents with Verbal Reinforcement Learning` (Shinn et al. 2023). I helped establish the formalisms in Reflexion during the early stages of the project, and I continue to think about the capabilities of large language models (LLMs). Lately, I've become interested in studies on interpretability, and the design of numerical experiments to study the inner mechanisms of transformers.

The ability to express an optimization problem in code is deeply intertwined with the choice of programming language. Some go as far as to write new languages for the expressed purpose of having a probabilistic programming paradigm (Holtzen et al. 2020). I am extremely invested in the Julia ecosystem, and I spend a lot of time exploring the nuances of different languages, their ability to express mathematical statements, and how we can use code LLMs to lower the barrier to entry of using different programming languages.

3. OBJECTIVES

As you might be able to tell, my research interests are a bit scattered. I try to keep everything aligned through the lens of optimization. This leads me to exploring the topology and geometry of data, AI and programming languages, numerical linear algebra and analysis, astronomy, and machine learning. At the end of the day, I like hard, sometimes even illposed problems that challenge you to find optimal solutions in the presence of constraints. During the Fall 2024 semester, I will be applying to PhD programs in mathematics. Beyond that, I will continue en route to a Professorship, dabbling in industry along the way to try and find ways for my research to help people.

4. AN ODE TO MY ADVISORS AND PROFESSORS

Throughout my career, I've been lucky enough to work with Professor Jacqueline McCleary at Northeastern University in the Department of Physics, Professor Calina Copos at Northeastern University in the Department of Mathematics, Dr. Joshua Wen at Northeastern University in the Department of Mathematics, and Dr. Qing Wu at the Air Force Research Laboratory Information Directorate. Along the way, I have met and collaborated with some incredible scientists at COSMOS-Web: The JWST Cosmic Origins Survey. There have been a number of courses at Northeastern that have truly changed my life. First and foremost, Riemannian Optimization, taught by Professor David Rosen. I am also blessed to have taken Advanced Linear Algebra with Professor Evan Dummit.

REFERENCES

Abbott, T. M. C., Aguena, M., Alarcon, A., et al. 2020, Phys. Rev. D, 102, 023509, doi: 10.1103/PhysRevD.102.023509

Abbott, T. M. C., Aguena, M., Alarcon, A., et al. 2022, PhRvD, 105, 023520, doi: 10.1103/PhysRevD.105.023520

Absil, P.-A., Mahony, R., & Sepulchre, R. 2008, Optimization Algorithms on Matrix Manifolds (Princeton, NJ: Princeton University Press), xvi+224

Berman, E., & McCleary, J. 2023, ShOpt.jl: A Julia Package for Empirical Point Spread Function Characterization of JWST NIRCam Data. https://arxiv.org/abs/2310.00071

Boumal, N. 2023, An introduction to optimization on smooth manifolds (Cambridge University Press), doi: 10.1017/9781009166164

Casey, C. M., Kartaltepe, J. S., Drakos, N. E., et al. 2023, The Astrophysical Journal, 954, 31, doi: 10.3847/1538-4357/acc2bc

Corasaniti, P.-S., Sereno, M., & Ettori, S. 2021, The Astrophysical Journal, 911, 82, doi: 10.3847/1538-4357/abe9a4

Holtzen, S., Van den Broeck, G., & Millstein, T. 2020, Proc. ACM Program. Lang., 4, doi: 10.1145/3428208

Rosen, D. M., Carlone, L., Bandeira, A. S., & Leonard, J. J. 2019, The International Journal of Robotics Research, 38, 95, doi: 10.1177/0278364918784361

Shinn, N., Cassano, F., Berman, E., et al. 2023, Reflexion: Language Agents with Verbal Reinforcement Learning. https://arxiv.org/abs/2303.11366