Statement of Purpose

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# Introduction

I am an aerospace engineer and scientific software developer who is passionate about computational dynamics. I have been fortunate to have had the opportunity to exercise this background to expand human space exploration at NASA. Now, I aspire to grow as a computational physicist, and expand astrophysical discovery through research.

As I continue to learn about open topics in astrophysics research, I am particularly drawn to research areas relating to galactic dynamics, large scale structure formation, and gravitational wave dynamics. I hope to be considered for graduate advisement by **Dr. Vogelsberger**, **Dr. Necib**, and **Dr. Hughes**. I am grateful for the opportunity to apply to the MIT Department of Physics’ PhD program; thank you for your consideration.

# Research Experience

My graduate research assistant experience under Dr. Dave Akin brought me into the weeds of constrained, performant software development. My final aerospace engineering course, Interplanetary Navigation & Guidance with Mr. Brent Barbee, introduced me to computational discovery and interdisciplinary research.

The University of Maryland’s Space Systems Lab ([SSL](https://ssl.umd.edu)) develops and maintains an 8DOF serial manipulator ([Ranger](https://ssl.umd.edu/ranger)) for satellite servicing and dexterous manipulation research. I independently developed the final components of the lab’s core robot software following a total rewrite: interfaces (C++ templates) and implementations for all kinematic solvers and Cartesian controllers. One kinematic [solver’s](https://onlinelibrary.wiley.com/doi/abs/10.1002/1097-4563(200009)17:9%3C453::AID-ROB1%3E3.0.CO;2-A) implementation introduced performance problems: the computation required several intermediate-Jacobian solutions, which I initially solved-for iteratively. After contributing the required [fixes](https://github.com/JuliaSymbolics/Symbolics.jl/pull/72), I used Julia’s [Symbolics.jl](https://symbolics.juliasymbolics.org/) to print analytical intermediate-Jacobian solutions to performant non-allocating C++ functions; as a result, each intermediate-Jacobian solve’s performance improved by a factor of two. This experience at SSL, and others, taught me how to write performant software for high-speed computations. Graduate course projects, under Mr. Barbee’s guidance, showed me how computation extends to physical discovery.

For my final M.S. course’s term project, I replicated halo orbit and invariant manifold computations as summarized by Megan Rund’s [thesis](https://digitalcommons.calpoly.edu/theses/1853/) on low-cost interplanetary transfer techniques. Intersections of manifolds can provide low-cost transfers across the solar system; NASA has labeled them [*Interplanetary Superhighways*](https://dataverse.jpl.nasa.gov/dataset.xhtml?persistentId=hdl:2014/51594). I [released](https://github.com/cadojo/CR3BP-Manifold-Research) initial conditions for over 130k periodic orbits near planets within our solar system, and published orbit and manifold solver codes to open source [Julia packages](https://github.com/cadojo/GeneralAstrodynamics.jl).

# Scientific Computing

All of the scientific software I write is published on GitHub under the username [@cadojo](https://github.com/cadojo), and is linked-to and summarized at my personal website: [loopy.codes](https://loopy.codes/packages).

# Research Aspirations

# Future Plans