Personal Statement

of Dante Buhl (Applied Math PhD applicant for Fall—2024)

Growing up in the Greater Sacramento Area and coming from a low-income family, I had never thought that I would want to become an academic, or at least attempt a PhD one day. And yet here I am at 22 years of age with a drive to learn more and make new insights in the field of fluid dynamics. I went to the University of California Santa Cruz for my undergrad in Mathematics and graduated in 3 short years with a GPA of 3.74 and highest honors in the major. Before my departure there, I found a department that was doing a really interesting fusion of mathematics and computer science, of course called Applied Mathematics, which had an amazing 4+1 master's program. That is, I would do some graduate level work in my senior year and then come back to finish my masters in only one additional year.

In the last two years, I've found a community of scholars that I really connect with and inspire me to do work that I had never considered before. I was raised to be an aspiring mathematician but I always had a knack for computers and loved the concept of making your own code. When I came to the Univeristy of California Santa Cruz and realized that most of the courses offered by the mathematics department weren't as glamourous as I thought they would be. It wasn't that the concept of Real Analysis, for example, was uninteresting to me. It was that I felt that I could not have done something with Real Analysis that somebody had not already done. The Art of Mathematics is thousands of years old, and that is part of what makes it so beautiful. It is in my favorite sense, the language of change, the very fabric of what our universe is made of. The community that I found, was a community of mathematicians who attemped to push the boundaries of known mathematics with the advent of new technologies. These mathematicians work in many academic departments of many different names, but I like to call them Applied Mathematicians. Applied Mathematics is a broad and ever-widening field, but most importantly it attempts to leave no questions unanswered.

My college journey so far has been really exciting. I've loved all things Math and Computer Science.

Now, a year later, I'm in the first year of my accelerated masters program working on a masters thesis on Stratified Turbulence in Stellar Flows with Pascale Garaud. I have already taken 2 graduate level Fluid Dynamics courses at UCSC, and spent a summer in Towson's REU program with Herve Nganguia studying numerical models of propulsion in fluids at micro scales using machine learning. It is sort of amazing how fast your life can change when you find something that really sparks your interest like that. And yet, I feel I'm still missing something. This year will end before I know it and I've only just started my exploration into Fluid Dynamics and Applied Math. There are simply more classes I want to take, more professors that I want to meet, and potentially more subjects to find and become enamored with.

Personal experience with these subjects have been developed in my work with Pascale Garaud in our exploration of Stably Stratified Turbulence generated with rotation and stochastic forcing in Stellar Fluids. This work is focused on using a HPC fortran script, called PADDI, which has been utilized on several supercomputers, and by Pascale and myself, most recently on San Diego's Supercomputer Cluster named Expanse.

PADDI is a code which relies on a spectral decomposition of Navier-Stokes terms and proceeds to perform discretized integration using several popular numerical methods techniques. My work has been focused on developing a stochastic forcing process compatible with the PADDI's discretization structure, and which relies on Gaussian Random Processes.

My other research experience over the summer of 2023 with Herve Nganguia and the rest of our research group (consisting of Garrett Hauser, Kristin Lloyd, Jazmin Sharp, and Samuel Armstrong), was focused on using a deep-learning python toolbox, DeepXDE, in order to attempt to reproduce an analytical result found in one of Nganguia's papers. This project was specifically dependent on GPU accelerated deep-learning using a Physics Informed Neural Network, PINN for short. Our experimentation relied on the attunement and experimentation with the "hyperparameters" of the neural network, and methods of boundary condition defintion in order to optimize the performance of the network. The specific PDE we used was the Navier-Stokes equations in spherical and spheroidal coordinate systems with the inclusion of the Boussinesque Approximation in a low Reynolds Number environment. Due to the scaling arguments of the problem, we were able to use the continuity equation to reduce Navier-Stokes equations even further by simplifying the diffusivity term expansion.

Besides my direct research experience in the field of fluid dynamics, I've completed several courses which would supplement my investigation into the field greatly. Those being "Intro Fluid Dynamics" and "Geophysical Fluid Dynamics", and I plan to take "Waves, Instabilities, and Turbuluence in Fluids" this Winter. My masters program at UC Santa Cruz in Scientific Computing and Applied Mathematics, SciCAM for short, also has a curriculum which is focused on numerical methods for linear algebra, differential equations, and high performance computing. All of which are very focused in further developing my ability to become a scientific researcher in the world of Direct Numerical Simulations and Fluid Dynamics.

Going into the future, I want to continue this line of work in the realm of DNS in order to study fluid dynamics as it is the perfect fusion of mathematics and computing in an interesting and seemingly endless field. The prospect of a physical lab to conduct fluids experiments is also highly alluring as I've seen smaller practical demonstrations which were highly motivating. Ultimately, the pursuit of knowledge in this field is all I desire and am prepared to dedicate several years of my life to. With my current and planned future experience, I will be a strong PhD applicant with a good foundation of previous research and expertise to start a long-term project.