CIERA
Center for Interdisciplinary Exploration and Research in Astrophysics

CIERA / Department of Physics & Astronomy
Northwestern University
1800 Sherman Ave, 8th Floor
Evanston, IL 60201

Northwestern University

November 15, 2022

Faculty Search Committee
Department of Physics and Astronomy
University of British Columbia

Dear Committee:

I am applying for the position of Assistant Professor at The Department of Physics and Astronomy at The University of British Columbia in Vancouver. With this letter, please find my curriculum vitae, publications list, a statement of research interests, a summary of teaching interests and experience, a diversity statement, and letters of reference from Prof. Benjamin Brown, Prof. Daniel Lecoanet, & Dr. Matteo Cantiello.

Astrophysical convection is ubiquitous, but is poorly understood and therefore offers exciting research avenues. The well-studied problem of Rayleigh-Bénard convection (RBC) lacks many of the complexities of astrophysical convection. For example, stars and planets have stratified atmospheres, global rotation, and long-timescale transients. On the other hand, simulations of astrophysical convection which include radiation hydrodynamics are often so complex that they become like observations themselves and are again difficult to gain understanding from. My research sits between these extremes: I try to study comprehensible physics problems which include one or some of the nuances in astrophysical research which I then work to describe in detail. I have found that the same fundamental scaling laws in RBC appear in stratified convective flows. I have gained insight into how to vary fundamental control parameters to separate turbulence and rotational constraint in rotating convection. I have extensively studied the interactions of fast and slow convective processes, paralleling the fast convection and slow evolution seen in stars.

My most influential work focuses on penetrative convection. Observations suggest that stellar structure models and 1D prescriptions of convection underestimate the size of convection zones. To match these observations, boundary mixing processes implemented in 1D stellar structure models have to be finely tuned and varied from one type of star to another. I have developed the first *a-priori* theory which can explain these observations, and follow-up work by Dr. Adam Jermyn suggests that this theory takes a step towards solving this decades-old problem. I discovered this process while running simulations in which I expected very little mixing at the convective boundary. Significantly, the convection zone advanced well beyond the expected boundary. Using my previous work on the long-term secular evolution of convection zones, I realized that I was witnessing a long-timescale relaxation process. Zahn and Roxburgh's work on penetrative convection in the 1980s and 90s provided me with analytical descriptions of this process. I modified their theory to account for the effects of viscous dissipation, which cannot be neglected even in the large Reynolds numbers regime of astrophysical flows (per the zeroth law of turbulence). This theory agreed well with laminar and turbulent three-dimensional simulations using the Dedalus code. I parameterized this theory for inclusion in 1D stellar structure models. I am currently collaborating with Dr. Cole

Johnston to implement this theoretical prescription into 1D MESA stellar evolution models to understand how this process affects stellar evolution. In my attached career plan, I discuss in more detail several possible directions for the development of this work.

Throughout my academic career, I have striven not only to conduct state-of-the-art research, but also to develop my pedagogical and mentoring expertise through workshop attendance and practice. I now provide research mentorship to five graduate students across two institutions (Northwestern and Univ. Colorado). All of these mentorship relationships have led to collaborative contributions on papers which are published or in prep (marked on my publication list). Within my research mentoring relationships and more broadly within my academic institution, I am dedicated to providing a just, equitable and inclusive teaching and research environment. During my postdoctoral fellowship at CIERA, I chaired the K12 education and public outreach taskforce, and I now serve as a core member of CIERA's JEDI (Justice, Equity, Diversity, Inclusion) committee, which has organized an external sociosystemic organizational development plan, including a departmental climate survey, in the coming academic year. I have a track record of participating in public outreach programs (please refer to my CV), and I am excited to continue to participate in outreach at UBC, particularly through involvement in the PHAS Outreach Program's summer camps and teacher support resources. I also plan to continue my EDI work at the departmental level by e.g., building more just hiring and admissions practices and would be happy to bring my experience in coordinating a climate survey to UBC so that the department can learn about and be responsive to its problem areas.

I am particularly excited about this job opportunity. My research naturally fits into your department's Astronomy & Astrophysics research area, and I see great potential for productive collaboration between myself and Profs. Heyl, Matthews, and Richer on topics like stellar evolution, stellar pulsations, and characterizing stellar populations. I bring knowledge of new research areas, e.g., spectral coding methods, interactions between convection and stable regions, and the fluid dynamics of rotation, magnetism, and multi-timescale processes. I am an expert at using the *Dedalus* code, and I hope to use it to expand my research horizons through collaborations outside of my past expertise. I would also be happy to help others at UBC learn how to apply this tool to their own research in a broad range of research areas such as biophysics. I value teaching and mentorship, and am an engaged member of my department community. For these reasons, I am an ideal candidate for this post.

If there are any other questions or concerns please do not hesitate to contact me. Thank you for your time and consideration.

Sincerely,

Evan H. Anders