C I E R A
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

June 10, 2022

Faculty Search Committee
School of Mathematics, Statistics and Physics
Newcastle University

Dear Committee:

I am applying for the position of Lecturer in Applied Mathematics at the Newcastle University School of Mathematics, Statistics and Physics. With this letter, please find my curriculum vitae and personal career plan.

Astrophysical convective processes are poorly understood and therefore offer 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. I investigate these nuances in my research. 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.

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 three institutions. Two of these mentorship relationships have already led to collaborative contributions on papers (marked on my CV). The other three mentees all have papers in preparation: Imogen Cresswell (Univ. Colorado) is finishing a paper on force balances in magnetoconvection, Whitney Powers (Univ. Colorado) is finishing a manuscript on stratified convection, and Emma Kaufman (Northwestern) is finishing a project on magnetic field instabilities in spherical geometry. 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 am particularly excited about this Lecturer position and the potential for productive collaboration between myself and Drs. Rogers, Wood, Guervilly, and Bushby on topics like the interactions between convection and stable regions, rotationally-constrained convection, stratified convection, and magnetoconvection. I bring knowledge of new research areas, e.g., multi-timescale processes, expertise with the open-source Dedalus code, and also multi-scale processes such as my "entropy rain" research. 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.

In support of my application, please feel free to contact the following individuals:

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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