CIERA
Center for Interdisciplinary Exploration and Research in Astrophysics

CIERA / Department of Physics & Astronomy
Northwestern University
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Northwestern University

October 11, 2022

Faculty Search Committee
Department of Physics
University of Oregon

Dear Committee:

I am applying for the position of Assistant Professor of Physics at the University of Oregon Department of Physics. With this letter, please find my curriculum vitae, statement of research plans, statement of teaching, and statement on diversity.

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 density-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, and I was surprised when 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 low-dissipation turbulent regime of astrophysical flows (per the zeroth law of turbulence). This theory agreed well with laminar and turbulent three-dimensional simulations that I ran using the Dedalus code. I parameterized this theory for inclusion in 1D stellar structure models, and I am currently working on an international collaboration with Dr. Cole Johnston to implement this theoretical prescription into 1D MESA stellar evolution models. In my research statement, I discuss 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 CV). 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 excited to continue my EDI work through involvement in programs like STEM CORE at the University of Oregon, and I'd love to participate in the professional development workshops offered through the Science Literacy Program to build upon my knowledge of best teaching and mentoring practices.

I am particularly excited about this University of Oregon faculty position. I bring knowledge expertise in astrophysical and geophysical convective flows that are currently not represented in the Physics department, but which could be used to forge connections and collaborations with the department of earth sciences, e.g., Profs. Dufek, Erickson, Karlstrom, and Paty. Beyond this, I am an expert at evolving PDEs using spectral methods and the *Dedalus* pseudospectral framework. Using this expertise, I see many opportunities for producitve collaboration within the Physics department in areas including biophysics and biofluidics (e.g., Profs. Parthasarathy, Paulose, and Ursell), and would be interested in expanding the collaboration network to experts in other departments at UO like Prof. Sutherland in Biology. I am also extremely interested in characterizing the evolution of massive stars and the distribution of their compact object remnants (massive stars and black holes), and would be excited to work alongside Profs. Farr and Frey in this endeavor. 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