PI Response for "Improved magnetoconvection models for precision astrophysics"

Reviewer 1 This reviewer asked, *" Are there any plans to use this fellowship as a platform to build a team by applying for future funding?"* Yes, I plan to apply for PhD students from the University's STFC DTP allocation, and I also hope to apply for student funding through Leverhulme to complement my Rutherford fellowship. While the University of Exeter cannot guarantee a proleptic lectureship with this fellowship, I hope to use this fellowship as a springboard towards obtaining a permanent position, and I plan to gain mentorship experience as a Rutherford fellow.

This reviewer also asked, *"Will the outputs of your approximations be directly comparable to the full radiative transfer?"* Yes, absolutely. Fundamental properties like the temperature, density, and velocity can be directly compared to full radiative hydrodynamical simulations. I will reach out to experts who use full radiative hydrodynamical codes (e.g., *Athena*) and obtain data for direct comparisons with my approximations to determine how valid the approximations are.

Finally, this reviewer asked, *" The convective blueshift work is interesting in its own right but, since the application mentions exoplanet surveys, I wonder this work will be incorporated into such exoplanet surveys. Will this work enable the convective signature to be removed from the data or will is just provide estimates of the typical magnitude of the convective blueshift expected? If it is the latter, how useful is this for exoplanet surveys?"* The goal of this work is to create a prescription for convective blueshift which can be used to remove the signature of convective blueshift from radial velocity measurements. This is achievable; if I can understand the convective velocities and the sizes of convective granules that occur across the HR diagram, such a prescription can be calibrated against simulations and applied to datasets. I note that this may not remove *all* the features of convection from radial velocity datasets, such as those associated with small-scale magnetic features like bright points and plages, but it will provide an excellent baseline and remove the first-order effects of convection from these datasets.

Reviewer 2 This reviewer noted that *" Task 3, while certainly feasible, I think is less likely to have a great impact; as the applicant acknowledges, consistency between 3D DNS and 1D stellar models has never really been achieved even under much simpler conditions than will be considered here, so it seems unlikely that a reconciliation between such models can be achieved in full-sphere DNS with imposed magnetic fields. Nevertheless, the results would contribute to the debate regarding convective transport in such objects."* This is an excellent point, and I want to somewhat clarify the goal of task 3. The goal in task 3 is not just to test if 1D implementations of magnetoconvection reflect the reality of 3D simulations or not. The goal is to understand how magnetic fields affects heat transport and thermal stratification in 3D spherical convection, and to determine if any 1D prescriptions do a good job of describing my simulations. If not, I hope to deliver a new 1D prescription for stellar evolution codes built using evidence from my simulations.

Reviewer 3 This reviewer had two comments about feasibility. In the first, they asked, *" 1) The proposal indicates that the global models are going to be fully compressible.... Such global models would normally make an approximation (e.g. anelastic) to filter out sound waves from the system and I wonder whether that might be necessary here in order to achieve the goals set out?"* My code, `Dedalus`, uses an implicit-explicit (IMEX) timestepping scheme; linear equation terms are timestepped implicitly while nonlinear terms are timestepped explicitly. Implicit timestepping does not have the rigid timestep constraints that more traditional explicit timestepping methods have. In fully compressible simulations, I implicitly timestep the linear terms associated with sound waves, so I can evolve low-Mach convection while taking timesteps which are large compared to the sound wave travel time. I used this technique for very low-Mach flows in previous work [1], and this is similar to the technique that Prof. Baraffe's group uses with the MUSIC (implicit) code. We will also use the accelerated evolution methods laid out in [2], which allowed us to thermally equilibrate extended penetrative zones while saving up to an order of magnitude of computing resources.

This reviewer also asked, *"2) I wonder how much computing time is needed in order to achieve these goals?"* I propose to study large suites of moderately turbulent convection for each proposed task. From past experience, each of these simulations take $\mathcal{O}(10^{4-5})$ cpu-hours to perform, and I will perform $\mathcal{O}(10^{1-2})$ simulations per study, so I will need access to an allocation of 10^{6-7} cpu-hours

(1-10 million), and there is flexibility in the number of simulations that I will perform based on how much computing time I will have access to. I have had success securing tens of millions of cpu-hours per year through my research group on machines like *NASA Pleiades* in the past, and Exeter's astrophysics group has access to a yearly allocation of roughly 20-30 million cpu-hours, which I will have shared access to. I do plan to apply for time on DiRAC, and if necessary I would explore seeking out time through other pools e.g., PRACE, but I do not think that would be needed for the scale of simulations proposed here.

References

[1] Anders, E. H., et al. 2017, PRF, 2, 083501

[2] —. 2022, ApJ, 926, 169