Abstract

1. Introduction

- Why M67
- Other work on M67 estimation (eg. DBossini, DStello)
- Other work using NN on stellar evolution
- Other work using HBM on clusters
- Summary of how the study works and lay out the plan for the rest of the paper

2. Data

- Where we got it from: Gaia
- What data we took: G, Bp and Rp band apparent mags, parallax (the whole cluster)
- M67 membership (DBossini) and cutting criteria
- Criteria of only using MS stars
- Plot of data CMD with all M67 members as gray dots
- Github link to raw data table

3. Grid of stellar models and its input physics

- Ask Tanda to write, can probably relegate a lot to the Interstellar I
- Used the grid of dwarfs with diffusion turned on

4. Hierarchical Bayesian model

4.1. Principles
  - Describe the theory of HBM and how the different levels of parameters connect with each other in the posterior equation/likelihood (can relegate a lot of the explanation to Interstellar I)
  - Justify prior choices (on the fundamentals)
  - Discuss about partial pooling MLT
  - Include a PGM and explain

4.2. Emulating stellar evolution codes with Neural Networks
  - Introduce the use of neural networks as a means of approximating stellar evolution models, where there is a trade off in accuracy for computational speed. However, the accuracy of the neural networks are such that they are not the limiting source of error.
  - Why use a NN with a HBM
  - Compare NN to generating tracks from MESA
  - Do we mention why we're only using dwarf stars (overfitting due to RGB)
  - Not sure the detail I need to go into on the inner workings of the NN. Reference Guy's paper for further details on how NNs work.

- Mention Cybenko
- The best NN tends to be found by an iterative process of tweaking these variables
- Mention how the NN connects to the training grid
- What kind of NN did we use? what were our inputs and outputs, remember to say what and why we used log10 on and the radius luminosity conversion stuff. I don't know if I should supply the input and output equation for our NN. Do I need to mention that it is trained on Delnu despite the fact it is never used?
- What is the importance of linking fundamentals and observables?
- Give the NN variables that were used. Did the application of certain variables cause problems and what did we do about it.
- End with the results of the NN

4.3. Relating intermediate parameters to observables

- Describe the mapping from R, Teff and surface feh into all the other stuff
- The training of a secondary NN to map from [Teff, logg, feh and Av] onto BCs (still yet to solve the Av problem with MIST!!!)
- Justify prior choices for mean Av, spread Av, dist mod, zero pt offset, mag err multiple
- The usage of surface feh data for 10 stars to better constraint initial feh
- The usage of cluster-mean parallax to better constraint dist mod

4.4. Modelling non-singular stars

- The binary mixture model
- (if implemented this way in the end:) The choice of simplification for the three bands to share the same q and binary distribution
- Justify using a "broad-stroke" mixture model only on the magnitudes instead of modelling the mass ratio of each pair of stars
- Justify prior choices for q, delta_mG and sigma_multiple

4.5. Sampling the posterior

- Pymc3 and NUTS sampler
- Discuss about chains, tuning and sampling steps, Rhats and effective sample size to justify the work

4.6. Tests of robustness/model biases/errors???

5. Results

- Numerical results in a table
- Corner plots
- Both max-pool MLT and partial-pool MLT
- Github link to table of individual stars results

6. Discussion

- Discuss about covariance and its implications

7. Conclusion

Acknowledgements