Improving Metal-Poor Stellar Evolution Models

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INTRODUCTION

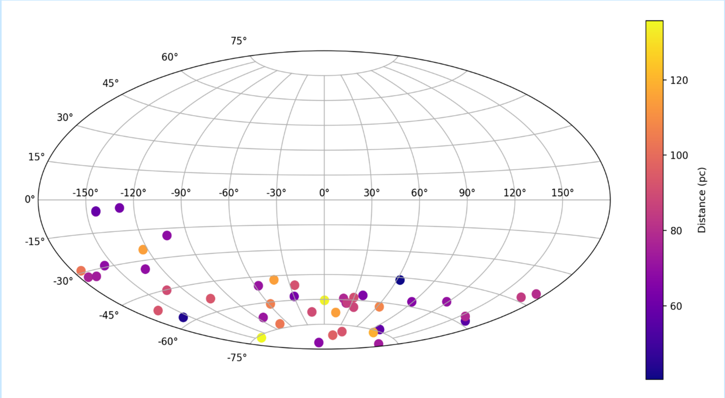

Figure 1: Spatial location and distances (from Gaia DR2) for stars whose spectra have been obtained for this project.

Current stellar evolution models require a number of assumptions and contain free parameters which are calibrated to produce accurate models of the Sun, and these same assumptions and calibrations are used to model the first stars formed in our galaxy, which have very few metals compared to the Sun. The European Gaia satellite Data Release 2 (Fig. 1) has recently determined the distances to a large number of stars, including many metal-poor stars. This provides us with a new opportunity to calibrate metal-poor stellar models, with the end goal being an improvement in the Dartmouth Stellar Evolution Database (DSED).

METHODS

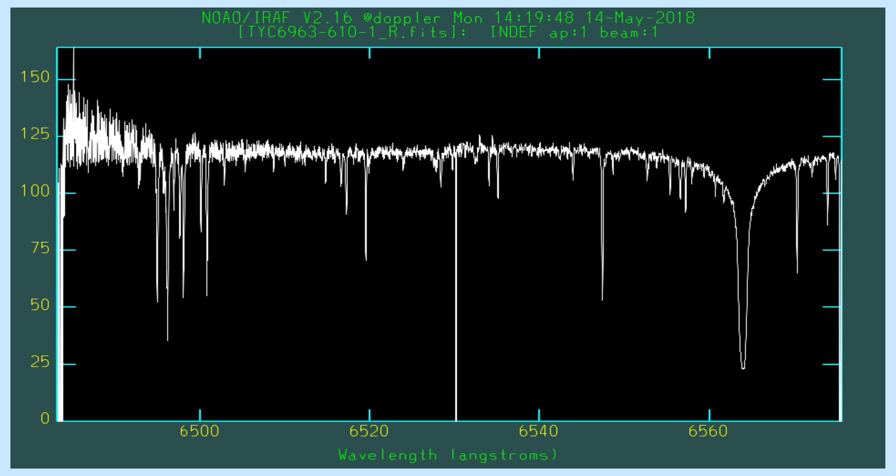

Figure 2: An example spectrum from one of the stars studied

We begin by using spectral data taken at the Southern African Large Telescope and measuring the equivalent widths (EW) of known spectral lines of various atomic transitions for our selected metal-poor stars (Fig 2). We then run the EW data through a program which compares it to stellar atmosphere models in order to find the relative abundances of the metals in the star. In particular, we are looking for the [Fe/H] value, which is a measure of the relative abundance of iron to hydrogen in the star we are measuring compared to the relative abundance in the Sun on a logarithmic scale.

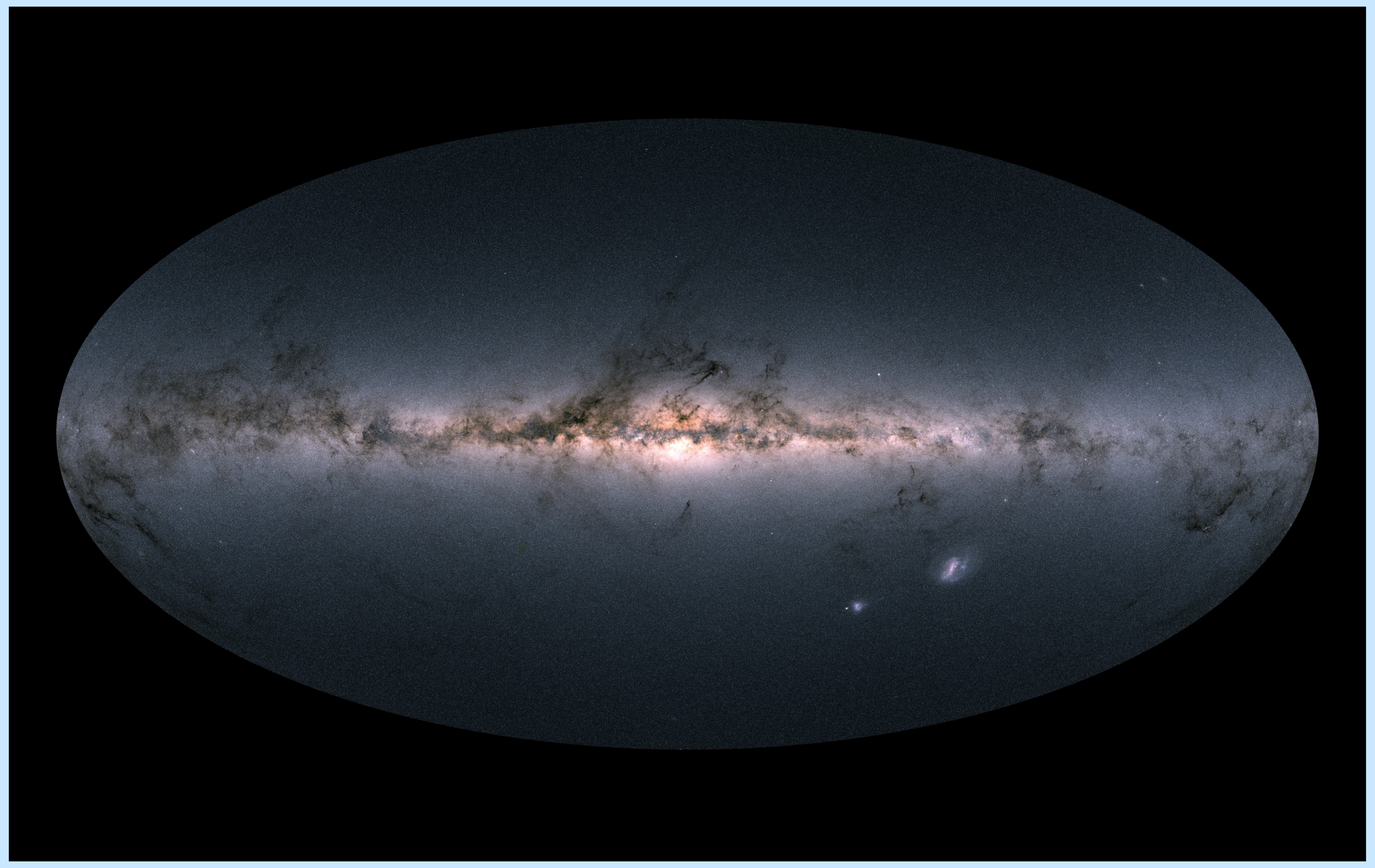

Figure 3: Gaia's all-sky view of the Milky Way (Image credit: ESA/Gaia/DPAC)

RESULTS

Once we complete the stellar atmosphere models for about twenty metal-poor stars, we plot them alongside the isochrones currently in DSED on an HR diagram using the absolute magnitudes calculated from Gaia parallaxes and color data taken from SIMBAD (Fig 4). A single isochrone shows us where current models predict a group of stars of the same general age and metallicity will fall on an HR diagram. An isochrone is a line and not a point due to variation in mass. Because we are working with metal-poor stars, we assume they are all older, Pop II stars. Because of this, we use an age of 12 Gyr when downloading the isochrones shown in Fig 4 from DSED.

RESULTS CONT.

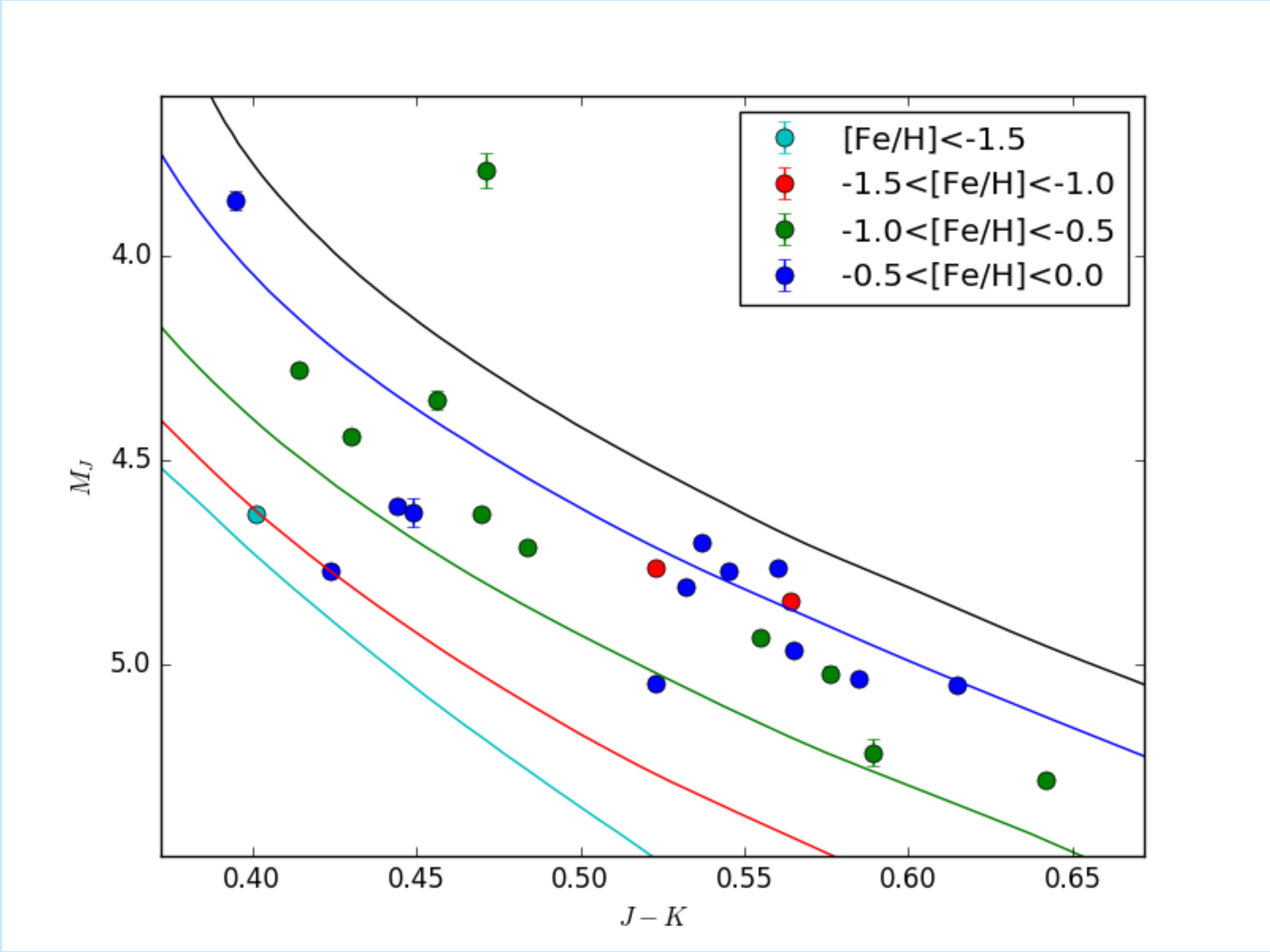

Figure 4: Current stellar model isochrones (solid lines; Cyan = -1.3; Green = -0.8; Blue = -0.3, Black = 0.0) shown alongside stars with measured [Fe/H] values.-2.0; Red =

CONCLUSIONS

When we plot the measured stars alongside our current models (Fig. 4), it becomes clear that they do not line up with the current models, nor do stars with similar [Fe/H] values seem to lie on similar lines as predicted by the models. This result requires further study, and suggests that current stellar evolution models need to be recalibrated for metal-poor stars.

FUTURE WORK

- Gaia DR3 will yield more accurate and precise parallax data
- New spectral data from SALT will increase our sample size
- Applications to the study of Globular Clusters

REFERENCES

E. O'Malley, A. McWilliam, B. Chaboyer, and I. Thompson. A Differential Abundance Analysis of Very Metal-poor Stars. *Astrophysical Journal,* 838:2, March 2017. doi:10.3847/1538-4357/aa62a2