MW-Gaia STSM

Star Formation Histories of Galactic Building Blocks

Emma Dodd from Kapteyn Institute, University of Groningen (Holland) spent one month (05/03-02/04/2023) at the University of Granada (Spain) to collaborate with Tomás Ruiz Lara.

During the work visit I met regularly with Tomás Ruiz Lara to learn all of the necessary steps of deriving the star formation histories for my samples of Thamnos and Sequoia. In the first two weeks I learnt how to run the codes on an example disk sample, learning the steps and how to interpret the outputs. Then I started to run on my refined 5D samples of Thamnos and Sequoia, identifying the signal and also the contamination in these sample. I tested how the number of stars affects the results and how taking a subsample changes the outcome, in order to check how robust, the preliminary results are. Since Thamnos (and also Sequoia but to a lesser extent) are contaminated by Gaia Enceladus debris, then the signal we are looking for is old and metal poor, but the contamination is also. This proved difficult for disentangling what signals are due to the substructure in question. This was something we had anticipated but we found a few extra problems along the way. I am currently running more tests to see if we can be convinced that the signal we think is Thamnos cannot be confused with a signal of Gaia Enceladus contamination. Due to degeneracies in age metallicity for isochrones we also have to test variations in multiple runs and slightly different samples to see how this changes the results.

We also made the first steps in discussing the steps of how can simulate completeness if we move from the samples defined in 5D to those defined in 6D.

During the visit I attended the group meetings of the host group where I learnt about a variety of topics, including a coding workshop and talks about the environmental effects on the stellar populations in dwarf galaxies. I presented my own work here during the visit, including both of my papers and the plan for this project. It was very useful to present to a different audience and get their feedback. I met virtually with Carme Gallart at the IAC with my host in Granada to discuss the plan going forward the project and get feedback on the steps taken so far. Carme is the expert in deriving the star formation histories and so having this connection is very valuable.

Furthermore, being in Granada and working closely with Tomás meant that I could progress a lot faster by asking questions and having regular meetings, and also receiving regular updates from the team in the IAC who are working on further developing and testing of the codes.

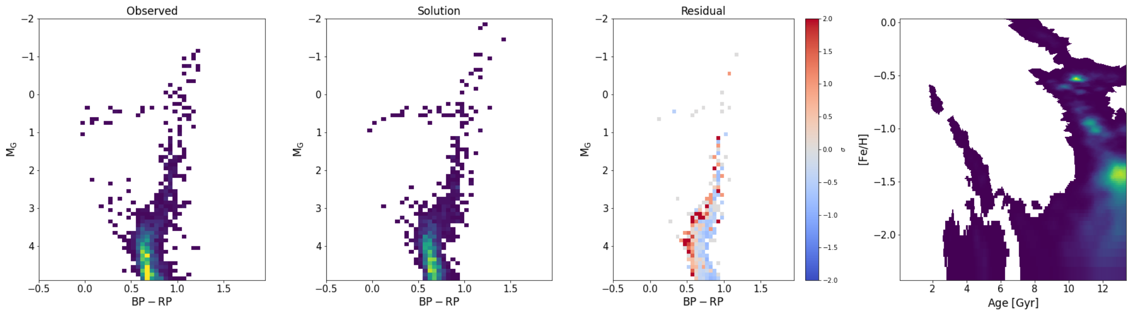
Description of the STSM main achievements and planned follow-up activities

The outcomes of the visit were to learn about the tools developed by Tomás Ruiz-Lara and colleagues, in order to fit colour magnitude data from Gaia samples and derive their star formation history.

We have successfully applied the SFH codes to my samples of Sequoia and Thamnos, running on various subsamples and also contamination samples to test the robustness. We ended the visit having made decisions on how to define our best samples, as planned in the outline. We are able to see hints of the results we were expecting for Thamnos and Sequoia, the CMD fitting successfully reproduces the metallicity distributions but we are doing more work now to refine which signals can arise from Gaia Enceladus contamination.

The plan will be to continue these careful tests and once we are able to confidently say which signal corresponds to Thamnos and which to contamination we will begin to write up the results to publish a paper on the SFH of both Thamnos and Sequoia. If we find from the tests that we cannot confidently separate the contamination in the SFH signal, then we can still publish this work to show what we can do if we can have larger and cleaner samples of Thamnos and Sequoia.

Currently the samples are selected using kinematical information but there is considerable overlap from accretion events in these spaces, especially in the region of Thamnos. However, we note that any selection we make on the data will need to mimicked in the synthetic CMD, therefore including e.g. chemical abundance for selecting cleaner samples will mean we need to think more about how we simulate the completeness of those samples. Furthermore, we planned to make the first steps into converting the codes such that we can select our samples in 6D i.e., with Gaia radial velocities, and simulate the completeness of the RVS sample in the synthetic CMD. This is something we discussed and started to make plans for, however, it is not the greatest priority right now as the samples do not appear to be that much cleaner when selecting in 6D to our 5D approach. Therefore, it will not reduce the issues we are having with Gaia Enceladus contamination. The most important steps now are to test how much an issue contamination is for interpreting the star formation histories of Thamnos and Sequoia. Once we are confident that the signals in age and metallicity space can be attributed to Thamnos/Sequoia stars, we can then make any steps to refine or improve the method, e.g. to convert our sample selections to 6D if needed, before publishing the results.



Galaxies' stellar haloes are known to build up through the accretion of smaller systems, with stars from the same progenitor deposited onto similar orbits. Thanks to the advent of Gaia data, we are now able to identify such merger debris and provide insights into the assembly history of our own Galaxy, as well as how mergers play a role in shaping the Galaxy. The local stellar halo is believed to be dominated by debris from a single merger, Gaia-Enceladus. Additionally, several other dynamical substructures have been uncovered, although their nature and characterisation is rather limited or non-existent. Focusing on two substructures, Thamnos and Sequoia, and fitting absolute colour-magnitude diagrams (CMDs) dominated by stars from these accreted systems, we are able to obtain age and metallicity distributions for the stars. In this case, we show the

Age-Metallicity distribution of a Thamnos sample which is contaminated by Gaia Enceladus stars. We see that the bulk of their stars are old and have [Fe/H] around -1.5, whereas some traces of an equally old and metal-poorer population is seen. Some contamination from the disc remains and is seen at higher metallicities. We assess the contamination in these samples, and in doing so the added age dimension will help us to interpret the halo substructures more comprehensively and aids our understanding of galaxy evolution in a broader context.