MW-Gaia WG1 Workshop

Revealed by Gaia: the central halo of the Milky Way

Cambridge (UK), 11th-13th September 2023

The workshop Revealed by Gaia: the central halo of the Milky Way took place as hybrid in the Lecture Theatre of the Hoyle Building at the Institute of Astronomy, Cambridge, UK, from 11th to 13th September 2023.

This was the fourteenth workshop of the CA18104 COST Action MW-Gaia and the sixth workshop of the Working Group 2 (WG2). The format of the workshop was based on invited talks (25+5min), contributed talks (15+5 min) and poster presentations (2-3 min)

The number of participants was limited. The selection of participants was based on the relevance of the proposed abstract, the importance of the workshop for the advancement of the career of the applicant as well as diversity (in gender, country, etc). As with all COST actions, early-career scientists were given priority.

Scientific motivation of the workshop

This MW-Gaia COST Action (www.mw-gaia.org) workshop focused on the central halo of the Milky Way (R<10 kpc). Given its proximity and high stellar density, the inner halo is an ideal target for stellar surveys. However, the central halo remains largely unstudied due to overwhelming contamination from the MW disc and high dust extinction. The inner accreted halo is predicted to host the earliest formed and the most primitive building blocks, but also to contain the strongest contribution from various in-situ components. While “unmixing” the inner halo would be ideal, relatively short dynamical timescales and strong perturbations from the Galactic bar make this incredibly difficult. In this workshop, we discussed the advances that have been made towards characterising the inner halo; focusing on both the accreted and in-situ components, past, present and future tracers of structure and the influence of the Galactic bar in reshaping halo dynamics. We also discussed what, as a community, we would like to focus on next, through synthesising the perspectives of simulators, theorists and observers.

This is an interactive meeting. Equal amount of time will be given to the planned presentations and the discussion sessions.

Topics of discussion:

- ✓ Accreted halo. Can we trace the accreted halo component? If so, in what space is it traced best, through chemistry, dynamics or a combination of both? How close to the Galactic Centre does the GS/E debris get? Is there evidence for additional large accretion events like Kraken/Heracles/Koala? Where are the primitive stars from the earliest accreted and smallest dwarfs?
- ✓ In-situ halo. While the exact formation channels contributing to the in-situ halo are still the subject of debate, three different in-situ channels have been proposed

to contribute to the inner halo of the Galaxy: the pre-disc Aurora/proto-Galaxy, the splashed disc induced by GS/E and earlier mergers and the star-burst. Can we trace and disentangle all three? What are their properties (total mass, shape, density distributions, metallicity distributions)? What is the contribution from disrupted globular clusters?

- ✓ Bar-halo interactions. How can we use bar-halo interactions to constrain the structure, dynamics and formation of the Galactic bar? When was the bar formed? Is there any connection to the GS/E merger? What are the signatures of the bar interaction in the stellar halo and its sub-structure: stream shepherding, chevron perturbations, spinning up, resonant trapping.
- ✓ Central MW tracers. RR Lyrae. Red Clump stars. Long Periodic Variables. Metal-poor stars.

Day One

The day began with the invited talk “Galactic halo and Gaia-Sausage-Enceladus main progenitors in cosmological simulations” Azedah Fattahi (Durham) and one contributed talk:

- ✓ “The diversity and similarity of Milky Way-like stellar haloes with radially anisotropic massive mergers” by Matthew Orkney (Barcelona)

Followed by 30 min discussion: What defines a MW analogue in simulations? Do we have close analogues of MW in any of the simulation suites? Do we need different simulations?

After coffee there were two more contributed talks:

- ✓ “GASTRO library: interpreting substructures of the Milky Way stellar halo with SPH + N-body single merger models” by João A. S. Amarante (Barcelona)
- ✓ “The early assembly history of the Milky Way” by Danny Horta (New York)

Followed by a discussion with topics: What defines the primordial MW? Is it possible to predict and recover the signature of the primordial MW in simulations and observations? What is in-situ?

After lunch there were three more contributed talks:

- ✓ “Mechanics of disk tilting as a result of satellite accretion” by Oren Slone (New York)
- ✓ “Dead man tells tales: MW stellar halo metallicity distribution reveals the past of the GSE-progenitor” by Sergey Khoperskov (Potsdam)
- ✓ “Mock surveys from cosmological simulations of Milky Way analogues” by Alex Riley (Durham)

Followed by a discussion on topics: What is left to be discovered when it comes to GS/E? Have we pinned down the properties of the GS/E-MW encounter? What role did the encounter play in reshaping the MW?

Day Two

The Morning Session began with the invited talk “Chemical signatures of in-situ and accreted stellar populations” (online) by Maria Bergemann (Heidelberg). Then two contributed talks:

- ✓ “Tidal debris from Omega Centauri discovered with chemo-kinematic tagging” by Kris Youakim (Stockholm)
- ✓ “Revealing the accretion that fuelled the formation of the Milky Way disk through chemical evolution” by Boquan Chen (Sydney)

It was followed by a discussion on the topics: Best chemical signatures to disentangle in-situ and accreted populations. Globular cluster chemical signatures.

After the coffee break the invited talk “Chemical tagging of the Galactic components: tracing the stellar populations in the inner Galaxy” by Anna Queiroz (Potsdam) was followed by a discussion: When does chemical tagging work best and why? Any new chemical tags that we did not know about?

After lunch the invited talk “Metal-poor stars in the centre of the Milky Way” by Anke Ardern-Arentsen (Cambridge) was followed by two contributed talks:

- ✓ “Chemodynamically Surveying the Ancient Heart of the Galaxy” (online) by Vedant Chandra (Harvard)
- ✓ “Tracing the Old, Metal-Poor Bulge: Milky Way Assembly through Observations of Old Stars” by Keith Hawkins (Austin)

With a discussion on topics: What are the primary drivers of chemical diversity in the low-metallicity regime? What information is encoded in the chemical abundance scatter?

After the coffee two contributed talks:

- ✓ “Dissecting the Stellar Halo Using Chemistry, Extreme Deconvolution and Principal Component Analysis“ by Nicole Buckley (Surrey)
- ✓ “Can we really pick and choose? Benchmarking various selections of Gaia Enceladus/Sausage stars in observations with simulations” by Andreia Carrillo (Durham)

Followed by a discussion on What chemical information is missing from cosmo sims to help us compare observations with models of MW formation? Or vice versa, what information is missing from observations?

Day Three

The Morning Session of the last day began with the invited talk “Stellar populations of the inner Galaxy: structure, kinematics, age and chemistry” by Jason Sanders (London) and two contributed talks:

- ✓ “Kinematic fractionation of the Milky Way boxy/peanut bulge seen in variable stars” by Marcin Semczuk (Barcelona)
- ✓ “CO in Cepheids – A route to reduce the dispersion on the Cepheid Leavitt Law (LL) for the Milky Way, and to obtain metallicities for large numbers of Cepheids” by Steve Ardern (Bath)

Then followed by a discussion on: How does the structure and kinematics of the bar depend on chemistry and age? Is there a classical bulge in the MW?

After the coffee break the invited talk “Tracing the low-metallicity planar stars under a rapidly slowing down bar” Zhen Yuan (Strasbourg) and a contributed talk:

- ✓ “Trapped in the disk: constraining the galactic bar properties using planar metal-poor stars” by Akshara Viswanathan (Groningen)

Followed with a discussion on: Are there discernible trends in the sub-structure properties on moving from the outer halo to the inner MW and the disk?

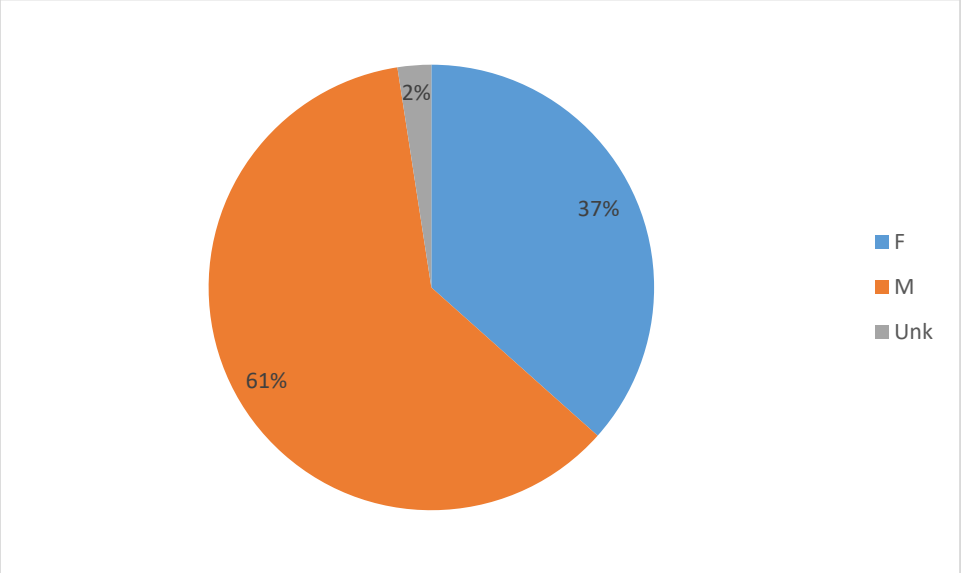
The Afternoon Session brought the invited talk “Bulge/bar formation in numerical simulations” by Victor Debattista (Central Lancashire) and two contributed talks

- ✓ “Accelerated phase-mixing in the stellar halo due to a rotating bar” by Elliot Davies (Cambridge)
- ✓ “Stellar halo substructure generated by bar resonances” by Adam Dillamore (Cambridge)

Followed by a discussion on: When and how was the MW’s bar created? Interactions between the bar and the stellar halo.

And a Final discussion after the coffee break to conclude the meeting.

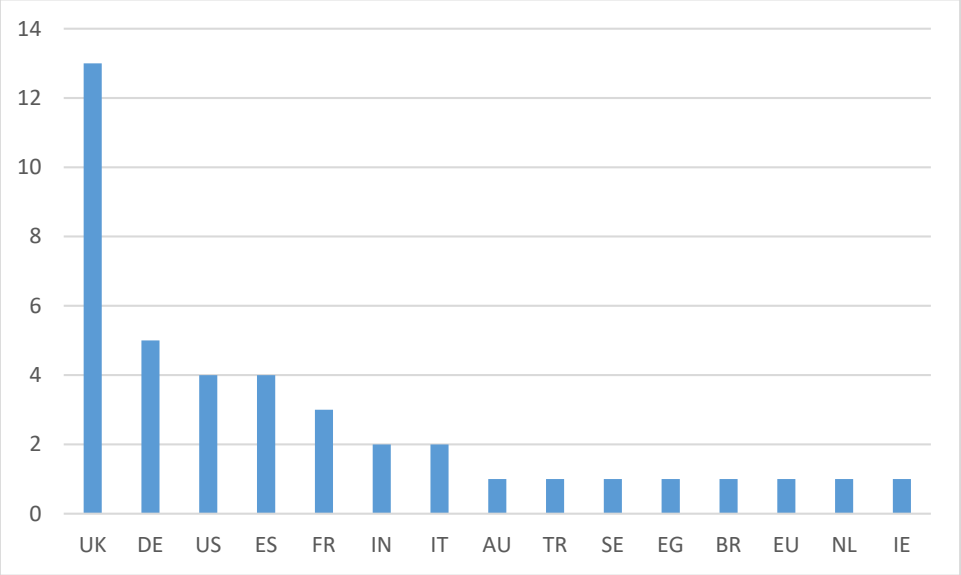
The workshop in numbers



The workshop was attended by 41 researchers (2 remotely), 37% of them female.

The SOC and LOC had a 38% (3 out of 8) of female researchers.

From the total, XX participants (%, including invited speakers) had financial support by the COST Action.



There were researchers from 15 different countries in Europe (mostly UK), US, India and Australia.

There were 24 presentations. 47% of female participants presented while 68% of male participants did. There were 7 Invited talks (57% female) and 17 Contributed talks (18% female).

Regarding career stage there were 4 Early Career Researchers (10% of young researchers).

Report prepared by Lola Balaguer-Núñez.