The Milky Way and Resolved Stellar Populations (SWG3)

2019 updates to the MSE Detailed Science Case

SWG3 co-leads:
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Overall goal: Galactic archaeology

Themes in the Detailed Science Case
• Complementing Gaia in the Milky Way
• Local Group dwarf galaxies
• M31 & M33 chemodynamics
• ISM mapping
Survey scope

MSE’s G<20 magnitude limit...

...means it can observe stars throughout all components of the Milky Way.
For context: other Hi-res GA projects

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<th>APOGEE-2</th>
<th>GALAH</th>
<th>WEAVE</th>
<th>4MOST</th>
<th>MOONS</th>
<th>MSE</th>
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<tr>
<td>Hem.</td>
<td>N &amp; S</td>
<td>S</td>
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<tr>
<td>λ</td>
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<td>H&lt;13</td>
<td>V&lt;14</td>
<td>V&lt;16</td>
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<td>H&lt;15.5</td>
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Survey scope

Precise abundances for 15+ elements from all of the main nucleosynthetic channels

- Iron peak, $\alpha$, light odd Z, r process, s process
- Requires $R \sim 40,000$
Survey scope

Large fraction of the Galactic volume covered
• All Galactic components at all Galactocentric radii
Observing millions of stars per year creates new possibilities
• Time-domain spectroscopy
• Rare objects

Gaia DR2 sky density of targets (per deg$^2$) to G=20, accessible to MSE ($\delta$>$-30^\circ$)
The ultimate Gaia followup

Position + distance + proper motion + RV + abundances

\[ 2D \rightarrow 3D \rightarrow 6D \rightarrow 15+D \]

Gaia will return RV and some abundances for \( G<13 \), and RV for \( G<16 \), but \( G \rightarrow 20 \) is an open discovery space.
The disk

The outer disk in situ:
- Structure, stellar ages, and signatures of interactions to the far edge of the disk

Disk dynamics:
- 3D velocity map across the full disk
- Mass distribution, ongoing perturbations
The bulge

Linking inner & outer substructures
Searching for primordial populations

Gonzalez et al. 2015
The halo

The outer halo in situ

- RGB stars to the virial radius
- Detail on streams known from photometry and astrometry

Rare and peculiar stars

- Extremely metal-poor
- r process rich

Globular clusters

- Milky Way and extragalactic
- Multiple stellar populations

Ibata et al. 2019
Chemical tagging

Gives different information for different Galactic components

• Disk: identify original star-forming groups, chart Galactic chemical evolution

• Bulge: differentiate primordial stars from later star formation, correlations between kinematic, spatial and abundance substructure

• Halo: separate in situ from accreted stars, specify the origin of streams (dwarf galaxy vs globular cluster)
Dwarf galaxy evolution

The Local Group, in co-moving size, is larger than the Hubble Deep Field at $z \sim 3$, and is a cosmologically representative volume at $z \sim 7$

- This gives a view of evolution at the bottom of the mass function that JWST can’t match

Boylan-Kolchin et al. 2015
Dwarf galaxy evolution

Observe ~all RSG, bright RGB, AGB stars in 70 Local Group dwarf galaxies

- Rough chemical tagging with 5-10 elements, identify rare and peculiar stars
- Internal kinematics -> separate binarity and velocity dispersion, examine dark matter halo masses (especially in UFDs)
- Repeat observations -> spectroscopic variability
The nearest L* galaxy

Two large projects in M31 and M33

• Complete, magnitude-limited observations of the outer halo to 150 kpc: structure, kinematics, [Fe/H] vs [\(\alpha/Fe\)]

“The next major advance in our understanding of [M31’s] structure and history requires a coherent and holistic view of stellar kinematics and abundances across its entire spatial extent” (DSC 5.5.1)
The nearest \( L^* \) galaxy

Two large projects in M31 and M33

- Disk/halo transition region: stellar populations, imprints of merger history

Kinematics in the M31 inner spheroid are complex. Metallicity and \( \alpha \) enhancement from MSE will provide crucial extra dimensionality for disentangling the components.
Galactic ISM

3D+ Galactic ISM map

- Using Gaia + spectroscopic distances
- Adding ISM kinematics and physical properties
- Investigate diffuse interstellar band (DIB) carriers

- Measurement of multiple DIBs across environments

Multi-phase ISM

- Molecular, diffuse and ionized phases across environments

Linking the ISM and stellar history

- Joint stellar + ISM observations

Lallement et al. 2019
Feedback and suggestions

Use the breakout session this afternoon to identify the most pressing things that need development so we can meet our science goals.

The MW/RSP SWG3 co-leads are Carine Babusiaux (carine.babusiaux@univ-grenoble-alpes.fr) and Sarah Martell (s.martell@unsw.edu.au) - we can’t be there in person this week but we’re always happy to hear from you.
• Specific surveys?
• Resolution requirements?
• What important things are missing from GA science case?
• White papers?