The Star Formation History of the Sagittarius dwarf galaxy and streams

Thomas de Boer

V. Belokurov, S. Koposov, N. W. Evans, D. Erkal and many more

Institute of Astronomy
Cambridge - United Kingdom
The Sagittarius stream(s)

Sgr is a large and luminous dwarf
- Progenitor mass: $\sim 10^9 M_\odot$ (SMC-like)
- Luminosity: $\sim 10^8 L_\odot$, $M_V \sim -15.2$
- 70% of luminosity in stream

Sgr stream:
- Largest stream in MW halo
- At least 1 full wrap around MW!

Important for studying halo formation through massive systems
(and in comparison to LG dSph)
One Sgr stream… or two?

Multiple sequences in Sgr stream!
‘bifurcation’ in North? Stream split?

Sgr stream can be separated in 2 components
->faint stream: diff distance, simpler populations

Open questions:
->stellar population differences?
->drawn from same progenitor?
->different pericentre passage?

Law & Majewski Sgr stream coordinates

Need to study the stellar content of Sgr!

(Koposov et al. 2012)
Photometric stream samples

SDSS Stripe 82 photometry
- single epoch and deep co-add -> photometric completeness
- Sgr based on Δ, B selection (Law & Majewski model)
- MW foreground correction using Galactic-mirrored fields (same l, inverse b)
- Distance gradient correction using distances from Koposov et al. 2012
Spectroscopic stream samples

Spectroscopic sample from SDSS/SEGUE
- atmospheric parameters (log g, log $T_{\text{eff}}$)
- radial velocities
- metallicity [Fe/H]
- average $\alpha$-element abundance [$\alpha$/Fe]

Select Sgr based on:
- spatial location
- radial velocity
- distance
- select only giants (log g<3)
Bright and faint streams

Combination of spectroscopy and photometry shows clear stellar population picture

**MSTO:**
extended distribution: multiple populations
faint stream shows simpler CMD
-> simpler stellar populations

**RGB:**
Bright stream bi-modal extended MDF
Faint stream more metal-poor
-> lacks strong metal-rich ([Fe/H]>-0.9) component
Combining all pieces: the SFH

Combine photometry and spectroscopy directly to constrain ages

Construct synthetic CMD’s
- arbitrary age, [Fe/H], [$\alpha$/Fe]
- different isochrone sets
- photometric completeness

Construct synthetic MDFs
- extract stars with similar magnitude range
- bin in [Fe/H]
- convolve with Gaussian

SFH using MSTO photometry (age sensitive) and RGB MDF (direct metallicity)
(de Boer et al 2012)
Fitting the SFH

Fit single-epoch as well as deep co-add
Fit with and without spectroscopy

Sensible residuals, models reproduce CMD
->overall small residuals (<3 sigma in most bins)
->blue stragglers (g-i<0) fit as young population
->small amount of positive residuals
MW subtraction not perfect?

Solutions without MDF prefer more metal-poor SFH
SFH shows tight sequence in age-[FeH] plane
-> stars formed in well-mixed, homogeneously enriched medium.

Similar results single-epoch and co-add photometry
-> MDF adds meaningful constraints on SFH

Sequence consistent with age and metallicity of GCs associated to Sgr
-> stream stars drawn from same population mix as Sgr

Change of slope at age 11-13 Gyr, consistent with Sgr alpha-element knee (de Boer et al. 2014)
-> supernovae Ia started contributing to abundance pattern 1-3 Gyr after start of star formation.

Star formation rate drops sharply at 5-7 Gyr
-> related to infall of Sgr into the MW?
Same tight sequence as in bright stream

-> Sgr dwarf is progenitor of the faint component as well as the bright one

Lower S/N of the stream results in the presence of more anomalous populations

-> metal-rich populations likely fit to red MW stars

Faint stream composed of simpler population mix than the bright stream

-> consistent with CMD morphology

Sequence dominated by old (>8 Gyr) metal poor stars

-> stream drawn from more pristine Sgr population mix

-> stripped earlier? from the outskirts?

Earlier pericentre passage of the stream?
Conclusions

First detailed quantitative study of the Sgr trailing stream

Sgr SFH of both components show a tight sequence in the plane of Age vs [Fe/H]
->star-formation and enrichment proceeded in a similar fashion for each part of the bifurcation.
->star-formation within Sgr took place in a well-mixed medium, homogeneously enriched in metals over 8 Gyr.

Comparison to Sgr GCs:
->both streams are consistent with Sgr populations
->Sgr dwarf is progenitor of the faint component as well as the bright one

Star formation rate drops rapidly around 5-7 Gyr ago
->could be caused by the infall of Sgr into the MW, coinciding with stripping of gas

Faint stream composed of simpler stellar population mix than the bright stream
-> dominated by old metal poor stars
-> lacking strong metal-rich component found in the bright stream MDF.

Faint stream likely produced by material stripped earlier and from the outskirts of Sgr.