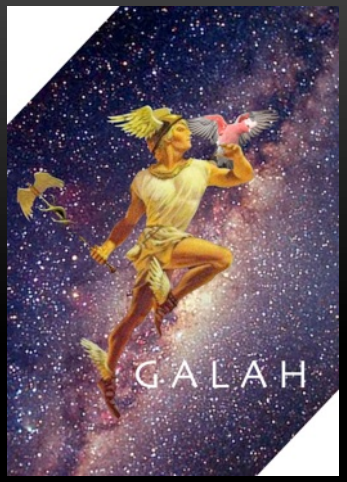
Texts



THE GALAH SURVEY AND SKYMAPPER

HOW TO FIND OUT WHAT YOU WANT TO KNOW WHEN YOU DON'T KNOW MUCH TO START WITH

Dr Elizabeth Wylie-de Boer

and

The GALAH Team

WHAT IS A GALAH?

FANTASY
(BEFORE)

REALITY
(AFTER)

WHAT IS THE GALAH SURVEY?

- GALactic Archaeology with HERMES survey on AAT
- GALAH has left the nest - January 2014
- 5-year, magnitude-limited (V~14) survey to observe 1 million stars across Southern Sky
- HERMES is 4-arm spectrograph to obtain complete wavelength coverage in 4 regions
- R ~ 28,000 (medium) or 45,000 (high) resolution mode
- Aim for SN of ~100 p.r.e for V~14 star in one hour exposure

WHO IS THE GALAH SURVEY?

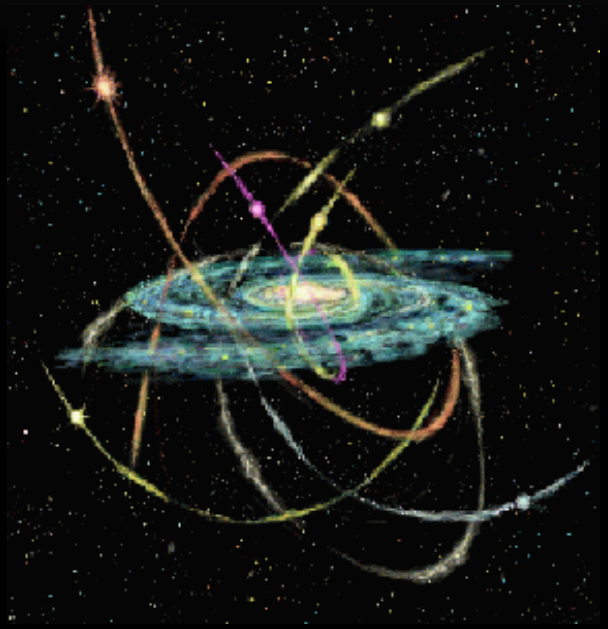
- ~40 strong Australian team

- AAO
- ANU
- U Sydney
- Macquarie
- Monash
- UNSW

- Invited Internationals:

- U of Texas (Austin)
- U Ljubljana
- MPA Garching
- U Hertfordshire
- U Padova
- U Cambridge

WHY IS THE GALAH SURVEY?



To identify the remains of
star-forming events and accretion events
that built up Galactic disk and bulge

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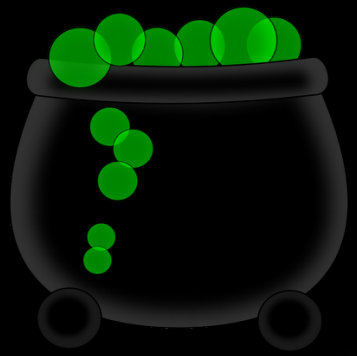

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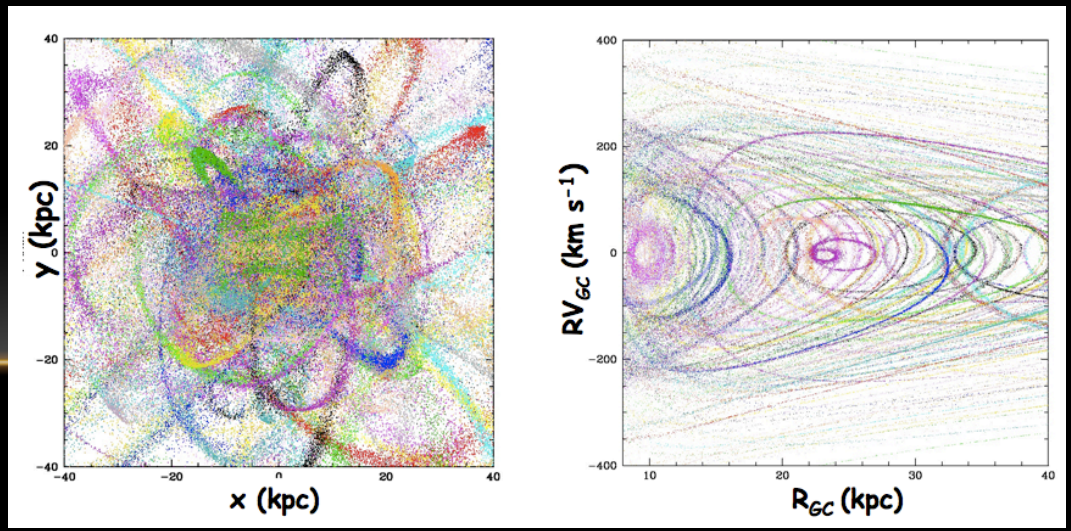
BASIS FOR GALACTIC ARCHAEOLOGY

- Fossil information is preserved in stars
- Seek signatures from time of Galaxy formation
  - Gives insight on processes that took place as Galaxy formed
- Aim to reconstruct the star-forming regions
  - Disk, bulge and halo
- Some dispersed aggregates can still be recognised kinematically as stellar moving groups
- For others the dynamics was lost through mixing processes
  - Can still recognize by chemical signatures

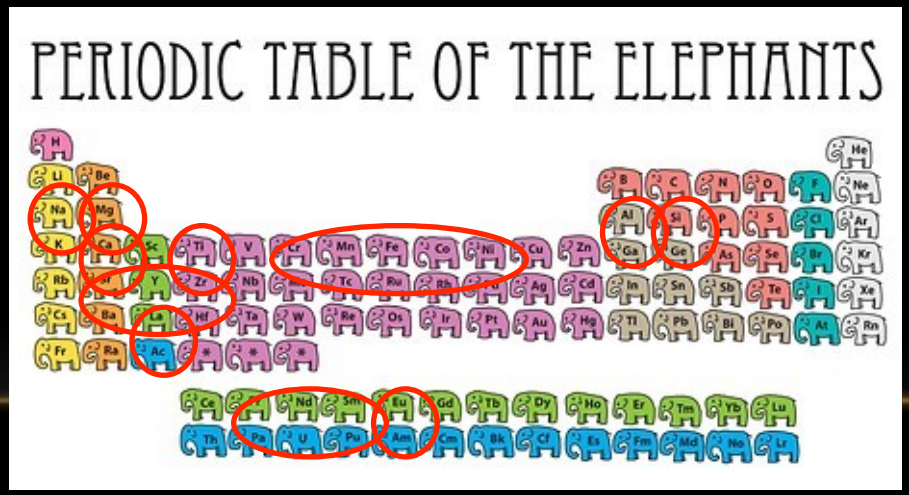


ASSUMPTIONS

- For chemical tagging to work, we require:
  - Stars form in large aggregates
  - Aggregates are chemically homogeneous
  - Aggregates have unique chemical signatures which do not vary in lockstep
    - Sufficient spread in abundances between aggregates so chemical signatures are distinguishable

CHEMICAL TAGGING

- Some debris will have phase mixed and become unrecognisable kinematically
- If the original star forming aggregate was chemically homogeneous, the stars will have retained its chemical abundance
- Even if kinematics fail us, can identify the stars from common chemistry
- Can we detect different sites using chemical tagging?
- Yes:
  - We need ~7 independent chemical elements with 4 measurable abundance levels to get 4^7 independent cells in chemical abundance space

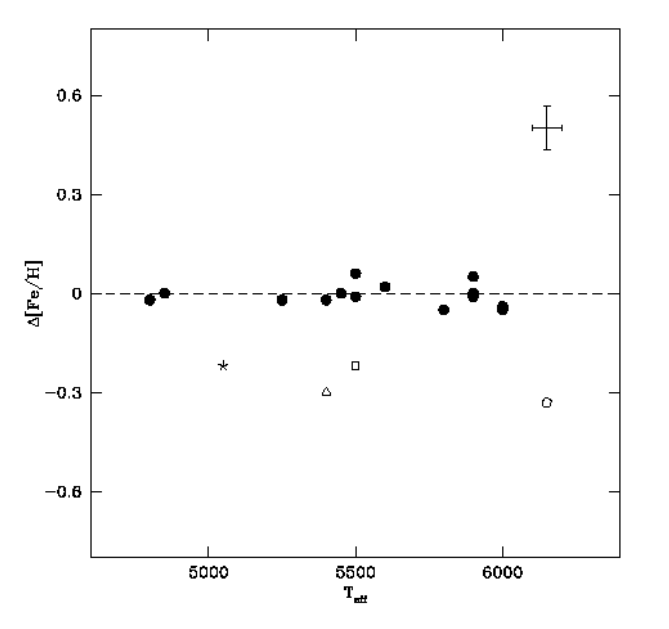


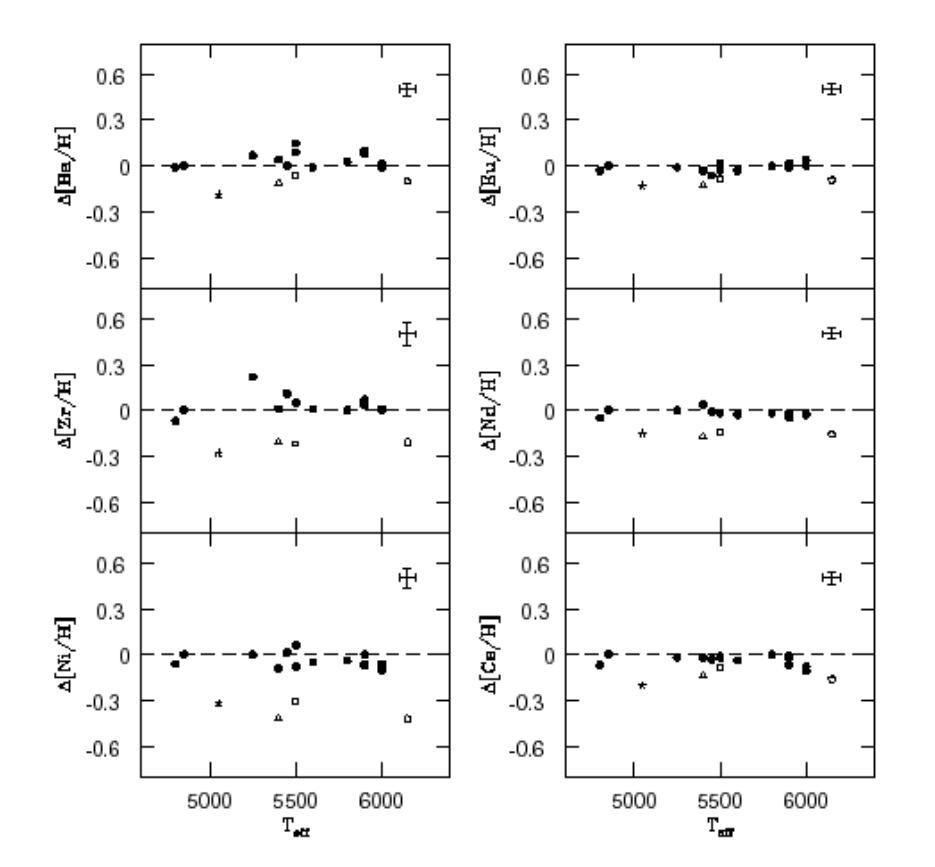
CAN IT WORK….?

- Of course!

THE POWER OF CHEMICAL TAGGING
HR1614 ABUNDANCES (DE SILVA ET AL., 2007)

- Very small spread in abundances - at 0.05 dex level

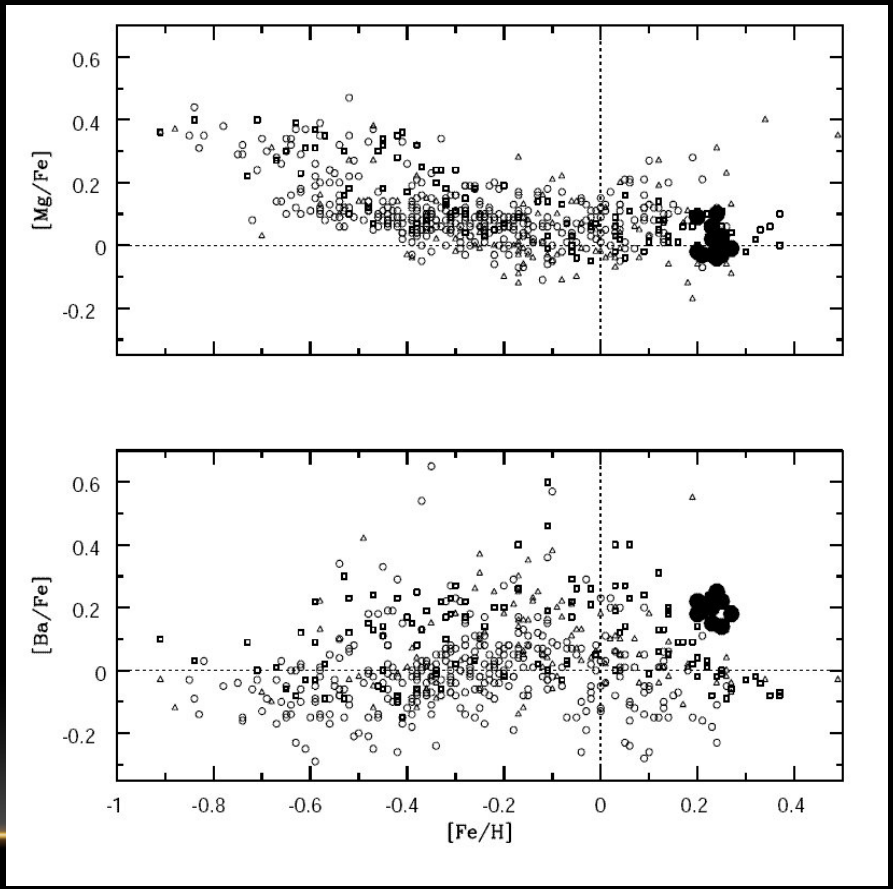




De Silva et al 2007

HR1614 - A DEFINITE BUNCH

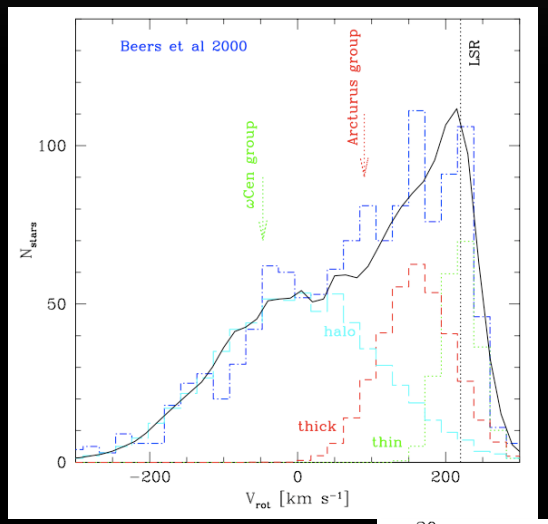
- Very tightly bound group in abundance space
- Indistinct from field stars
- Chemically homogenous
- Similar kinematics
- Star-forming region



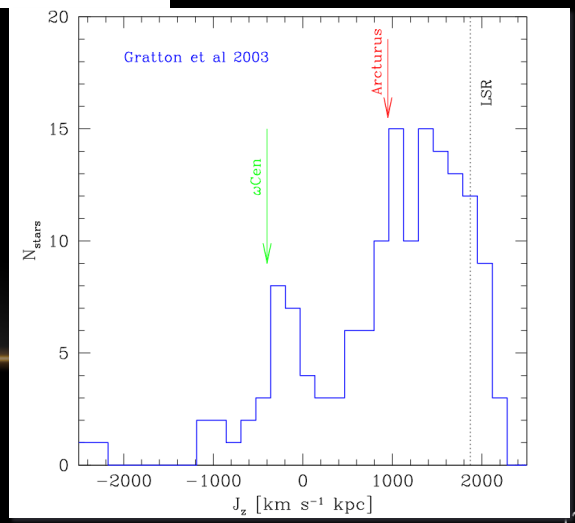
ANOTHER EXAMPLE – OMEGA CEN DEBRIS

(WYLIE-DE BOER ET AL., 2010)

- Omega Cen is surviving nucleus of dwarf galaxy that had outer stellar envelope removed via tidal stripping (Freeman 1993)
- Metallicity distribution, multiple populations and abundance anomalies support this theory (Norris and da Costa, 1995)
- Omega Cen remnants prominent in kinematic space

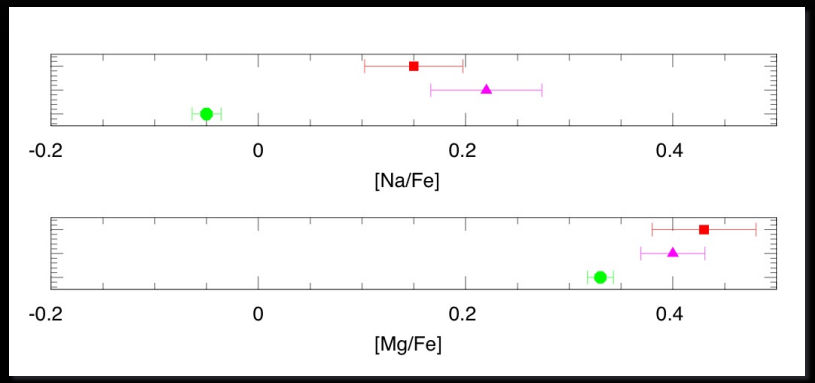


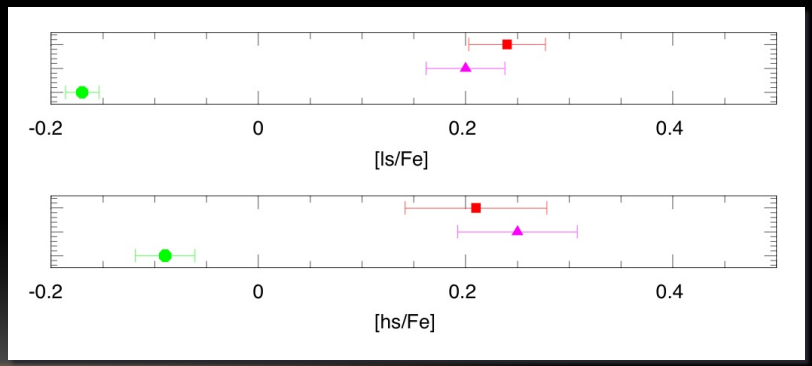
Meza et al. 2005



KAPTEYN GROUP ABUNDANCES

- Overlap in Omega Cen and Kapteyn in Na, Mg, ls and hs
- Distinct from field/halo populaton
- No chemical homogeneity
- Distinct from field, same as Omega Cen
- Omega Cen debris





SO…..

- If our Galaxy formed by accreting many smaller galaxies….
- There remain a lot more of these to be found ☺

- GALAH has set out to undertake a large sample survey in order to chemically tag the solar neighbourhood and find some more of these star-formation sites

THE GALAH MISSION, CHEMICALLY SPEAKING

- Abundance differences to ~0.05 dex in order to find groups via chemical tagging
- An automated way of taking 'limited' initial information and obtaining all the stuff we want:
  - T_{eff}, log g, [M/H], ξ_t, V_{rad}, V_{rot}, [X/Fe]
  - Oddness (binarity, fast rotation etc)

- ……. Enter Theremin (the GALAH automated analysis pipeline)

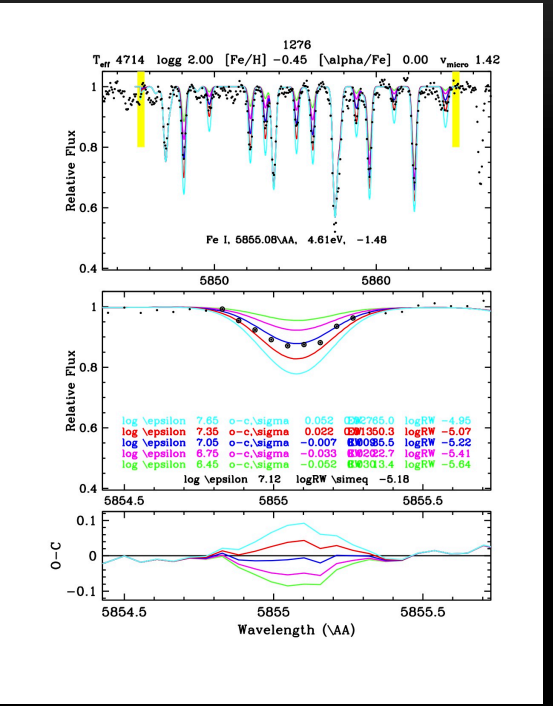
THEREMIN SUMMARY

- Input: observed stellar spectra (presumably) and photometry. That is all.
  - 2MASS - J, H, K
  - APASS - B, V, g', r', i'
- Required Output: Teff, gravity, metallicity, microturbulence, abundances for 29 elements, uncertainties

- Hard bit is the stellar parameters
- Initial guess includes photometric temperatures
  - V-K is good for T < 9,000K
  - J, H, K gives small Teff variations
- Spectrum synthesis with equivalent width analysis to iterate over T, g, m/H

PURELY SPECTROSCOPIC

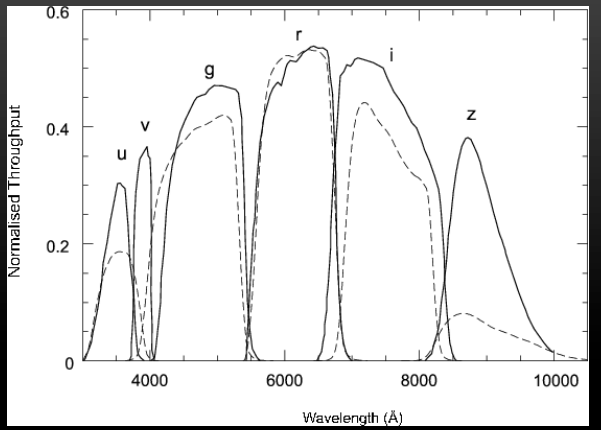
- 4 wavelength regions, B, G, R, NIR, ~1000Å total
- ~180 Ti I, II and Fe I, II lines
- Spectrum synthesis of each line, best fit EW
- Use
  - Ex Pot balance for Teff
  - REW balance for microturbulence
  - Ionisation balance for gravity
  - m/H in = m/H out for metallicity
- Iterative process – the better the initial guess the less iterations required
- Can set tolerances, # iterations, sigma clipping
  - → Flexibility for all datasets



GALAH FINAL PRODUCT

- Database of 1 million stars
- Raw data
- Reduce spectra
- Radial velocities
- Temperatures, gravities, metallicities, microturbulence
- Abundances for 29 elements (in most stars)
- Uncertainties for all values

HOW CAN SKYMAPPER HELP?



- GALAH will run abundance pipeline on own computer
  - NOT NCI as originally planned! ☺
- SkyMapper u, v, g, r, i, z can provide a much broader temperature estimate
  - V-K is good for T < 9000K, but u-v, g-i provides sanity check
- SkyMapper can break the degeneracy between gravity and metallicity (magical v filter) – CRITICAL!
- Give GALAH a heads-up on any variability, single-lined binaries
- SkyMapper should provide good reddening estimates

- What to do next:
- SkyMapper complete SSS, reduce SkyMapper data, full calibrations, cross-checks, write into GALAH database

WHAT CAN GALAH + SKYMAPPER DO?

- SkyMapper Photometry will help initial GALAH estimates for T, **g, m/H**
- GALAH will provide more precise and accurate Teff, along with errors

- SkyMapper Photometry + calibrated GALAH temperatures
  - → Extensive interstellar extinction study – both extinction map and shape of extinction curve

WHAT CAN GALAH + SKYMAPPER + GAIA DO?

Stellar Parameters + Abundances + Photometry + Positions + Kinematics

for 1 million Southern stars

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