Abundance structure and chemical evolution of the Galactic disc

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Milky Way panorama

The Lund Milky Way panorama (hand painted 1x2 m)
NGC 891
NGC 891

Thin disc
NGC 891

Thin disc

Thick disc
NGC 891

Thin disc  Thick disc  Bulge

Milky Way look-alike?
The dichotomy of the Galactic disc

Scale heights:

Thick disk: $\sim 1000$ pc (1450)
Thin disk: $\sim 300$ pc

Local densities:

Thick disk: $\sim 10\%$ (2%)  
Thin disk: $\sim 90\%$ (98%)
Galactic stellar populations

Solar neighbourhood (Hipparcos, i.e. ~200pc radius), heavily dominated by disk stars

~90% thin disk stars
~10% thick disk stars
~0.1% halo stars

All populations have their highest concentrations in the plane!
The dichotomy of the Galactic disc

Bensby et al., 2004, A&A, 415, 155

Filled symbols represent kinematically hot thick disc stars

Open symbols represent kinematically cold thin disc stars

Uncomplete sample, stars were selected based on their kinematic properties to be possible members of either of the two discs.

Still, the two samples clearly show different abundance trends

However, two extreme samples, What about stars with less extreme kinematic properties?
The dichotomy of the Galactic disc

Volume limited sample of nearby stars show divided abundance trends.

Teff > 5300K

Size of points proportional to age of the stars.

Substructure in velocity space

Beers et al. (2000) catalogue, kinematically un-biased sample of 2106 stars with $-4.0 < [\text{Fe/H}] < 0.0$.

Decomposed into three Gaussian distributions: 
- halo
- thick disk
- thin disk

Excess of stars at $V_{\text{rot}} \approx 170 \text{ km/s}$ ($V_{\text{LSR}} \approx -50 \text{ km/s}$) attributed to the Hercules stream

Rotates as the thick disk!

Arcturus moving group – remnant stars of the “last major merger”?

Navarro et al. (2004)
Substructure in velocity space


\[ v_{\text{pec}} \] is the total space velocity, i.e. \( U_{\text{LSR}}, V_{\text{LSR}}, \text{ and } W_{\text{LSR}} \) combined.
A new stellar sample

899 kinematically selected F and G dwarf stars

$R > 60000$

$S/N > 200$

complete 400 – 980 nm

MIKE @ Magellan
UVES @ VLT
FEROS @ ESO 1.5m & 2.2m
SOFIN @ NOT
A new stellar sample

283 stars with thick disc kinematics
A new stellar sample

283 stars with thick disc kinematics

428 stars with thin disc kinematics
A new stellar sample

283 stars with thick disc kinematics

428 stars with thin disc kinematics

87 stars with Hercules stream kinematics
A new stellar sample

283 stars with thick disc kinematics

428 stars with thin disc kinematics

87 stars with Hercules stream kinematics

63 stars with “in between” kinematics
A new stellar sample

283 stars with thick disc kinematics

428 stars with thin disc kinematics

87 stars with Hercules stream kinematics

63 stars with “in between” kinematics

38 stars with halo kinematics
A new stellar sample - questions?

How metal-rich is the thick disc?
A new stellar sample - questions?

- How metal-rich is the thick disc?
- How metal-poor is the thin disc?
A new stellar sample - questions?

- How metal-rich is the thick disc?
- How metal-poor is the thin disc?
- “In between” stars – thin or thick, or a population of their own?
A new stellar sample - questions?

How metal-rich is the thick disc?

How metal-poor is the thin disc?

“In between” stars – thin or thick, or a population of their own?

The interface between the metal-rich halo and metal-poor thick disc?
Abundances - Titanium

Stars with thick disc kinematics

red line = running median of the thick disc

Stars with thin disc kinematics

blue line = running median of the thin disc
Abundances - Titanium

$td/d < 0.5$

$td/d > 2$

$[\text{Fe/Ti}]$ vs $[\text{Ti/H}]$
Abundances - Titanium

Thin disk, td/d<0.5, (age>8 in red)

Thick disk, td/d>2, (age<7 in blue)
Abundances - Titanium

\[ \text{age}_{\text{high}} < 7 \text{ Gyr} \]

\[ \text{age}_{\text{low}} > 8 \text{ Gyr} \]
Kinematic confusion...

Stars selected purely on kinematics

Stars selected purely on their ages

Toomre diagram for the age selected samples

Many young stars have hot kinematics!!
Hercules-stream stars

A wide spread in age and metallicity

Abundance ratios not seen in dSph in the Local Group

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Most likely the result of a phenomenon originating inside the Milky Way, possibly the bar

Either inner disk stars, or due to the bar's outer Lindblad resonance
A bulge-thick disc connection?

In situ Bulge dwarf stars, observed while being optically magnified during microlensing events.

Abundance trend in the Bulge is essentially identical to what we see in the nearby thick disc!

(postner 106 at IAUS265)

* What is the Bulge?
* What is the thick disc?
* Are they the same?
* Is the bar responsible for the kinematic heating of the thick disc?
Abundance trends in the inner disc?

A sample of giants stars that we just observed.

Will trace the abundance trends in the Galactic disc at approximately 4, 8, and 12 kpc from the Galactic centre.
(short) Summary

- Galactic disc consists of two distinctly different disc systems (ages, abundances, and kinematics), indicating a complex history for the Milky Way – how did two so different disc systems form?
- Kinematic confusion, maybe age criteria is better?
- Hercules stream is likely a dynamic effect, (and not of extra-galactic origin.....)
- Bulge trend is very similar to what is seen in the nearby thick disc...

.....see also tomorrow's talk(s) at IAUS 265