Local Group, Local Cosmology

Symposium 5 - EWASS 2013, 8-9 July 2013, Turku, Finland

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Mateo 1998

“...as many as 15-20 more LG galaxies may be hidden at low latitudes, up to half of which may be satellites of the Milky Way”
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1.2 Discovery of the Local Group

Fig. 1.1. Number of known Local Group members as a function

Van den Bergh 2000

Local Group
WHAT HAS BEEN FOUND

Local Group

Willman+05, Zucker+06a/b, Belokurov+06/07/08/13

Milky Way satellites

- Classical dwarfs ~ 11
- Ultra-faint dwarfs ~ 19

SDSS DR8
Least luminous, least massive and least metal-rich galaxies
STAR FORMATION HISTORIES

Wide-field cameras, ACS, … + SFH algorithms

Quantitative constraints on star formation at all ages
Multi-objects/high-resolution spectroscopy

Can we observe the building blocks of the Milky Way halo?
TOWARD THE METAL-POOR END

Most metal-deficient star with $Z = 4.5 \times 10^{-5} Z_\odot$ Caffau+11

No metal-free stars have been observed so far
Local Cosmology

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The first stars are predicted to form at $z \sim 20-30$ in $M \approx 10^6 M_\odot$ minihaloes $T_{\text{vir}} < 10^4 K$

Proto-stellar clouds $M_J \approx 1000 M_\odot$

High accretion rate $\frac{dM}{dt} \approx M_J / t_{ff} \approx c_s^3 / G \approx T^{3/2}$

$M_{\text{PopIII}} \approx (30-100) M_\odot$

No METAL-FREE stars have been observed so far

Cooling channels in primordial gas

$n_{H} = 0.045 \text{ cm}^{-3}$

$n_{H_2} = 0.1\% n_{H}$

Barkana&Loeb01
THE FIRST STARS

Omukai&Nishi98; Abel,Brian&Norman02; Bromm+02; Omukai&Palla03; Bromm&Loeb04; O'Shea&Norman06; O'Shea+07; Tan&McKee04; McKee&Tan08; Ripamonti+02; Schleicher+09/10; Turk+09/11; Yoshida+06/08; Hosokawa+11; Clark+11; Greif+12

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The first stars are predicted to form at \( z \sim 20-30 \) in \( M \approx 10^6 \, M_\odot \) minihaloes \( T_{\text{vir}} < 10^4 \, K \)

Proto-stellar clouds \( M_J \approx 1000 \, M_\odot \)

High accretion rate \( \frac{dM}{dt} \approx \frac{M_J}{t_{ff}} \approx \frac{c_s^3}{G} \approx T^{3/2} \)

\( M_{\text{PopIII}} \approx (30-100) \, M_\odot \)

The first stars were likely more massive than today forming stars
What physical process drives the transition from massive PopIII to normal PopII/I stars?

Metal-line cooling if \( Z > 10^{-4} \, Z \)

Dust cooling if \( Z > 10^{-6} \, Z \)

Bromm+01; Bromm&Loeb03; Santoro&Shull04

Schneider+02/06/12; Omukai+05; Clark+08; Hocuk&Spaans10; Dopita+11
Pop III stars

\[ M_{\text{ch}} \approx (30-100) \, M_\odot \]

\[ Z \leq Z_{\text{cr}} \]

\[ Z_{\text{cr}} = 10^{-5\pm1} Z_\odot \]

High mass

Low mass

\[ f_{\text{dep}} = \frac{M_{\text{dust}}}{M_{\text{mat}} + M_{\text{dust}}} \]

Pop II/I stars

\[ M_{\text{ch}} \approx 1 \, M_\odot \]

\[ Z > Z_{\text{cr}} \]

Formation of the first low-mass stars

SDSSJ102915

Caffau+11

Schneider+12

Courtesy of R. Schneider
Evolution of the minimum mass of star-forming haloes

What is the mass of the first galaxies that can survive feedback processes?
Ultra-faint dwarfs might be the living fossils of the first H$_2$-cooling minihaloes

Ultra-faint dwarfs

SF suppressed before the end of reionization $z \geq 6$
What is the origin of very metal-poor DLAs and their connection with halo stars?
QUESTIONs FOR THE SYMPOSIUM

What is the influence of the environment on the evolution of dwarf galaxies?

Can we observe the building blocks of the Milky Way halo?

Where are second generation stars?

Are ultra-faint dwarfs the living fossils of minihaloes?

What is the origin of very metal-poor DLAs and their connection with halo stars?

Is astro-archaeology the best strategy to study the properties of the first stars/galaxies?