AGES AND METALLICITIES OF NUCLEAR CLUSTERS IN DWARF GALAXIES
and their relation to massive Galactic GCs
Outline

The not so normal Galactic GCs

Nuclear GCs in Dwarf Galaxies

Both formed in similar environment?
The not so normal Galactic GCs

Complex Populations:
- Split in MS, RGB, SGB, HB
- Large spread in light elements
- High helium abundance
- One dominant population (e.g. 75% ω Cen, 65% NGC 2808)

NGC 2808 (Piotto et al 2007)
The not so normal Galactic GCs

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  (e.g. 75% $\omega$Cen, 65% NGC 2808)

$\omega$Cen (Piotto+05)

$Z=10^{-3}$, $Y=0.246$

$Z=2\times10^{-3}$, $Y=0.218$

$Z=2\times10^{-3}$, $Y=0.35$

$Z=2\times10^{-3}$, $Y=0.45$

$(m-M)_0 = 13.35$

$E(B-V) = 0.12$

$\text{NGC 2808 (Piotto et al 2007)}$
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Hot Horizontal Branch
- Hot HB stars $T_{\text{eff}} > 10^4$ K
- HB morphology strong function of mass (e.g. Recio-Blanco'06)
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Dalessandro+08 Ferraro+04
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Mass - metallicity

Spread in iron

Carretta et al. (2010)
The not so normal Galactic GCs

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**Mass - metalliclicity**

**Deep potential**

**Formed as nuclei?**

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Carretta et al. (2010)
**THE not so normal GALACTIC GCs**

**Central Escape velocity to tidal radius**

$$v_{esc} = f_c \sqrt{\frac{M_{cl}}{r_h}} \ [\text{km/s}]$$

- **Self enrichment if** $\dot{U}_{wind} < U_{esc}$
- **AGB~20 km/s** (D’Antona+01,08)
- **Fast rotators <100 km/s** (Decressin+07)
- $\dot{U}_{wind} \sim Z_{0.5} \ L_{0.25}$ (Marshal+04)

- **Metal enrichment by recurrent gas accretion** (Pflamm-Altenburg & Kroupa 2009)

Georgiev et al. (2009b)
Central escape velocity to tidal radius

- Self-enrichment if $\omega_{\text{wind}} < \omega_{\text{esc}}$

AGB $\sim 20 \text{ km/s}$ (D'Antona+01,08)

Fast rotators <100 km/s (Decressin+07)

$\omega_{\text{wind}} \sim Z^{0.5} L^{0.25}$ (Marshal+04)

- Metal enrichment by recurrent gas accretion (Pflamm-Altenburg & Kroupa 2009)

The not so normal Galactic GCs

Georgiev et al. (2009b)
68 dwarf galaxies with $M_V > -17$ mag at $D = 2 - 10$ Mpc (Georgiev et al. 2008, 2009a)
7 (10%) “nucleated” dIrrs (Georgiev et al. 2009b) High $S_L$ (Georgiev et al. 2010)
Spectroscopy of Nuclear GCs

VLT/FORS2
Grism 600B
MOS
3300-6210A
1.5 Å / pix
**Ages and Metallicities of Nuclear GCs**

**Full Spectral Fitting**
(Ulys, Koleva et al. 2009)

**Vazdekis models (2010)**
60 Myr < Age < 18 Gyr
-2.3 < [Fe/H] < 0.2 dex

**Georgiev et al. (2011, in prep.)**
**Ages and Metallicities of Nuclear GCs**

![Graph showing metallicities and ages of nuclear GCs](image)

**KK 197 nGC**
- Best fit Vazdekis model
- Age = 14 Gyr, [Fe/H] = -1.4 dex

**M-C best**
- Age = 11.5 Gyr, [Fe/H] = -2.0 dex

**Georgiev et al. (2011, in prep.)**
Ages and Metallicities of Nuclear GCs

Georgiev et al. (2011, in prep.)
Age = 14 Gyr, [Fe/H] = -1.4 dex

200 Myr, [Fe/H] = -0.2 dex

4.5 Gyr, [Fe/H] = -1.7 dex

11.5 Gyr, [Fe/H] = -2.0

8.5 Gyr, [Fe/H] = -2.1

8.5 Gyr, [Fe/H] = -2.1
$V_{\text{esc}}$ vs. Metallicities for nGCs and EHB-GCs

Georgiev et al. (2011, in prep.)
Expansion of nGCs by potential removal

Georgiev et al. (2009b)
Expansion of nGCs by potential removal

Georgiev et al. (2009b)
Conclusions

Ages and metallicities of nGCs

Cover a wide range
- in age, but mostly old (~ few Gyrs to 14Gyr)
- metallicity, but mostly metal poor ([Fe/H] < -1.5dex)
- multiple populations, Blue HBs?

Massive Galactic GCs

Require a formation in “heavy” environment

Stay Tuned
- nGCs dynamical masses (UVES)
- Dwarf galaxies kinematics