Near-infrared luminosity function of galaxies in distant clusters

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The near-infrared luminosity function as a tool to study galaxy evolution

- well established at redshift zero, providing a zero-point for evolutionary studies at higher redshift
- less affected by dust extinction (compared to bluer wavelengths)
- small dependence of k-correction on galaxy type
- provides a proxy to the stellar mass function, since observed K-band light reasonably traces stellar mass even at redshift ~ 1
- observed over a wide look-back time range sets constraints on when the bulk of the stars formed and when the bulk of the galaxy mass was assembled
Distant Galaxy Clusters

We studied 3 X-ray luminous clusters in the redshift range $1.1 < z < 1.3$

- already massive and dynamically evolved
- already host massive evolved galaxies
- already show a clear color-magnitude sequence
- provide a high-density counterpart to the study of field galaxies, thus probing the effects of environment on galaxy evolution
RDCS J0910+5422 @ z=1.11 (Stanford et al. 2002)

$T_{\text{gas}} \sim 7 \text{keV}, M_{\text{tot}} \sim 5 \times 10^{14} \, M_{\odot}$

Observed in X-rays (Chandra), optical + NIR (HST, Palomar 200''), IR (Spitzer)
RDCS J1252+2927 @ z=1.24 (Rosati et al. 2004)

$T_{\text{gas}} \sim 5.2 \text{keV}, M_{\text{tot}} \sim 1.6 \cdot 10^{14} M_{\odot}$

Observed in X-rays (Chandra), optical + NIR (HST, VLT), IR (Spitzer)
The Lynx supercluster

2 galaxy clusters at z~1.26/1.27
7 galaxy groups at z~1.26 (Nakata et al. 2004)

~3Mpc @z=1.26
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~3Mpc @z=1.26

RX J0848+4453 @ z=1.27 (Stanford et al. 1997, Rosati et al. 1999)

T_{gas} \sim 2.9\text{keV}, M_{tot} \sim 1.4 \cdot 10^{14} \text{M}_{\odot}

Observed in X-rays (Chandra), optical and NIR (KPNO/4m, HST)
The K-band luminosity function at $z \sim 1.2$

The individual luminosity functions have been determined via statistical subtraction.

![Graph showing K-band luminosity function for Cluster field and Control field at CI1252.]
The individual luminosity functions have been determined via statistical subtraction.

The $K$-band luminosity function at $z \sim 1.2$.
The K-band luminosity function at $z \sim 1.2$

Composite LF of cluster galaxies at $1.11 < z < 1.27$
The K-band luminosity function at $z \sim 1.2$

...compared to the field galaxy LF at $z \sim 1-1.5$
The K-band luminosity function at $z \sim 1.2$

...compared to the local cluster galaxies LF

![Graph showing the comparison between the K-band luminosity function at $z \sim 1.2$ and the local LF. The graph shows that the local LFs are brightened by 1.3 mag.](image)
The $K^*$ redshift evolution up to redshift $\sim 1.2$ is compatible with passive evolution of a stellar population formed at $z \geq 2$.
The LF bright end is already dominated by evolved galaxies

morph. early types
(Blakeslee et al. 2003)

red-sequence gals

early and late
spectral types
(Toft et al. 2004)
The stellar mass function of cluster galaxies at z~1.2

From the K-band LF it is possible to derive an estimate of the stellar mass function:
SED fitting with 9 passbands from B to 4.5\( \mu \)m

B VR\( i \)z J K 3.6 4.5 B VR\( i \)z J K 3.6 4.5

VLT/FORS HST/ACS VLT/ISAAC Spitzer/IRAC
Massive galaxies with old stars

i-z CM @ z=1.24 Blakeslee et al. 2003
redshifts from R. Demarco (PhD Thesis)
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Conclusions

- The evolution of the NIR luminosity function of bright galaxies in X-ray luminous clusters is consistent with passive evolution up to redshift ~ 1.2

- The redshift evolution of $K^*$ is consistent with the bulk of the stars in such bright galaxies being formed at redshift >2, as indicated by the CMR evolution, and by SED fitting of bright members in the restframe [0.2 – 2]μm wavelength range

- No significant difference can be seen between the shapes of the z~1.2 and the local LFs of cluster galaxies (once a brightening of ~1.3 mag is applied to the local LF to account for passive evolution of the stellar populations)

- No significant difference can be seen between the shapes of cluster and field (bright end) LFs at z~1

- The bright end of the cluster galaxies LF appears to be dominated by galaxies already evolved both morphologically and spectrophotometrically