Local Clusters And The Halo Occupancy Function

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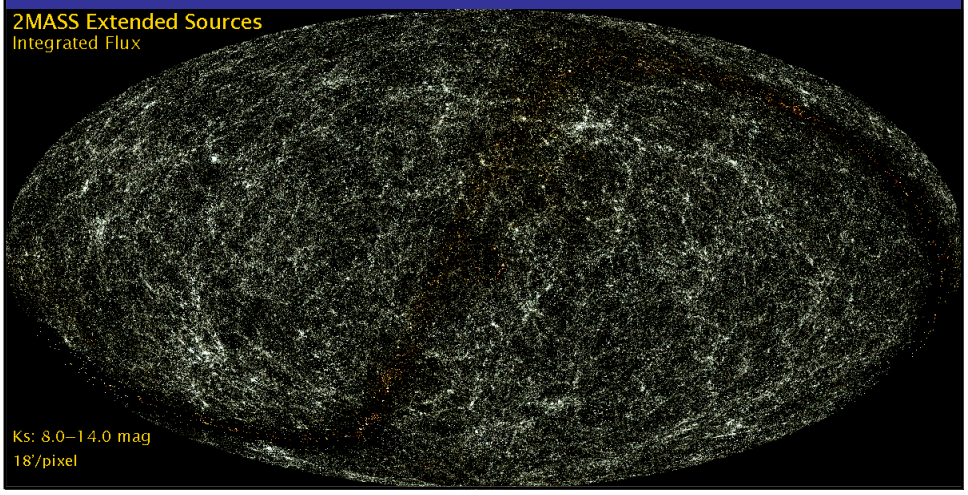


Complete cluster catalogs can be used to determine:

- power spectrum normalization (sigma8)
- matter density (omega)
- equation of state (w)
- halo occupancy function N(M) needed for the "halo model" of large scale structure

The catalogs can be made from:

- optical surveys -- almost all from old photographic data
- X-ray surveys -- mainly Einstein/ROSAT
- weak lensing surveys -- just starting
- SZ surveys -- just starting

We are building a modern, all-sky optical cluster catalog by combining the galaxies in the 2MASS infrared survey with a matched filter algorithm calibrated and checked against synthetic catalogs generated from N-body simulations and X-ray surveys.

Our initial sample consists of:
- 98000 galaxies,
- complete to an extinction corrected limit K<12.25 mag, <z>~0.05
- with |b|>5 degrees (92% of the sky),
- and redshifts that are 90% complete for K<11.25 mag, 33% complete for 11.25<K<12.25, and 50% complete overall.

For each cluster we obtain:
- A likelihood for the cluster
- The number of member galaxies
- A velocity dispersion estimate
- Matches to known clusters and their properties

What does the "number of galaxies in a cluster" mean?

- Clusters do not have edges -- need to set a fiducial radius
- Cluster galaxies follow a luminosity function -- need to set a fiducial luminosity

- Theoretical studies use the virial radius defined by the region with and average density 200 times the critical density. For a bias of unity, the overdensity of galaxies inside the virial radius is 200/omega, or 666 for omega=0.3.
- The observed number of galaxies depends on the magnitude limit and the cluster redshift, but we can fit for the expected number of L>L* galaxies.

-----> N*666 = the number of L>L* galaxies inside the (3D) region with a galaxy overdensity 666 times the background.

If you use a different definition you will get a different halo occupancy function!

For example, the number of L>L* galaxies inside a fixed 0.8Mpc/h aperture scales as N*666^(3/4).

Cluster #1
-ln(L)=513
-N*666=12.4(1.4)
-cz=5300km/s
-T=6.4(0.1)keV

Cluster #2
-- ln(L)=408
--N*666 = 20.3 (1.8)
--cz=6800km/s
--T=8.1(0.3)keV

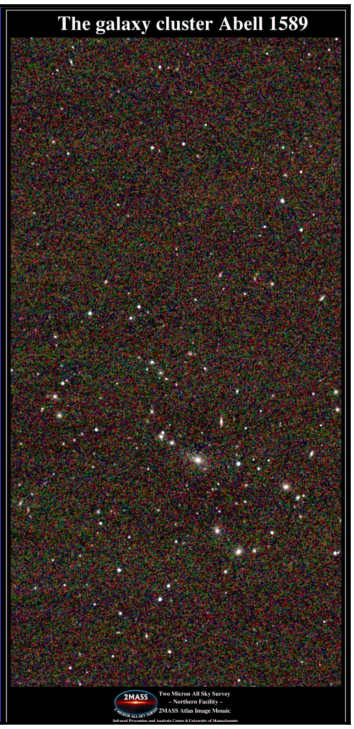
Cluster #5
-- ln(L)=317
-- N*666=6.1 (0.6)
-- cz=3700km/s
--T=3.8 (0.2)keV

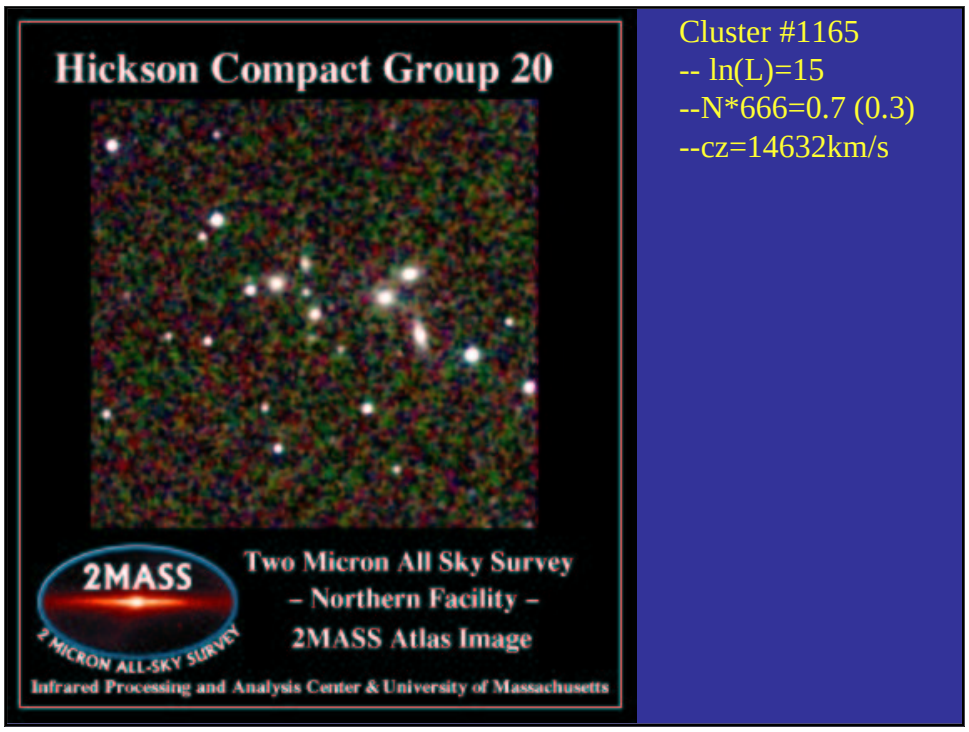
Cluster #8
-ln(L)=198
-N*666=5.2 (0.6)
-cz=4600km/s
-T=2.3(0.1) keV

Cluster #21
-- ln(L)=130
--N*666=39.3(6.3)
--cz=14423km/s
--T=5.4(0.2)keV

Cluster #256
-ln(L)=34
-N*666=3.9(1.2)
-cz=12700km/s
-T=3.4(0.1) keV

Cluster #539
-ln(L)=22
-N*666=22.0(8.4)
-cz=21600km/s

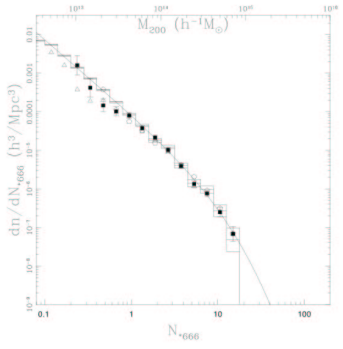




Cluster #1165
-- ln(L)=15
--N*666=0.7 (0.3)
--cz=14632km/s

Completeness/False Positive Rates

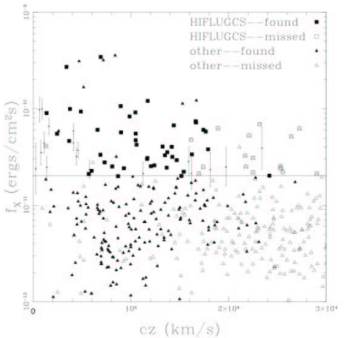
Very good for clusters with 3 or more galaxies



Cluster number function
Synthetic catalog

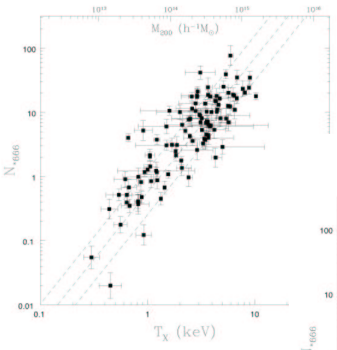
Get input occupancy function and cluster number function back in tests on synthetic catalogs from N-body simulations

Find essentially all ROSAT X-ray clusters - for cz<15000km/s -- many misses are problems in the automatic matcher, low cz groups whose angular size is big compared to the ROSAT field of view, or are clusters with X-ray AGN.

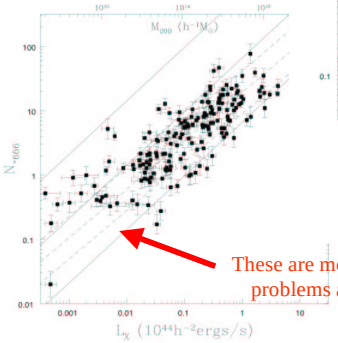


Completeness compared to ROSAT

Good correlation between N*666 and mass estimators

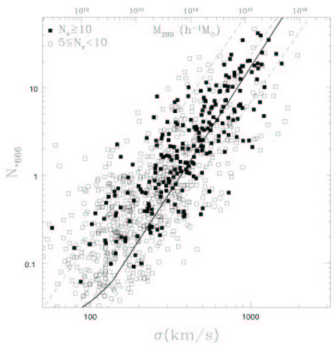


X-ray temperature

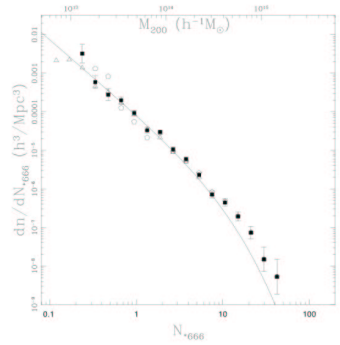


These are mostly X-ray problems at low L!

X-ray luminosity



Velocity dispersion



Number function

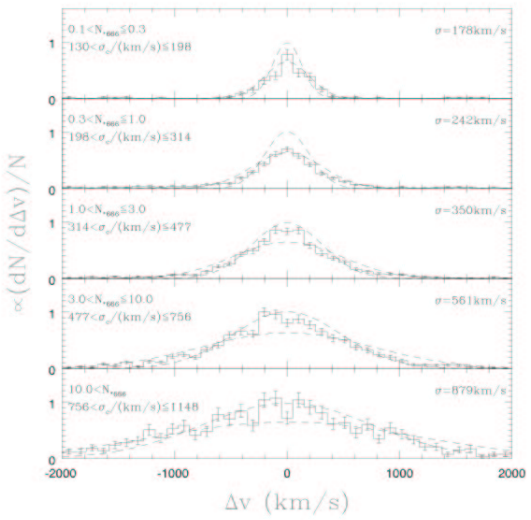
Number function extends over almost 2 decades in group/cluster richness.

Halo occupancy function

Log(N*666)=(1.44+/-0.17)+(1.10+/-0.09)Log(M200/10^15)

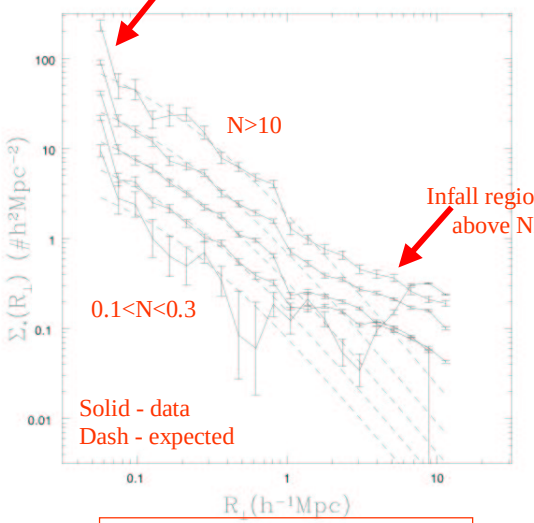
Dominant uncertainty is conversion of Lx/Tx/sigma into mass.

K-band light ~ stellar mass, so N*666~M200 means that stellar mass traces total mass. Star formation weighted bands (e.g. B or far-IR) should show flatter slopes N*666~M200^(0.6-0.7)



Average velocity histograms as a function of N*666

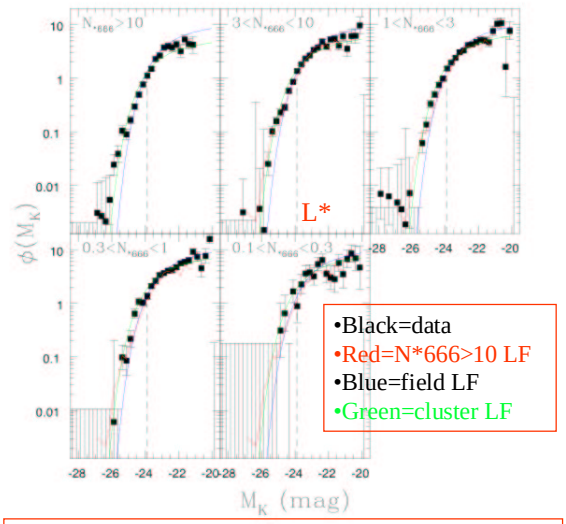
By stacking clusters in N*666 bins we can check the matched filter parameters



Projected galaxy surface density (L* galaxies per Mpc^2)

Galaxy profile closely follows NFW profile used for the filter (for R<h/Mpc used in fits).

n.b. this is a version of the galaxy-cluster cross correlation function as a function of cluster richness (mass).



Cluster galaxy luminosity function per unit N*666

For L>0.1L* the luminosity function does not depend on richness, but differs from the field.

Next Steps

- Updating the synthetic catalogs -- dynamic range in mass, galaxy assignment
  Adding IR color information, field/cluster LF to algorithm
- Redo cluster search on deeper sample (K<13.25 mag, about 400,000 galaxies)
- More extensive comparisons to X-ray data
- Estimate occupancy function N(L|M) rather than just N*(M)
- Omega/sigma8 estimates