Missing Satellite Problem Outside of the Local Group

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$z=4.01, \sigma_{vel} = 268\pm59 \text{ km/s}$

LCDM has a few possible flaws on small scales

**Cusp-Core problem:**
the dark matter density profile of LCDM subhalos is too steep

**Missing satellite problem:**
there are too many LCDM subhalos

**Too-big-to-fail problem:**
the most massive subhalos are too concentrated

**Satellite-plane problem:**
anisotropic distribution and coherent motion of dwarf galaxies around MW + M31 are hard to reproduce

Oh et al. 2011
Moore et al. 1999
Boylan-Kolchin et al. 2012
Pawlowski et al. 2013
The missing satellite problem

Baryon physics may be a possible solution, but...

Moore et al. 1999
DM only simulation

Sawala et al. 2014
DM + Baryon simulation
NGC2950 : d=14.9 Mpc (Tonry et al. 2001)

Seeing: 0.5 arcsec in g-band, ~1.0 arcsec in i-band

Exp. = 30min each

M*=1.7e10 Msun, M_DM=6.6e+11 Msun, r200=176 kpc or 40.5 arcmin
NGC3245 : d=20.9 Mpc (Tonry et al. 2001)

Seeing: 0.5 arcsec in g-band, ~1.0 arcsec in i-band

Exp. = 30min each

M* = 4.0e10 Msun, M_DM = 1.4e+12 Msun, r200 = 227 kpc
or 37.3 arcmin
Dwarf galaxy selection

Dwarf candidates (~100 objects per HSC field of view) are visually inspected and junk objects and other artifacts are removed. The dwarf candidates are sorted into two: secure dwarf or possible dwarf.
We do the same exercise in a blank field and the contamination of field dwarf galaxies is statistically subtracted.
Simulations: detection completeness and flux biases

Detection completeness

Dwarf galaxies in the Local Group
Cumulative luminosity function

The shade is from the COCO simulations.

Cumulative luminosity function

The large scatter both in simulations and observations demonstrates the importance of statistical sample to address the missing satellite problem.

Any cosmological tests on a single halo (i.e., Local Group) should be taken with a gran of salt!

Comparison with Geha et al.

The Geha17 lines are more reliable, but we go deeper. Our photometric approach is complementary.

Size-luminosity relation:

- Dwarf galaxies in the Local Group
- Dwarf galaxies around N2950 + N3245

Statistical analyses do not seem to indicate strong alignments of the satellites.

What we find in the pilot observation

We have started a survey to statistically address the missing satellite problem with Hyper Suprime-Cam on Subaru.

Our pilot observation shows that there is a large diversity in the abundance of dwarf galaxies for MW-like mass halos.

Now moving on to construct a larger sample...
NGC779 : d=21.6 Mpc (Tully-Fisher; Sorce+ 2014)
Seeing: 0.5 arcsec in g-band, ~0.7 arcsec in i-band
Exp. = 30min each
B=11.7mag (MB=-20.1), V=11.1mag (MV=-20.7)
M*=5.0e10 Msun, M_DM=1.9e+12 Msun, r200=248.6 kpc or 37.6 arcmin
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<tr>
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We have a lot of data! We need to process and analyze them, but I am busy...

I am looking for a postdoc to work with me on these data. If you are interested, come talk to me!