Constrain the satellite fraction in HSC

Looking forward to DESI

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Overview

Goal

Constrain the high mass ($\log(M_*/M_\odot) \gtrsim 11.5$) satellite fraction ($f_\mathrm{sat}$) in Hyper Suprime-Cam (HSC) observations. Why HSC? Large volume – more massive galaxies, deep images – better M_*.

How

- In an N-body simulation, map some halo property (*e.g.* $M_\mathrm{halo,peak}$, V_max@M_peak) to M_*, with some scatter.
- Optimize this mapping in to fit some HSC observations (*e.g.* SMF, clustering).
- Measure f_sat in the best fitting mock.

See also

Reddick 2013 did this for SDSS

Observations + Simulation data

Hyper Suprime Cam

- $\sim 4500, 30$ $\log(M_*/M_\odot) > 11.5,\ 12$
- $z \sim 0.3$
- $\sim 95\%$ spec-z.

MDPL

- $1000\ \mathrm{Mpc\,h^{-1}}$
- Snapshot at $z \sim 0.37$

Fitting choices

Halo Parameter

$M_* = f(\mathrm{halo\,property})$. We build models with V_{max}@M_{peak} and $M_{\mathrm{halo,peak}}$.

Functional form

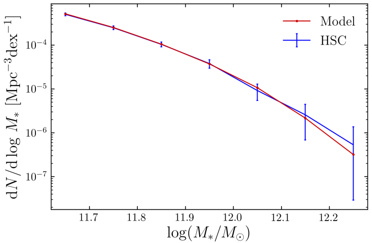
We use the 5 parameter form from Behroozi 2010 (though only 3 are needed), and a linear scatter – $\sigma(\mathrm{halo\,property})$.

Fitting Data

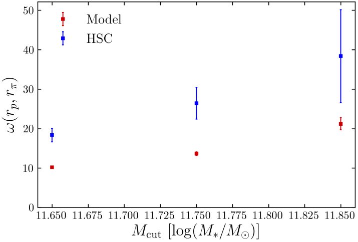
- The SMF
- Counts in cylinders: $\xi(r_p, r_\pi)$ in a single $r_p < 1\,\mathrm{Mpc}$ and $r_\pi < 10\,\mathrm{Mpc}$ bin. HSC doesn't have enough data for a more detailed measurement of clustering. This is a cross correlation between galaxies $\log(M_*/M_\odot) > M_{cut}$ and $M_{cut} - 0.1 < \log(M_*/M_\odot) < M_{cut}$.

Fits with $M_{\rm halo}$

SMF

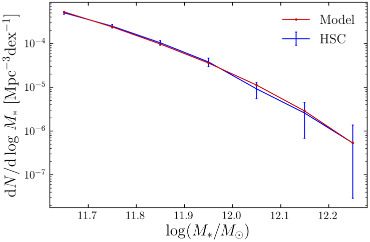


Clustering

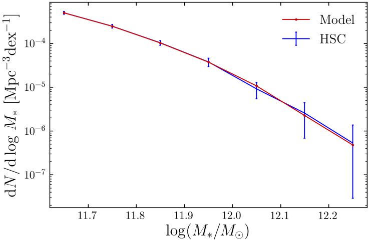


Bestfit Models 1: SMF

V_{max}@M_{peak}

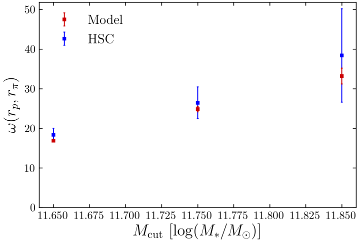


$M_{\mathrm{halo,peak}}$

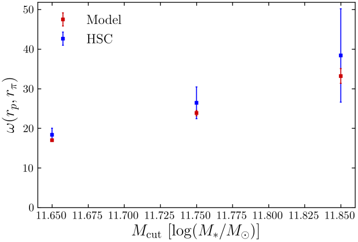


Bestfit Models 2: Clustering

$V_{\mathrm{max}}@M_{\mathrm{peak}}$



$M_{\mathrm{halo,peak}}$



Results 1: $f_{\rm sat}$

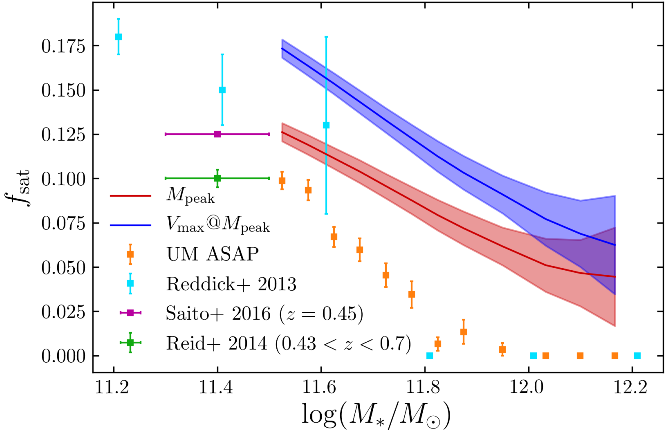


Figure: Errors on the UM are statistical from the bestfit. Errors on our mocks include the uncertainty of the parameters.

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Modelling RSD in DESI with the UM?

UM Parameters

Table 2. Table of parameters.

Symbol	Description	Equation	Parameters	Section
$\sigma_{\mathrm{SF}}(z)$	Scatter in SFR for star-forming galaxies	3	2	3.2
$V(z)$	Characteristic $v_{\max}$ in SFR – $v_{\max}$ relation	6	4	3.2
$\epsilon(z)$	Characteristic SFR in SFR – $v_{\max}$ relation	7	4	3.2
$\alpha(z)$	Faint-end slope of SFR – $v_{\max}$ relation	8	4	3.2
$\beta(z)$	Massive-end slope of SFR – $v_{\max}$ relation	9	3	3.2
$\gamma(z)$	Strength of Gaussian efficiency boost in SFR – $v_{\max}$ relation	10	3	3.2
δ	Width of Gaussian efficiency boost in SFR – $v_{\max}$ relation	11	1	3.2
$Q_{\min}(z)$	Minimum quenched fraction	13	2	3.2
$V_Q(z)$	Characteristic $v_{\max}$ for quenching	14	3	3.2
$\sigma_{VQ}(z)$	Characteristic $v_{\max}$ width over which quenching happens	15	3	3.2
$r_c(z)$	Rank correlation between halo assembly history ($\Delta v_{\max}$) and SFR	16	4	3.2
τ_R	Correlation time for long-timescale random contributions to SFR rank	–	1	3.2
f_{short}	Fraction of short-timescale random contributions to SFR rank	19	1	3.2
T_{orphan}	Threshold for $v_{\max}/v_{\mathrm{Mpeak}}$ at which disrupted haloes are no longer tracked	–	1	3.3
f_{merge}	Fraction of host halo's radius below which disrupted satellites merge into the central galaxy	–	1	3.3
α_{dust}	Characteristic rate at which dust increases with UV luminosity	22	1	3.4
$M_{\mathrm{dust}}(z)$	Characteristic UV luminosity for dust to become important	23	2	3.4
$\mu(z)$	Systematic offset in both observed stellar masses and SFRs	24	2	3.5
$\kappa(z)$	Additional systematic offset in observed SFRs	25	1	3.5
$\sigma_{\mathrm{SM,obs}}(z)$	Random error in recovering stellar masses	26	1	3.5
$\sigma_{\mathrm{SFR,obs}}(z)$	Random error in recovering SFRs	27	0	3.5

Notes. $\Delta v_{\max}$ is described by Eq. 1 in §3.1. Symbols followed by "(z)" depend on redshift and are described by multiple parameters (see equation references above). τ_R is expressed in units of the halo dynamical time ($(\sqrt{\frac{4}{3}\pi G\rho_{\mathrm{vir}}})^{-1}$) and so has an implicit redshift dependence. The total number of model parameters is 44.

Questions

- Thoughts about the incompatible f_{sat} in seemingly reasonably models?
- Can we use X-ray observations to measure f_{sat} in observations?
- Are there other ways in which centrals can be distinguished from satellites? Shape, orientation, something else?
- N-body resolution requirements for the UM to do RSD?
- How many UM params can be cut?