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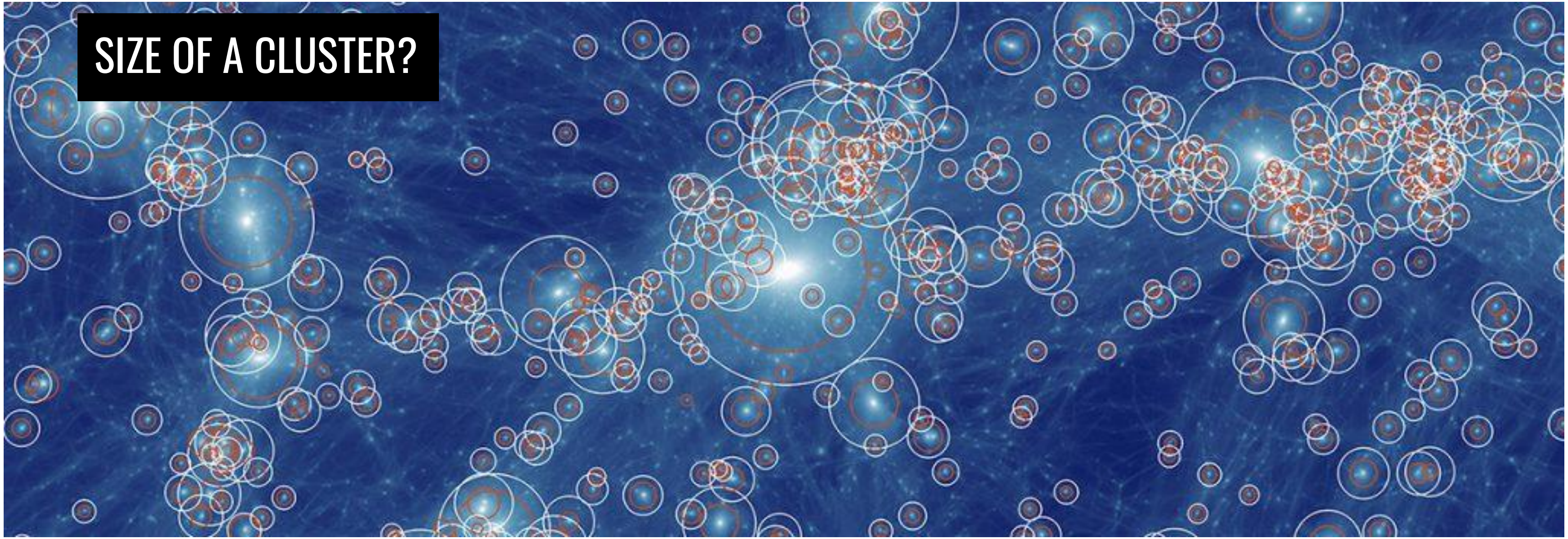
FAPESP
FUNDAÇÃO DE AMPARO À PESQUISA DO ESTADO DE SÃO PAULO

Galaxy Cluster Mass Estimation Through The Splashback Radius.

Gabriel-Silva and Sodré (submitted)

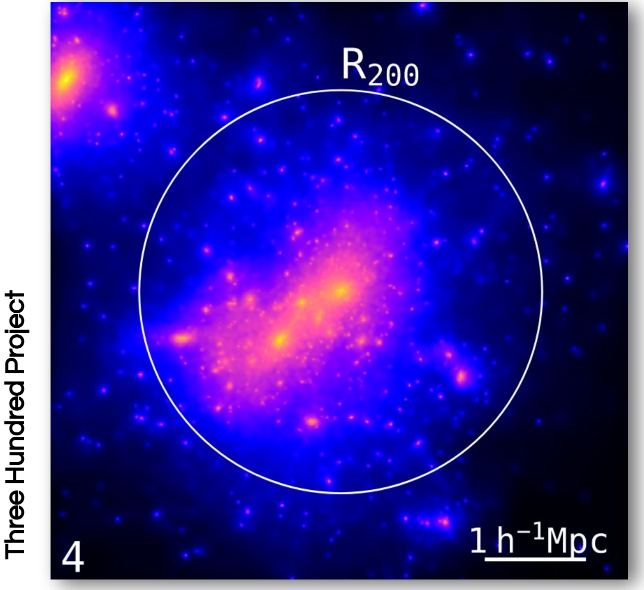
1. Introduction



Credit: SPARTA

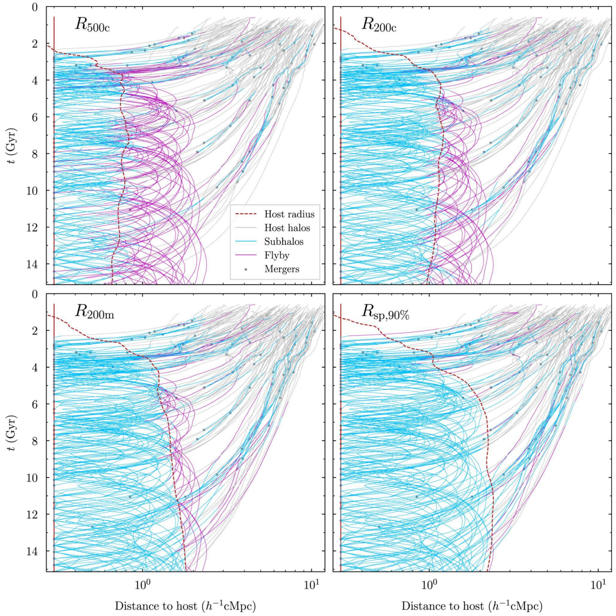
Mass Through Splashback.

Spherical Collapse



- Traditional definitions of halo boundary come from spherical collapse, where solutions point that the system is "virialized" inside a sphere of density ~ $200\rho_{\Delta}$, resulting in the R_{200};
- **Problem:** a lot of satellite galaxies found outside R_{200} (Wetzel+2014) and subhalos getting striped even far (Behroozi+2014);
- **Bigger problem:** any definition which rely on spherical overdensity can result in pseudo-evolution (Diemer+2013);

Solution: Splashback



Diemer2021

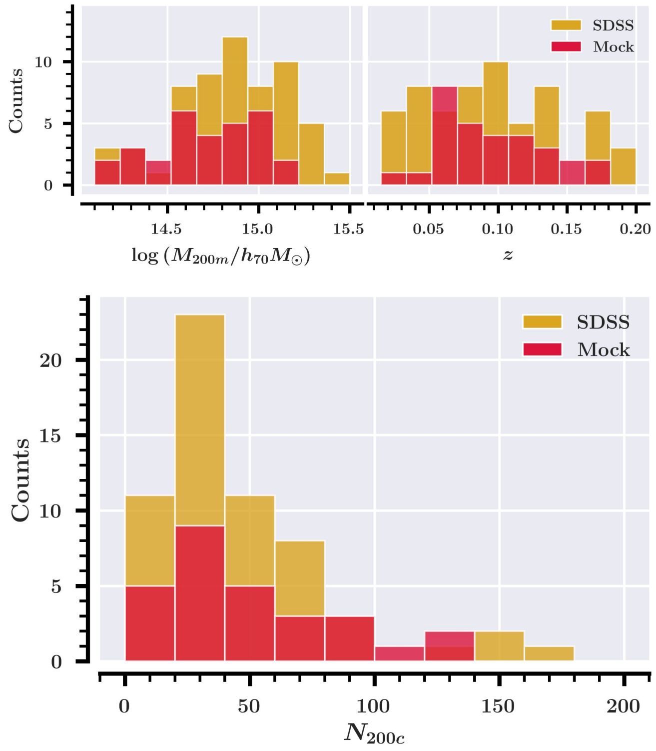
- First orbital apocenter of accreted matter;
- Physical boundary separating the orbiting (~virialized) region from the infalling region;
- Most natural halo radius: $M_{sp} = M(<R_{sp})$ includes all the matter that was accreted by a given redshift z;
- **Not sensitive to pseudo-evolution.**
- Directly observed by modeling the surface number density (More+2016; Adhikari+2016; Umetsu+2017).

2. Data & Methods:

Cumulative distributions

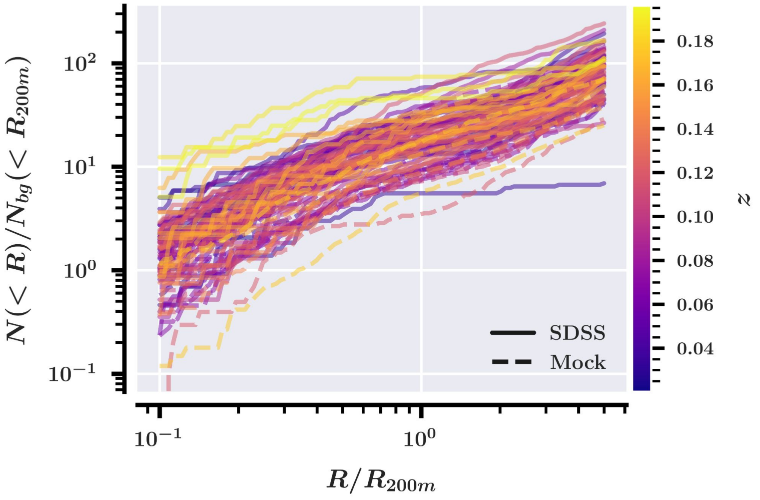
Data

- Weak-lensing mass catalog (Sereno2015, Herbonnet+2020)+ SDSS spectroscopic data (~60 clusters);
- Mock catalog (Araya-Araya+2021) (~30 clusters);
- **Cluster membership:**
  - $|\Delta_v| < 3\sigma_v$
  - r < -20.13 mag



Methods

- **Cumulative model:**
  - $N(<R) = 2\pi\int\Sigma(R)R\,dR$
  - $\Sigma = \Sigma_{1\text{-halo}} f_t + \Sigma_{2\text{-halo}}$
  - $f_t = \exp[-(R/R_t)^t]$
  - $\Sigma_{2\text{-halo}} = \rho_m[(R/r_{out})^{1-\gamma}\beta_{func} + 1]$
  - $\Sigma_{1\text{-halo}}$ = **Sérsic… or NFW…**
- **Splashback mass:**
  - $M(<r) = 4\pi\int r^2 M_{200}\,dr/(4\pi r_s^3 g_c) f_t/[x(1+x)^2]$
  - $Msp \equiv M(<R_{sp})$



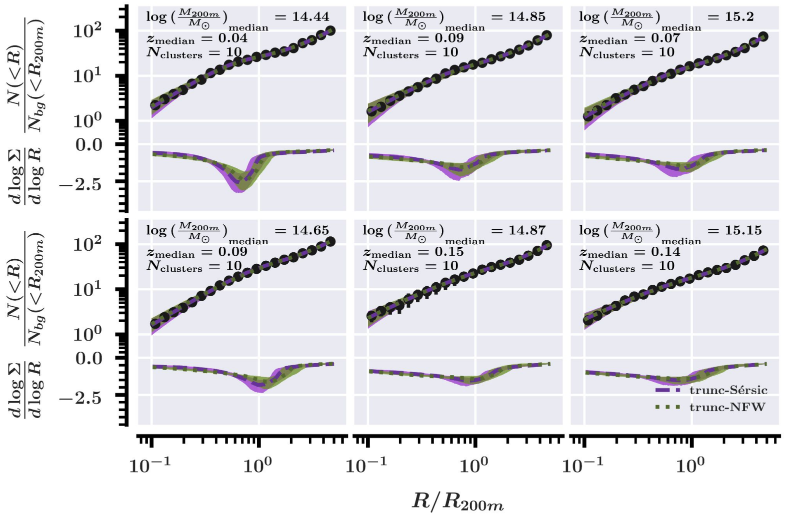
3. Results: Model & Constraints

RATIO R_{sp}/R_{200m}?

Parameter	Value	Type
ρ_s	0–500	Uniform
r_s	0.1–1.5	Uniform
R_t	0.1–8.0	Uniform
τ	4 ± 0.8	Gaussian
ρ_m	0–100	Uniform
r_{out}	1.5	Fixed
γ	1.7 ± 0.4	Gaussian

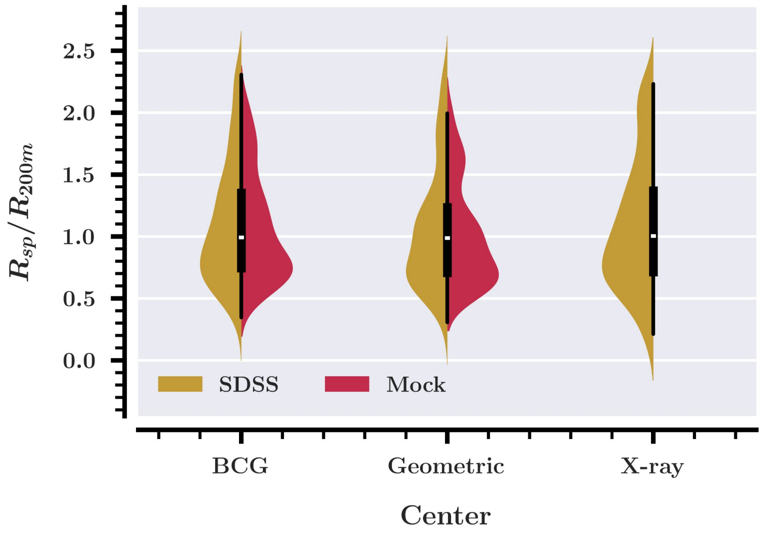
Model Selection

- ❑ Tested on stacked profiles;
- ❑ Similar performances between models;
- ❑ NFW produces larger R_{sp};
- ❑ In terms of χ^2, AIC and BIC, NFW outperforms Sérsic model;
- ❑ Same metrics show that a truncation function better fits the data.



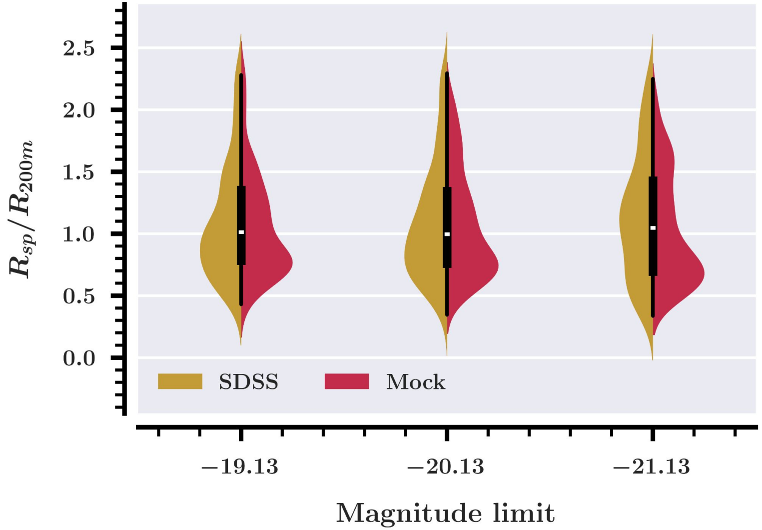
Center Definition

- The choice of cluster center does not affect the results;
- Importantly, no highly perturbed clusters in the samples;
- $R_{sp}/R_{200m} \approx 1$;
- Miscentering maybe does not play an important role.



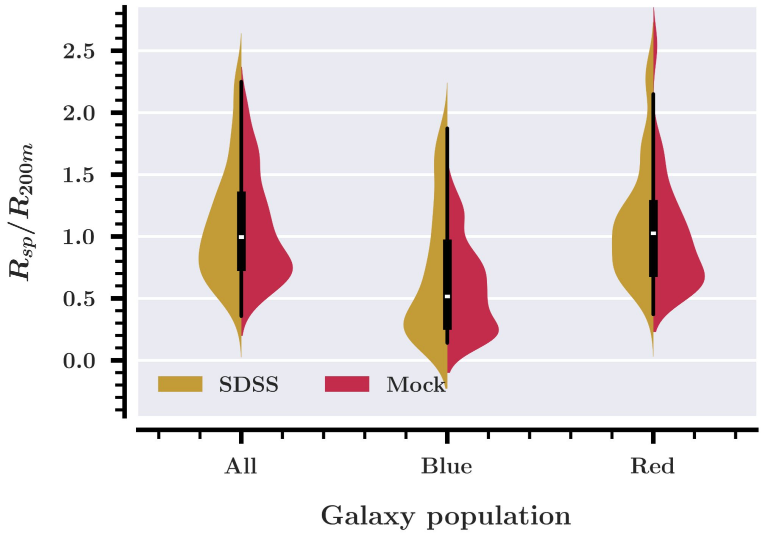
Magnitude Limit

- ❑ Magnitude limit of the sample does not change R_{sp} distributions;
- ❑ $R_{sp}/R_{200m} \approx 1$;
- ❑ Could indicate that Dynamical Friction (DF) does not affect R_{sp} measurements;
- ❑ Importantly, maybe the galaxies selected by these limits are not massive enough to in fact experience DF.



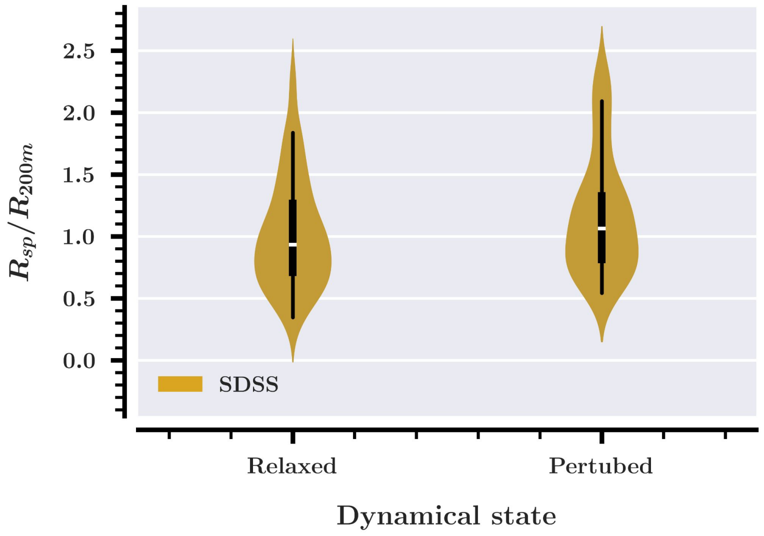
Galaxy Colors

- Blue galaxies have systematically lower R_{sp} than red galaxies and all population;
- Similar to Adhikari+2020;
- Could indicate that blue galaxies are recent infallers and have not reach their orbit apocenter yet.



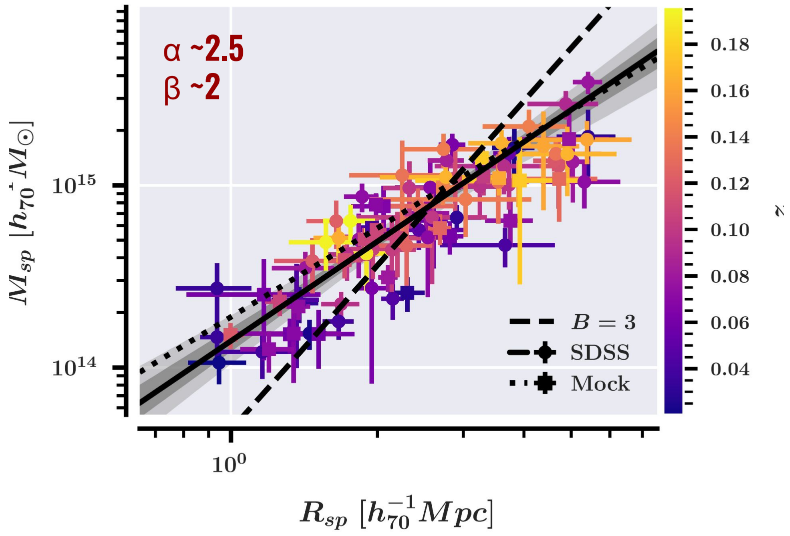
Dynamical State

- Distinction made by:
  - $\Delta m_{1,4} < 1$ mag;
  - $D_{X\text{-}BCG} > 0.02R_{200c}$;
- Importantly, no highly perturbed clusters in the sample;
- Perturbed clusters have greater R_{sp}/R_{200m} ratio.



M_{sp}-R_{sp} Relation

- Mass fitting shows redshift dependence:
  - $M_{sp} \propto (1+z)^{\alpha} R_{sp}^{\beta}$
- Strong correlation between R_{sp} and M_{sp} (dispersion ~0.15 dex);
- Including or not a redshift dependence do not change significantly the results (redshift interval is too small for proper fitting).



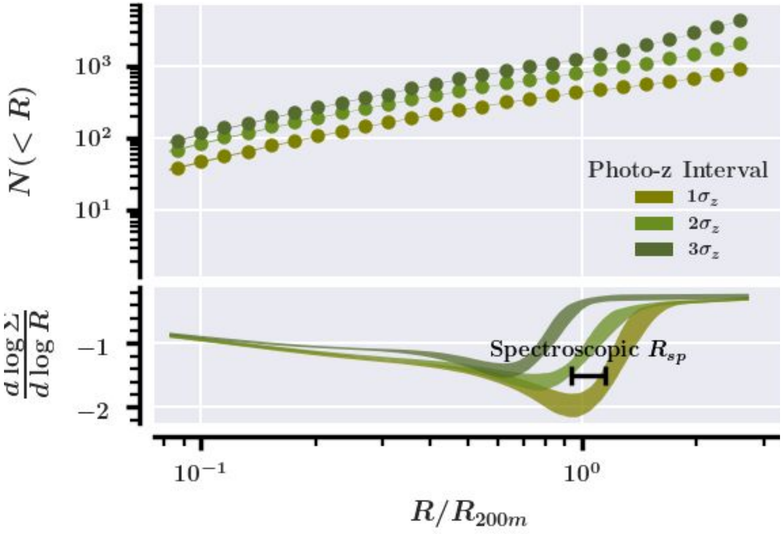
4. Future Perspectives:

Photometry?

R_{sp} from Photo-zs

- ❑ Pretty feasible!
- ❑ Contamination impact a lot on the results, lowering the values;
- ❑ By setting a fixed interval and re-calibrating the M_{sp}-R_{sp} relation, we could estimate cluster sizes and masses solely based on photometric information.

Coma Cluster from SDSS



Thank you!

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Expanding The Boundaries Of Dark Matter Halo Conference
Shanghai, China, 05-29-2025

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