The Edge of Dark Matter Halos

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The edge of dark matter halos

N-body simulations suggested that certain halos have a sharp boundary/edge.

Diemer & Kravtsov 2014
Infall and turnaround

First turnaround

\[ v_r = 0 \]
\[ r = R_{sp} \]

Second turnaround
= Splashback radius

Can we find this in real clusters?

Diemer & Kravstov (2014)
Adhikari, Dalal & Chamberlain (2014)
More et al. (2015)
We have found the edge of halos around galaxy clusters. This edge moves in if gravity is stronger or dark matter self-interacts.

*Baxter et al 2017; Chang et al:*

https://arxiv.org/abs/1702.01722; 1710.06808
Gravitational lensing by a cluster

Unlensed

Lensed

Image credit: Jim Bosch
The challenge: to get unbiased information from noisy data. We measure elongations of 1 part in $10^5$!
The edge of halos: mass vs. light

- Have we observed a true phase-space boundary?
- Is it at the radius expected in CDM halos?
- Do galaxies and mass track each other? Yes.
- What new physics can we test at the boundary?
Spare slides
galaxy images -> dark matter

Images
• Raw images -> Processed “co-added” images
• Individual galaxy image -> shape parameters
• Galaxy + surrounding light -> fitting for both

Catalogs
• Catalog of ~100 numbers per galaxy for ~100 million galaxies
  -> classification and clustering
  – Data spans the domains of color, time and spatial separation (sky)

Dark Matter
• Nonlocal map making, inference
Summary of Open Problems

- **Galaxy shape measurement**
  - Public challenges on simulated images
  - Principal Component Analysis…let the data do the talking
- **Galaxy clustering and Covariance matrix estimation**
  - Tree codes to handle millions of objects
- **Cosmological parameter estimation**
  - Interpolation in high-dimension space
  - CosmoSIS software framework: public code for all steps of analysis
- **Supernova Classification Challenge**
  - ``Real-time” analysis of time series data
Big Data from LSST

3 Gigapixel camera
2000 exposures per night -> 20TB per night
10 year survey -> 100 PB data

3 billion galaxies, 10 million supernovae

~100 000 alerts/ night worldwide, within 60 seconds

Within its first month of operation in 2020 LSST will survey more of the Universe than all previous telescopes built by mankind

Ongoing Dark Energy Survey’s publicly available dataset is already very interesting.