Correlations between galaxy angular momenta and initial conditions

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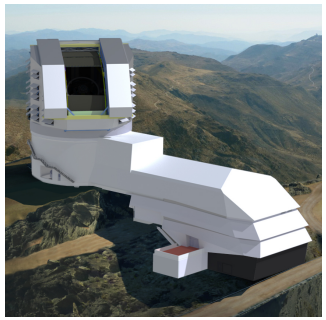
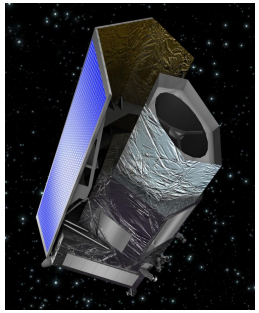
It is nice to have more data

- Why: tensions, beyond LCDM, ...

- Plan A – build new instruments





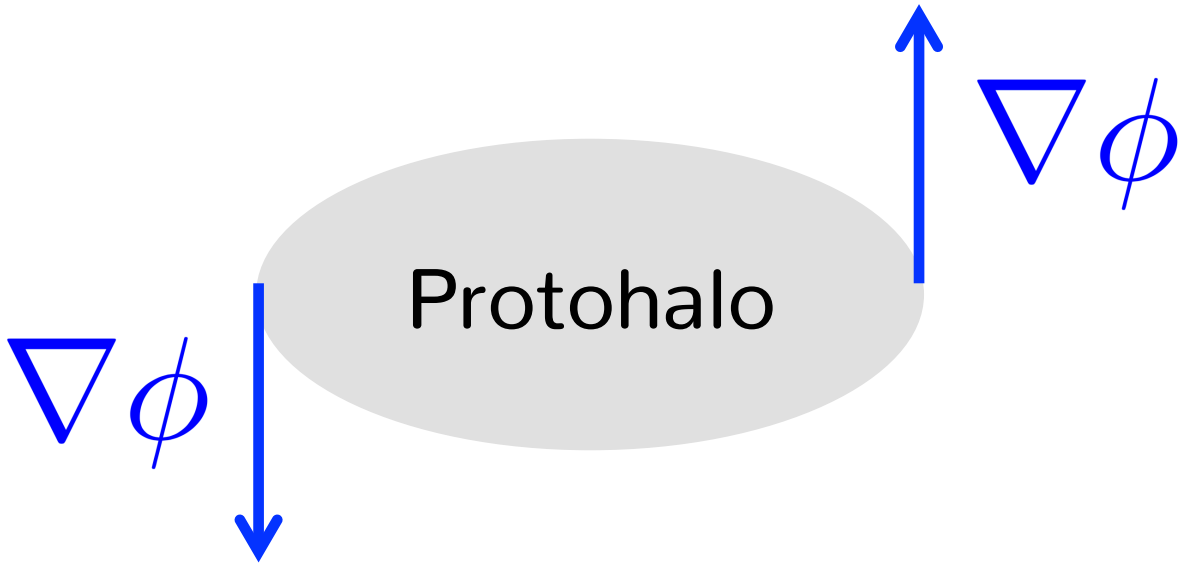
- Plan B – do more with the data we have

Galaxy angular momentum

- Additional information that we are ignoring

Origin of galaxy angular momenta

- Torqueing by inhomogeneous tidal field



Tidal Torque Theory

$$L_i \propto \sum_{jkm} \epsilon_{ijk} I_{jm} \partial_m \partial_k \phi$$

Angular momentum of DM halo

Protohalo moment of inertia

Tidal field

White, ApJ 286, 38

Our model for galaxy ang. mom.

- Substitute for the moment of inertia

$$L_i \propto \sum_{jkm} \epsilon_{ijk} \partial_j \partial_m \rho \partial_m \partial_k \phi$$

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Tidal field

Yu, PM+, PRL 124, 101302

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Protohalo "moment of inertia"

Tidal field

- Smooth the fields on O(Mpc) scale

Yu, PM+, PRL 124, 101302

Check with simulations

- In DM-only, n-body simulations this formula predicts directions of angular momenta of DM haloes “quite well”

Yu, PM+, PRL 124, 101302

Check with SDSS data

PM+, Nature Astronomy 5, 283

Check with SDSS data

- Angular momentum vector:

Toward us

Away from us

PM+, Nature Astronomy 5, 283

Check with SDSS data

- GalaxyZoo provides CW/ACW classifications

PM+, Nature Astronomy 5, 283

Check with SDSS data

- Project ELUCID reconstructed initial fields ϕ and ρ from SDSS galaxy position

- We use this estimate to predict the galaxy angular momenta

$$L_i \propto \sum_{jkm} \epsilon_{ijk} \partial_j \partial_m \rho \partial_m \partial_k \phi$$

PM+, Nature Astronomy 5, 283

Check with SDSS data

- Convert angular momentum prediction to clockwise/anticlockwise prediction

- Calculate how often our prediction is correct

PM+, Nature Astronomy 5, 283

Check with SDSS data

- We find excess over what would be expected if our guesses were purely random

- Significance of about 3 sigma

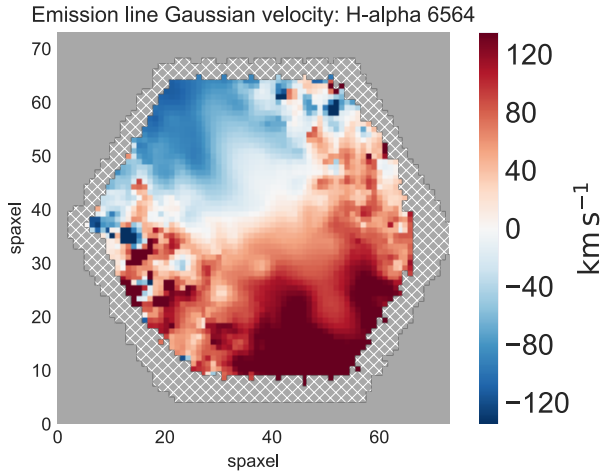
PM+, Nature Astronomy 5, 283

Why only 3 sigma?

- Limitation unclear:
  - ELUCID reconstruction uncertain on small scales
  - Galaxy / DM halo decorrelation?

Other observational handles

- Field spectroscopy



- Shapes of spiral galaxies

PM+, Nature Astronomy 5, 283 / PM+, PRD 105, 083504

Applications

- Help IC reconstruction on O(Mpc) scales
- Primordial parity violation in LSS
- Primordial non-Gaussianity, GW

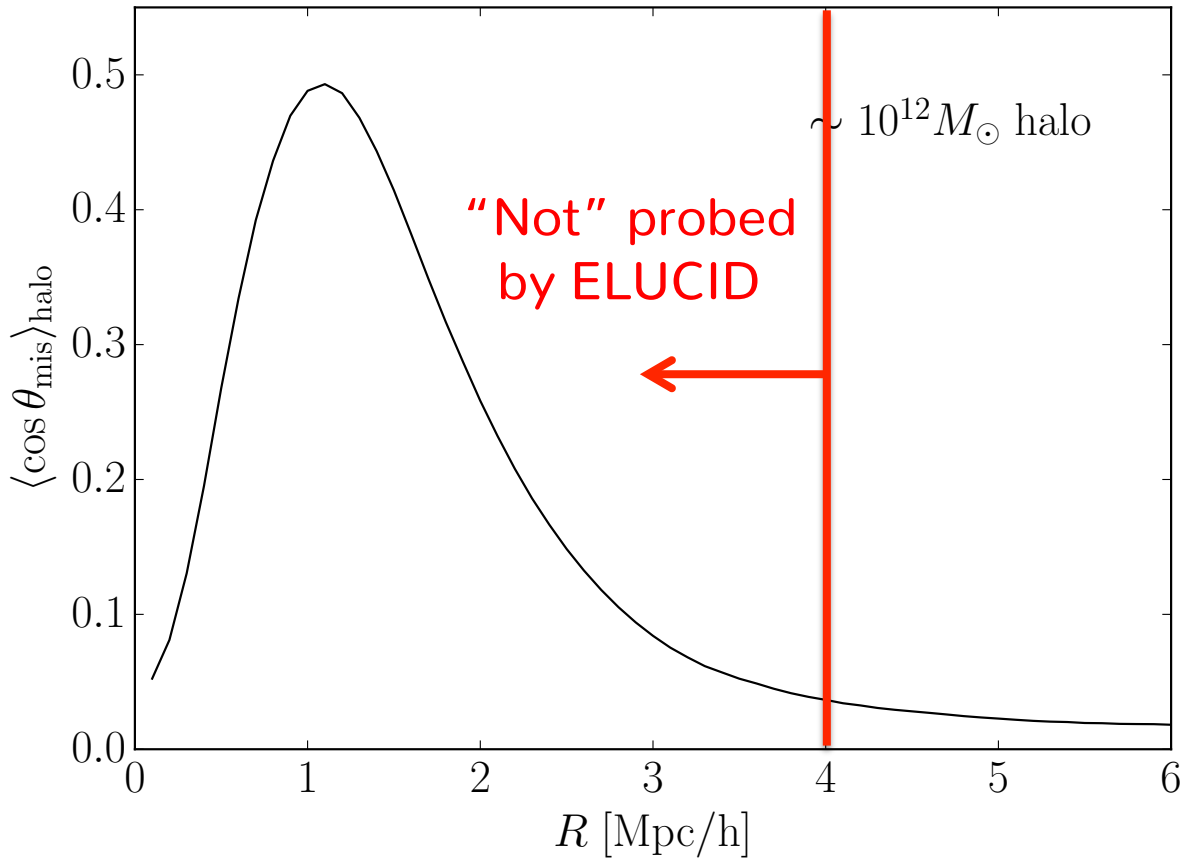
PM+, PRD 105, 083512

Summary

- Presented a formula predicting galaxy angular momenta from ICs
- Found hints of this relation in the experimental data (≈ 3 significance)
- Potential to probe interesting fundamental physics

THANK YOU

Why is correlation so small?



Why correlation so small?