

Relics from the Early Universe in Cosmic Voids

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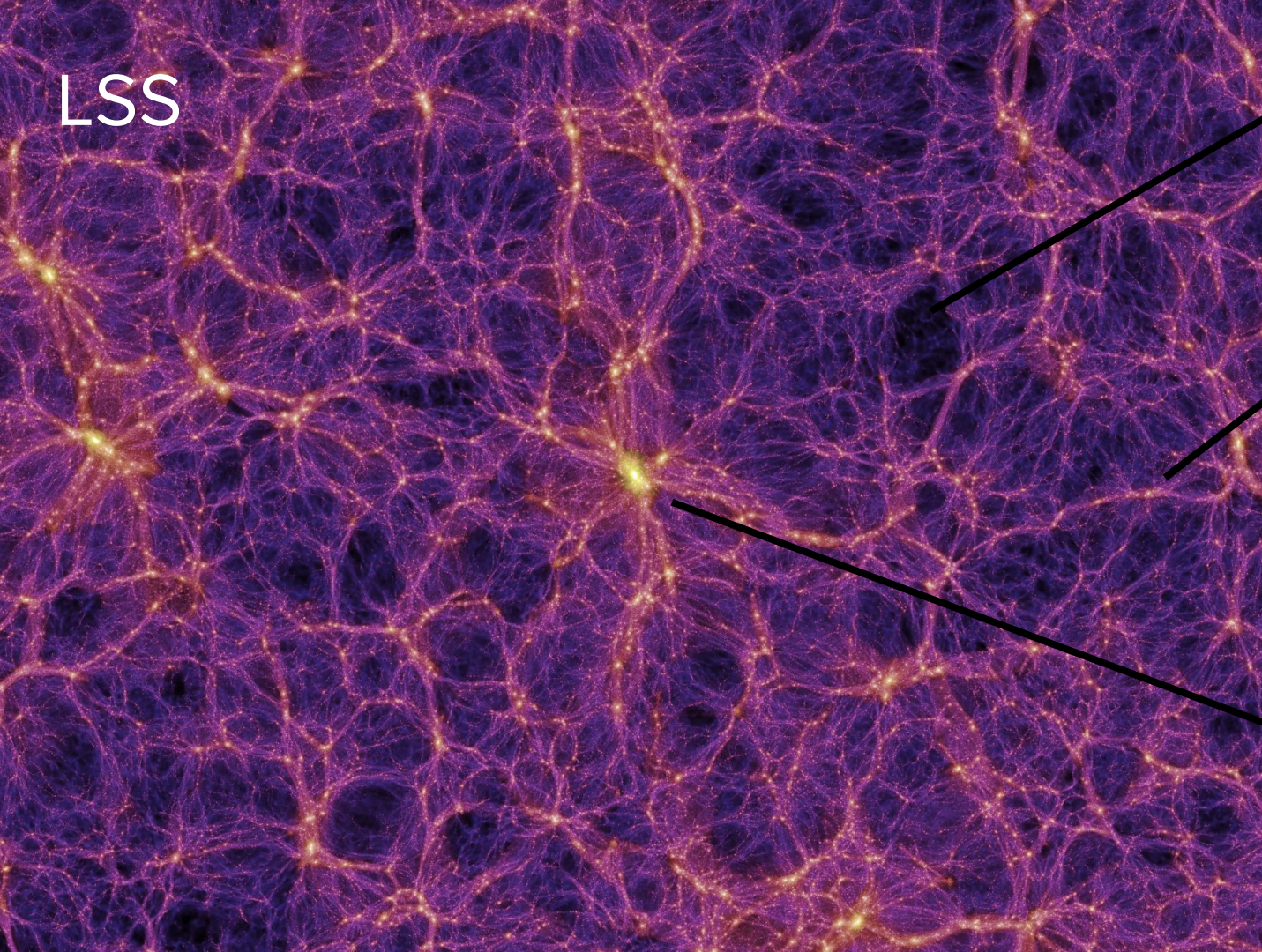
LSS

Voids

Walls/Filaments

Clusters

Credits - Millenium Simulation Project



Voids

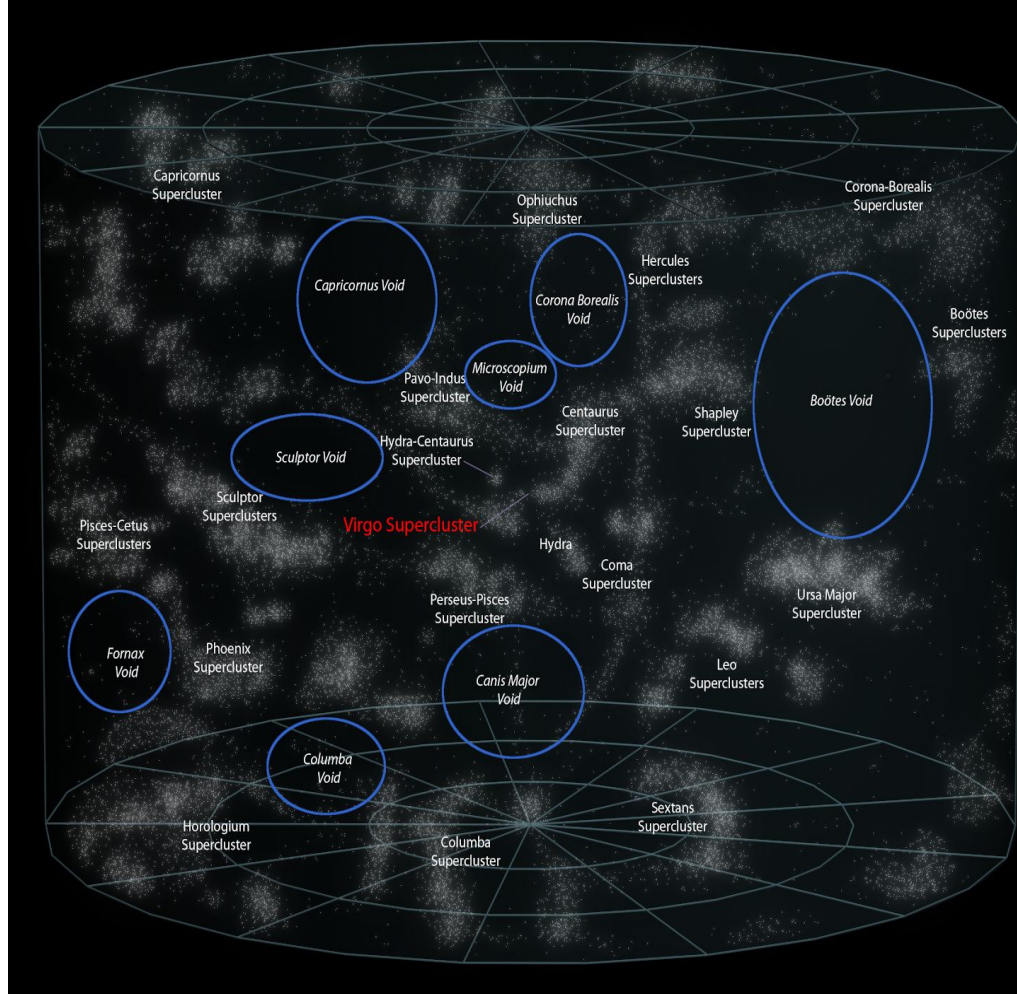
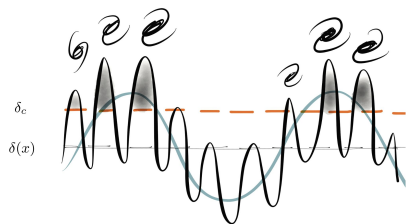
Diameter - 10 to 100 megaparsecs - huge

Under-dense

Expanding

Why voids?

- Linear dynamics - spherical evolution
- Scale-dependent +/- biases



Goal

Using voids for testing early universe

- Primordial non-Gaussianity (local)
- Cosmological Parity Violation

Data - Quijote simulations

- 512^3 CDM particles in 1Gpc side cube
- VIDE (ZOBOV) used to detect watershed voids

Statistics analysed over 450 (450 TB) such simulations -

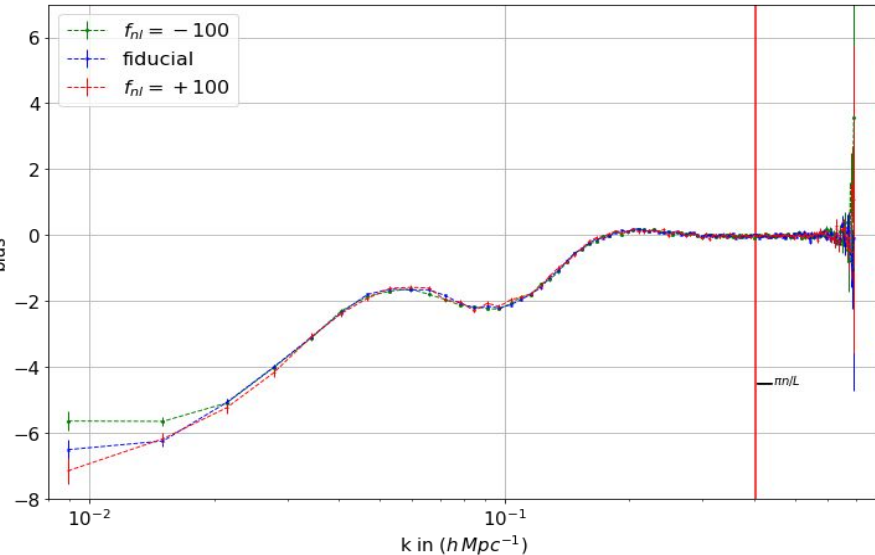
- Power spectrum - related to density field
- Bias
- Other void properties like radius and ellipticity
- Parity statistics involving pseudoscalars

Primordial non-Gaussianity

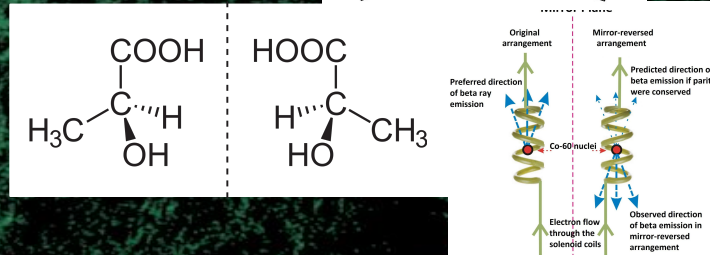
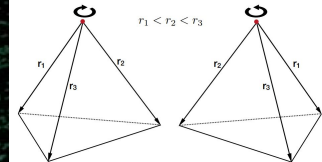
$$\langle \Phi(\mathbf{k}_1) \Phi(\mathbf{k}_2) \Phi(\mathbf{k}_3) \rangle = (2\pi)^3 \delta^{(3)}(\mathbf{k}_1 + \mathbf{k}_2 + \mathbf{k}_3) B_\Phi(k_1, k_2, k_3)$$

$$B_\Phi^{\text{local}}(k_1, k_2, k_3) = 2f_{\text{NL}}^{\text{local}} P_\Phi(k_1) P_\Phi(k_2) + 2 \text{ perm.}$$

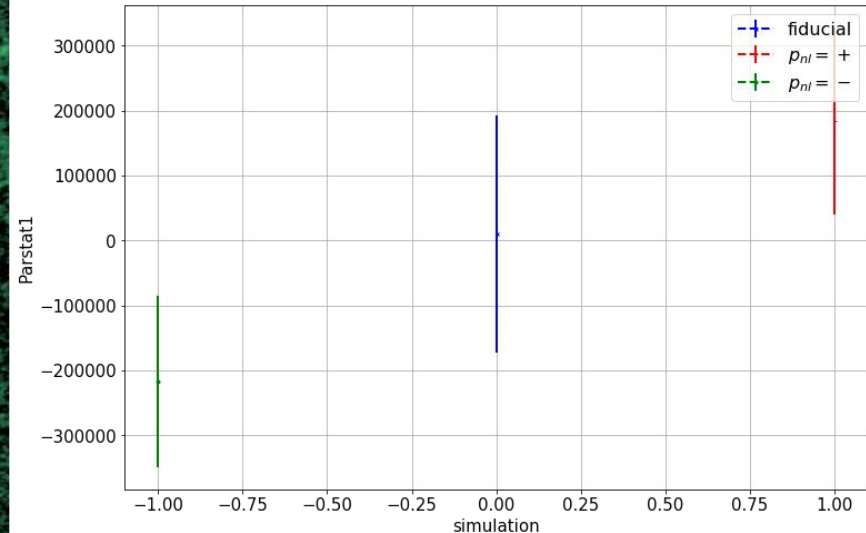
Bias vs k



Parity Violation



Parstat1 works?



Things learnt

Robustness and assumption check
at every step

Parallel computing

Analysing heavy data

Detours are natural and essential

Collaboration

All part of the 'Research process'

Thank You!
