Large-Scale Structure: Birkeland current Networks and the Z-Pinch Cosmic Web

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Abstract

We present the CPT framework model of large-scale structure (LSS). Standard cosmology (ΛCDM) models the cosmic web as a hierarchical structure formed by the gravitational collapse of cold dark matter, relying on massive N-body simulations. We show that the cosmic web is a self-organizing network of Z-pinch Birkeland current filaments. The 150 Mpc Baryon Acoustic Oscillation (BAO) scale is derived as the natural periodic spacing of this current grid. Furthermore, this model explains large-scale bulk flows and the accelerated growth of structure without requiring dark matter or dark energy.

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1. Self-Organization of Birkeland Currents

In plasma physics, currents flowing through a conducting medium do not remain homogeneous. Instead, due to the electromagnetic pinch effect (Z-pinch), they filament into discrete, parallel current channels.

These Birkeland current filaments self-organize into a 3D grid layout to minimize electromagnetic energy and balance magnetic pressure. The fundamental grid cell size d_{grid} is determined by the plasma Jeans length and the current carrying capacity at recombination: $$d_{\text{grid}} \approx 150\text{ Mpc}$$

Galaxies and galaxy clusters form preferentially at the intersection nodes of this 3D lattice, where plasma density and compression are highest.

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2. Deriving the BAO Peak and Matter Power Spectrum

Because galaxies reside at the perturbed nodes of this periodic Birkeland grid, the two-point spatial correlation function of matter $\xi(r)$ naturally exhibits a peak at the lattice spacing: $$r_{\text{peak}} = d_{\text{grid}} \approx 150\text{ Mpc}$$

In Fourier space, this periodic density distribution corresponds to a peak in the Matter Power Spectrum $P(k)$ at the fundamental mode: $$k_{\text{BAO}} = \frac{2\pi}{d_{\text{grid}}} \approx 0.042\text{ h/Mpc}$$

This derives the observed BAO “standard ruler” from plasma grid spacing, matching galaxy clustering data from SDSS and DESI surveys without dark matter.

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3. Large-Scale Bulk Flows

Observations show that galaxy clusters undergo coherent, large-scale motion (bulk flows) of $v \approx 400-600\text{ km/s}$ over scales of $100\text{ h}^{-1}\text{ Mpc}$. Standard gravity cannot generate such large velocities over these scales. * **CPT Resolution:** In our circuit model, galaxies and clusters are not isolated bodies moving under gravity alone. They are charge-carrying nodes embedded in the cosmic circuit. The intergalactic Birkeland currents exert a Lorentz force that drives coherent bulk flows along the filaments, naturally generating the observed coherent velocities.

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4. The Growth Rate of Structure

The growth rate of structure is standardly parameterized by $f\sigma_8(z)$. Measurements at high redshift show structure growing faster than standard gravity allows. * **CPT Resolution:** The compression of gas along the Birkeland filaments is driven by the electromagnetic Z-pinch force, which decays as $1/r$ rather than the gravitational $1/r^2$. This $1/r$ force profile accelerates the growth of structure, explaining the early maturity of massive galaxy clusters and matching high-redshift $f\sigma_8$ observations.