Topological Echoes of Primordial Physics in the Universe at Large Scales

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We present a pipeline for characterizing and constraining initial conditions in **cosmology** via persistent homology. We compute the multiscale topology of the large-scale distribution of **dark matter halos** in simulations using persistent homology, and use **persistence images** and curves constructed from persistence diagrams to detect **non-Gaussianity** in the initial conditions of these simulations.

$$\zeta(\mathbf{x}) = \zeta_G(\mathbf{x}) + \frac{3}{5} f_{\rm NL}^{\rm loc} \left(\zeta_G(\mathbf{x})^2 - \left\langle \zeta_G(\mathbf{x})^2 \right\rangle \right)$$

$f_{\rm NL}^{\rm loc} \neq 0$ would tell us a lot about fundamental physics!

long paper: arXiv:2009.04819

code:
https://gitlab.com/mbiagetti/persistent_homology_lss

simulations:
https://mbiagetti.gitlab.io/cosmos/nbody/