Contribution ID: **177** Type: **Plenary/Parallel talk**

A Needle in a Haystack - Characterizing Primordial Non-Gaussianity with Machine Learning to Probe the Early Universe

The detection of non-Gaussianity in primordial perturbations offers monumental new information about the early Universe. All models of inflation predict at least some level of primordial non-Gaussianity, and many models result in potentially observable non-Gaussian signatures. While detection efforts thus far have not found any significant primordial non-Gaussianity, they are not sensitive to all possible forms of non-Gaussianity. We go beyond past approaches by employing machine learning to characterize spatially localized and intermittent primordial non-Gaussianity that results from novel multi-field models of inflation. In particular, we use a multi-layered, 'deep-learning' formulation of Independent Component Analysis (ICA). Previously unexplored in the search for primordial non-Gaussianity, ICA is an unsupervised machine learning method used to separate generic non-Gaussian signals. Working with massive 1D simulations of curvature-perturbation fields with spatially localized and intermittent non-Gaussianity, we demonstrate that even in its standard form with some assumptions about the data, ICA effectively recovers the global presentation of non-Gaussianity. We then generate a large number of multi-scale component-separation layers. Each layer is composed of three steps: linear scale-filtering, non-linear ICA, and non-linear localized anomaly-extraction. Our adapted-ICA algorithm demonstrates promising detection of non-Gaussianity in a multi-scale, localized manner.

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Session Classification: Parallel Session Main Cupula: DM

Track Classification: Statistical Methods and Tensions in Cosmology