**Galactos: Computing the Anisotropic 3-point Correlation Function for 2 Billion Galaxies**

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**Quantifying the structure of the universe**

How does the balance between gravity and dark energy shape the distribution of matter in the Universe?

- Distribution of matter in the Universe can be characterized by using galaxy locations to construct correlation functions.
- The three-point correlation function (3PCF) compares counts of triplets of galaxies with a random distribution – excess correlation indicates clustering of matter on a particular distance scale.
- Naive algorithm scales as the cube of the number of galaxies considered.

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**Novel algorithm for evaluating the 3PCF**

- Expand the galaxy density in basis of spherical harmonics and radial distance bins.
- Change of basis allows 3PCF to be evaluated from distribution of galaxy pairs: scales as $O(N_{basis} N^2) < O(N^3)$.
- Anisotropy: directionality means we can study galaxies moving in their local gravity field, in addition to expansion of the universe: additional insight into the nature of gravity.

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**Results**

Strong scaling of Galactos code on Cori, using the Outer Rim dataset corresponding to 128 nodes (28.8 million galaxies).

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**Achievements**

- We have solved an open problem in cosmology for the next decade. Galactos can compute the 3PCF of all galaxies in the observable universe on Cori in one day.

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**References:**