Contribution ID: **77** Type: **not specified**

Turning dispersion into signal: Density-split analyses of pairwise velocities

Tuesday, July 15, 2025 4:00 PM (25 minutes)

Pairwise velocities of the large-scale structure encode valuable information about the growth of structure. They can be observed indirectly through redshift-space distortions and the kinetic Sunyaev–Zeldovich effect. Whether Gaussian or non-Gaussian, pairwise velocity has a broad distribution, but the cosmologically useful information lies primarily in the mean —the streaming velocities; the dispersion around the mean is often treated as a nuisance. This conventional approach reduces the constraining power of our observations. Here, we show that this does not have to be the case, provided the physics behind the dispersion is understood. By splitting the halo/galaxy samples according to their density environments and measuring the streaming velocities separately, we demonstrate that the total signal-to-noise is several times greater than in conventional global measurements of the pairwise velocity distribution (PVD). By splitting the data, we avoid cancellation between these opposing velocities, effectively turning what would be considered dispersion in the global PVD into a signal. Our findings indicate substantial potential for improving the analysis of PVD observations using the kinetic Sunyaev-Zeldovich effect and redshift-space distortions.

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Session Classification: Contributions