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Peculiar Velocity Reconstruction from Simulations and Observations Using Deep Learning Algorithms

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In this paper, we introduce a U-Net model of deep learning algorithms for reconstructions of the 3D peculiar velocity field, which simplifies the reconstruction process with enhanced precision. We test the adaptability of the U-Net model with simulation data under more realistic conditions, including the redshift space distortion effect and halo mass threshold. Our results show that the U-Net model outperforms the analytical method that runs under ideal conditions, with a 16% improvement in precision, 13% in residuals, 18% in correlation coefficient, and 27% in average coherence. The deep learning algorithm exhibits exceptional capacities to capture velocity features in nonlinear regions and substantially improve reconstruction precision in boundary regions. We then apply the U-Net model trained under Sloan Digital Sky Survey (SDSS) observational conditions to the SDSS Data Release 7 data for observational 3D peculiar velocity reconstructions.

Author: WANG, Yuyu

Presenter: WANG, Yuyu

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