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First Principles Simulations of Microscale Turbulence in the Solar Wind

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Recent advances in observational and computational techniques have enabled significant progress in the understanding of kinetic-scale turbulent cascades in magnetized plasmas. These findings have important implications for models of turbulent heating and particle energization in weakly collisional space and astrophysical plasmas, including the observationally accessible solar wind. Here, a set of massively parallel particle simulations are performed to investigate the nature of turbulent fluctuations below the ion spectral break in the solar wind. Using a fully kinetic description in three spatial dimensions, the field polarization properties and a turbulence anisotropy analysis are employed to identify the self-consistently cascaded fluctuations as kinetic Alfven waves. Special attention is paid to the role of coherent structure formation, which gives rise to intermittent statistics of the magnetic field and of the electron density. A longstanding debate on the relative importance of waves and coherent structures is addressed. Based on a set of novel diagnostic measures, combined with in situ spacecraft observations, it is argued that the kinetic-scale structures themselves carry wavelike features.