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We present a broad review of frequent observations and theoretical models of 1/f noise in the heliosphere, and highlight the relevance of NASA’s Polarimeter to UNify the Corona and Heliosphere (PUNCH) mission for advancing these studies. First identified in voltage fluctuations of vacuum tubes, scale-invariant 1/f spectra have since been reported in a wide range of systems — from cardiac dynamics to loudness fluctuations in music — suggesting the presence of a generic, universal mechanism.

The superposition principle is an analytical model in which correlated signals with scale-invariantly distributed correlation times combine to produce 1/f spectrum. Although idealized, this model is consistent with broader theoretical paradigms such as inverse cascade and self-organized criticality, both of which are known to generate scale-invariant fluctuations. Using both synthetic time series and in situ measurements from the Advanced Composition Explorer (ACE) mission at 1 au, we demonstrate the robustness of the superposition principle in producing and preserving 1/f behavior.

At 1 au, the trace of the magnetic field power spectrum exhibits 1/f scaling from around 1e-4 Hz (comparable to the turbulence correlation timescale) down to about 1e-6 Hz (corresponding to the solar rotation period). The low-frequency part suggests an 1/f origin rooted in coronal processes or in the solar dynamo. We will show preliminary analysis of low-frequency and low-wavenumber spectral behavior using PUNCH data. With high-resolution, wide-field coronal imaging capable of disentangling spatial and temporal variability, PUNCH offers an unprecedented opportunity to investigate the formation and evolution of 1/f-type structures.
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