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Intermittency of Electron Density in Interstellar Kinetic Alfvén Wave Turbulence[1]

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Pulsar radiation pulses broaden as they propagate through interstellar space. The observed scaling of the pulse duration with distance to source indicates that the electron density fluctuations that broaden the pulse do not obey a Gaussian distribution. Instead they obey a Levy distribution, which contains an enhanced power-law tail. The physical mechanisms responsible for this tail remain to be established. We show that a Levy distribution arises from magnetic turbulence near the Larmor-radius scale where electron density actively couples to the magnetic field through kinetic Alfvén wave (KAW) fluctuations. The analysis reveals a new type of turbulent intermittency mediated by compressive effects in electron physics rather than advection. Using analytic theory and computation we show that coherent structures form in the current, magnetic field, and density of decaying KAW turbulence. These structures avoid mixing by the turbulence because they have a strongly sheared magnetic field that refracts turbulence away from them. The required shear places these structures in the tail of the distribution function. Their probability is enhanced because decay by turbulent mixing is suppressed by the refraction. The current structures are localized but Ampere's law and KAW equipartition give coherent density and magnetic field extended spatial envelopes. These envelopes decay as r^{-1} outside the current structure. This structure leads to a probability distribution function with a power-law tail. The probability of density gradient decays as $(\nabla n_e)^{-2}$, a Levy distribution. Because there are laboratory plasmas with magnetic turbulence at the Larmor-radius scale, it should be possible to look for these effects in the laboratory.

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