Exponential Frequency Spectra, Lorentzian Pulses and Intermittent Transport in Pressure Gradients

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An extensive experimental and modeling study of the spontaneous fluctuations driven by pressure gradients in a magnetized plasma has identified the development of broadband turbulence having an exponential frequency dependence for frequencies below the ion cyclotron frequency. Locally, the exponential spectrum arises from temporal pulses having a unique Lorentzian shape. The single scaling time is a fraction of a period of the linearly unstable drift-Alfvén modes. The pulses exhibit positive and negative polarity depending on the spatial location relative to the position of maximum gradient and are a manifestation of extended, spatially-complex structures. These features arise above a critical wave amplitude corresponding to large Péclet number, i.e., when convection becomes more important than diffusion. The appearance of the structures results in intermittent, non-local rearrangements of the pressure profile. Two completely different experimental situations have been explored in the Large Plasma Device (LAPD-U) operated by the Basic Plasma Science Facility (BaPSF) at UCLA. One experiment involves a controlled, pure temperature gradient in which a small electron beam creates a hot electron temperature filament embedded in the center of a large, cold magnetized plasma. The other experiment consists of a limiter-edge configuration that uses a metallic plate inserted at the plasma edge to establish a sharp density gradient in the nominal plasma column of the LAPD-U. Both exhibit similar exponential spectra and Lorentzian pulses. A numerical study that combines classical transport with convection due to drift waves illustrates the formation of the complex structures leading to the Lorentzian pulses. It is also found in such a model that an externally imposed flow can suppress the pulses, depending on its direction relative to the direction of propagation of the waves. Since the exponential spectra has been observed under totally different conditions, and has been reported also by other researchers in different confinement devices (helical, tokamak) it is strongly suggestive that the phenomena is a universal feature associated with pressure gradients in magnetized plasmas.