

Beam or temperature anisotropy instabilities in unmagnetized plasma

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Both Weibel (1959) and Fried (1959) demonstrated that an anisotropic distribution function can lead to a purely growing electromagnetic instability, commonly referred to as the Weibel instability. This instability arises because the Lorentz force from a perturbed magnetic field induces a current that amplifies the perturbation, resulting in spontaneous growth. Traditionally, the Weibel instability has been attributed to macroscopic temperature anisotropy. However, recent studies suggest that its properties depend not only on temperature anisotropy but also on the specific form of the distribution function. For example, Silva (2021) showed that different distribution functions with the same temperature anisotropy can produce varying growth rates and wavevector directions. Similarly, Zaheer (2007) compared Maxwellian, kappa, and generalized (r, q) distribution functions with the same effective temperature, demonstrating that the instability characteristics are highly sensitive to the particular form of the distribution function. In this study, we will discuss the detailed properties of these instabilities in unmagnetized plasmas.

Keywords: Weibel Instability, anisotropic distribution function, PIC simulation