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Modelling of kinetic instabilities in low-temperature plasmas

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Instabilities are a common phenomenon present in a wide range of different plasma devices. Such instabilities can result from macroscopic effects, such as gradients in the plasma properties, or microscopic (kinetic) effects associated with the particle distribution functions themselves. These latter instabilities are typically characterised by short-wavelengths (of the order of the Debye length) and high-frequencies (of the order of the ion plasma frequency), and can play an important role in particle transport. Modelling of kinetic instabilities is a challenge since they cannot in general be described by plasma fluid equations, and the Boltzmann or Vlasov equations often prove too difficult to solve directly. In these situations, particle-in-cell (PIC) simulations are the "go-to" tool, but for multi-dimensional, large-scale, or high-density problems, even these simulations can be too demanding due to strict numerical stability criteria. Using as an example electron drift instabilities in magnetised plasmas, a hybrid approach is discussed that combines elements of fluid modelling, kinetic theory, and Monte Carlo simulations. An Initial comparison with full PIC simulations offers promise for this new technique to more rapidly, and self-consistently, model kinetic instabilities.