Landau Damping in Weakly Collisional Plasmas

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Understanding the flow of energy between wave and particle degrees of freedom in weakly collisional plasma is a complex problem that has received considerable attention over many years. The classic work of Landau on the damping of waves in collisionless plasmas has, for many years served as the central paradigm. However, it is well known that the weakly damped modes in Landau's theory do not fully represent the collective degrees of freedom of a plasma in the collisionless limit. Although one may argue that the damped degrees of freedom do not play any dynamical role in linear plasma behavior, except in exotic phenomena such as echoes, this is not entirely true. In general one has to redo the Landau calculation for the actual particle distribution functions of interest. It turns out that the number of dynamically relevant (weakly damped) wave modes depends on the details of these distributions.

In Landau's theory, the stable collective modes are not normal modes. The fundamental modes of the collisionless theory are the singular functions called Case-Van Kampen modes. In the presence of weak collisions the complete set of degrees of freedom has yet another form. We will discuss the status of experimental and theoretical work on the nature of the full collective wave spectrum in weakly collisional plasmas and how it affects the understanding of wave-particle interactions in plamas.