



Computing the Generalized Plasma Dispersion Function for Ionospheric Plasmas

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Kinetic plasma studies, such as those relating to the ionospheric plasmas, often require computing integrals of the velocity distribution over a complex-valued pole. The standard method is to solve the integral in the complex plane using the Plemelj theorem, resulting in the standard plasma dispersion function for Maxwellian plasmas. For non-Maxwellian plasmas, the Plemelj theorem does not generalize to an analytic form, and computational methods must be used. Here, a new computational method is presented that accurately integrates a non-Maxwellian velocity distribution over an arbitrary set of complex valued poles. This method works by keeping the integration contour on the real line, and applying a trapezoid rule-like integration scheme over all discretized intervals. In intervals containing a pole, the velocity distribution is linearly interpolated, and the analytic result for the integral over a linear function is used. The integration scheme is validated by comparing its results to the analytic plasma dispersion function for Maxwellian distributions. We then show the utility of this method by computing the Thomson scattering spectra for several non-Maxwellian distributions: the kappa, super Gaussian, and toroidal distributions. Thomson scattering is a valuable plasma diagnostic tool for both laboratory and space plasmas, but the technique relies on fitting measured wave spectra to a forward model, which typically assumes Maxwellian plasmas. Therefore, this integration method can expand the capabilities of Thomson scatter diagnostics to regimes where the plasma is non-Maxwellian, including high energy density plasmas, frictionally heated plasmas in the ionosphere, and plasmas with a substantial suprathermal electron tail.