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Stable time-domain differential equations which reproduce the warm plasma dielectric tensor

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Nonlinear and transient phenomena are of great interest in plasma physics [1]. The ability to model such phenomena is a major advantage of time-domain computational techniques.

In [2], we derived stable (provably conservative) time-domain constitutive differential equations which, in the frequency domain, reproduce a finite-order approximation to the dielectric tensor for hot Maxwellian plasmas [3]. In [2], the approximation was accurate to second order in the thermal velocity and only valid for perpendicular propagation, with the electric field perpendicular to the background magnetic field (i.e. reproducing the x-y block of the dielectric tensor). Later [4], we also reproduced the zz-block of the dielectric tensor in this fashion.

This stable approximation is obtained using carefully-chosen rational rather than polynomial approximations to the special functions in the dielectric tensor, which are then related to time-domain differential equations by means of the Fourier transform [5].

Here, we will obtain a conservative set of time-domain differential equations which reproduces, in the frequency domain, the warm plasma dielectric tensor to second order in the thermal velocity and first order in the parallel wavenumber.

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