Thomson scattering at high temperatures is dominated by Landau damping and can be approximated as collisionless.

\begin{equation}
\pi n_{e}(k,\omega) = \frac{2}{\sqrt{\pi}} \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \frac{1}{\sqrt{l_{nc}^{2} + (\omega_{ce} - \omega)^{2}}} \\
\epsilon(k,\omega) = 1 + 4\pi n_{e}(k,\omega) \int \frac{d^{3}p}{(2\pi)^{3}} \frac{p^{2}f_{0}(\frac{p}{m})}{E_{0} - \epsilon_{0} - E_{p} + i\Gamma_{0}}
\end{equation}

Collisionless: \( n_{0}(k) = \frac{1}{\pi^{3/2}} \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \frac{1}{\sqrt{l_{nc}^{2} + (\omega_{ce} - \omega)^{2}}} \)

Laplace transform variable

\[ \epsilon(k,\omega) \] collisional velocity dependent: \( \gamma_{\epsilon}(k) \)

In the limit \( k \rightarrow 0 \), it can be shown that

\[ x_{f} = \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \left[ 1 - \epsilon(k,\omega) \right] \left( \epsilon(x,\omega) \right) \]

where

\[ x_{f} = \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \left[ 1 - \epsilon(k,\omega) \right] \left( \epsilon(x,\omega) \right) \]

Collisional velocity dependent: \( \gamma(x,\omega) \)

Damping in time causes spectral widening and lower spectral peaks.

The electron temperature was observed to rise from an initial 5 eV to 20 eV in 20 ps. Over this time the density increases from \( 0.8 \times 10^{19} \) cm\(^{-3}\) to its plateau at \( 1.1 \times 10^{19} \) cm\(^{-3}\).

The Thomson-scattering data were fit late in time to find both the electron temperature and density.

The spectra are then fit for a second time taking into account the effects of temporal temperature gradients using the heating rate from the first fit.

The collisional dielectric function, \( \epsilon(k,\omega) \), can be solved in an analogous manner to the collisionless case except it requires two inputs: \( x_{k} \) and \( x_{f} \).

\[ \epsilon(k,\omega) = 1 + 4\pi n_{e}(k,\omega) \int \frac{d^{3}p}{(2\pi)^{3}} \frac{p^{2}f_{0}(\frac{p}{m})}{E_{0} - \epsilon_{0} - E_{p} + i\Gamma_{0}} \]

\[ \epsilon(k,\omega) = 1 + 4\pi n_{e}(k,\omega) \int \frac{d^{3}p}{(2\pi)^{3}} \frac{p^{2}f_{0}(\frac{p}{m})}{E_{0} - \epsilon_{0} - E_{p} + i\Gamma_{0}} \]

It can be shown that the dielectric function reduces to

\[ \epsilon(k,\omega) = 1 + 4\pi n_{e}(k,\omega) \int \frac{d^{3}p}{(2\pi)^{3}} \frac{p^{2}f_{0}(\frac{p}{m})}{E_{0} - \epsilon_{0} - E_{p} + i\Gamma_{0}} \]

where

\[ x_{f} = \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \left[ 1 - \epsilon(k,\omega) \right] \left( \epsilon(x,\omega) \right) \]

Landau damping

Collisional damping

\[ x_{f} = \frac{\omega_{pe}^{2}}{\omega_{ce}^{2}} \left[ 1 - \epsilon(k,\omega) \right] \left( \epsilon(x,\omega) \right) \]

This function has collisional damping at low temperatures and Landau damping at high temperatures.