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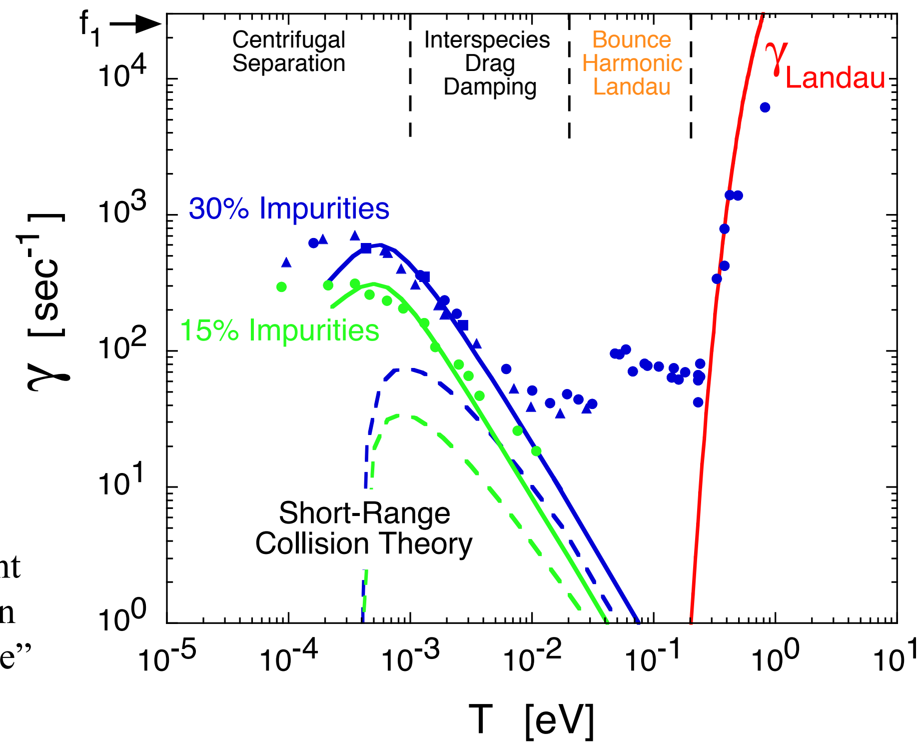
Plasma Wave Damping, from Hot to Cold

The laser-cooled and laser-diagnosed pure ion plasmas of the “IV” apparatus allow plasma wave damping rates γ to be studied over an exceedingly wide temperature range, with $10^{-4} < T < 1$ eV.

At high temperatures (T ~ 0.5 eV), Landau damping dominates. Quantitative agreement with Landau theory is obtained for small amplitude waves, and nonlinear particle trapping is observed for larger amplitude waves.

At lower energies (T ~ 0.1eV), prototypical Landau damping becomes exponentially weak, but the same Landau interaction occurs with *bounce harmonics* of the wave. Recent experiments (Anderegg 2016) and theory (Ashourvan 2014) in this temperature regime have demonstrated that axial “squeeze” trapping increases these *bounce harmonics*, causing stronger damping as predicted by theory.

At cryogenic temperatures ($T \leq 10^{-2}$ eV), collisions with impurity species causes a “drag” on the majority species, which directly damps the wave motions. Here, drag damping measurements provide the first experimental confirmation of recent theory predicting enhanced collisional slowing due to long-range collisions (Dubin 2014). At ultra-low temperatures, the various species become separated radially due to centrifugal effects, and the drag damping is observed to decrease.



Understanding these wave damping mechanisms is important for the wide variety of cold ion trapping devices, with applications from atomic physics and fundamental constants to chemical spectroscopy to anti-matter containment.

F. Anderegg, Accepted to Phys. Plasmas (2016)

A. Ashourvan, Phys. Plasmas **21**, 052109 (2014)

D. Dubin, Phys. Plasmas **21**, 052108 (2014)