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Bounce-harmonic Landau Damping of Plasma Waves[1]

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We present measurement of plasma wave damping, spanning the temperature regimes of direct Landau damping, bounce-harmonic Landau damping, inter-species drag damping, and viscous damping. Direct Landau damping is dominant at high temperatures, but becomes negligible as $\bar{v} < v_{ph}/5$. The measurements are conducted in trapped pure ion plasmas contained in Penning-Malmberg trap, with wave-coherent LIF diagnostics of particle velocities. Our focus is on bounce harmonics damping, controlled by an applied "squeeze" potential, which generates harmonics in the wave potential and in the particle dynamics. A particle moving in z experiences a non-sinusoidal mode potential caused by the squeeze, producing high spatial harmonics with lower phase velocity. These harmonics are Landau damped even when the mode phase velocity v_{ph} is large compared to the thermal velocity $\bar{v}$, since the n^{th} harmonic is resonant with a particle bouncing at velocity $v_b = v_{ph}/n$. Here we increase the bounce harmonics through applied squeeze potential; but some harmonics are always present in finite length systems. For our centered squeeze geometry, theory shows that only odd harmonics are generated, and predicts the Landau damping rate from v_{ph}/n. Experimentally, the squeeze potential increases the wave damping and reduces its frequency. The frequency shift occurs because the squeeze potential reduces the number of particle where the mode velocity is the largest, therefore reducing the mode frequency. We observe an increase in the damping proportional to V_s^2, and a frequency reduction proportional to V_s , in quantitative agreement with theory[3]. Wave-coherent laser induced fluorescence allows direct observation of bounce resonances on the particle distribution, here predominantly at $v_{ph}/3$. A clear increase of the bounce harmonics is visible on the particle distribution when the squeeze potential is applied.

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[2]In collaboration with M. Affolter, A.A. Kabantsev, A. Ashourvan, D.H.E. Dubin, C.F. Driscoll.
[3]A.Ashourvan, D.H.E. Dubin, Phys. Plas. **21**, 052109, 2014.