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First Test of Long-Range Collisional Drag via Plasma Wave Damping[1]

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In magnetized plasmas, the rate of particle collisions is enhanced over classical predictions when the cyclotron radius r_c is less than the Debye length λ_D. Classical theories describe local velocity scattering collisions with impact parameters $\rho < r_c$. However, when $r_c < \lambda_D$, long-range collisions exchange energy and momentum over the range $r_c < \rho < \lambda_D$ with negligible parallel-perpendicular velocity scattering. Previous experiments and theory have shown that these long-range collisions enhance cross-field diffusion, heat transport, and viscosity by orders of magnitude over classical predictions[2]. Here, we present the first experimental confirmation of a new theory[3], which predicts enhanced parallel velocity slowing due to these long-range collisions. These experiments measure the damping of Trivelpiece-Gould waves in a multispecies pure ion plasma. The damping is dominated by interspecies collisional drag when Landau damping is weak. In this "drag damping" regime, the measured damping rates exceed classical predictions of collisional drag damping by as much as an order of magnitude, but agree with the new long-range enhanced collision theory. The enhanced slowing is most significant for strong magnetization and low temperatures. For example, the slowing of anti-protons at a density of 10^7 cm^{-3} and a temperature of 10 K in a 6 T trap is enhanced by a factor of 30.

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[2]C. F. Driscoll et al., Phys. Plasmas **9**, 1905 (2002)

[3]D.H.E. Dubin, Phys. Plasmas **21**, 052108 (2014)