Novel effects in Slowing due to Long Range Collisions

The UCSD group has developed wide-ranging theory and experiments describing transport from long range collisions with impact parameter $\rho$ larger than the cyclotron radius $r_c$

These collisions are in addition to the standard short-range collisions with $b<\rho<r_c$

In nonneutral plasmas the long range collisions cause:
- Cross-field diffusion enhanced by 10x
- Heat transport enhanced by 100x, independent of B
- Viscosity enhanced by $10^5$x, increasing with B

We have now shown that long range collisions also can strongly enhance collisional slowing $V_s$


A new fundamental length scale $d$ was identified: $d = b\left(\sqrt{v^2 / b^2 V_s^2}\right)^{1/5}$, $b = e^2 / T$, $\bar{v} = \sqrt{T / m}$

For $\rho<d$: long range collisions are two-body and point-like; particles either reflect or pass by
For $\rho>d$: multiple weak collisions occur simultaneously; particles diffuse in velocity

The short range Coulomb logarithm (green) is enhanced by two new terms from long-range collisions (red). This applies to Penning trap plasmas for both matter and antimatter, for some astrophysical plasmas, and even for the edge region of tokomak plasmas.

$$V_s = \sqrt{\pi n \bar{v} b^2} \ln \Lambda; \text{ where } \ln \Lambda = \left\{ h \ln(d / r_c) + 2 \ln(\lambda_D / d) + \frac{4}{3} \ln(r_c / b) \right\},$$

$h = 5.899$ for repulsive collisions; $h = 0$ for attractive collisions