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Revisiting extremely high energy QED bremsstrahlung in matter

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Very high energy electrons passing through ordinary matter initiate electromagnetic showers that are produced by bremsstrahlung and pair production. At extremely high energies, the quantum-mechanical duration of these processes becomes longer than the mean free time for elastic scattering in the medium, which leads to a significant suppression of bremsstrahlung (and pair production). This phenomenon is known as the Landau–Pomeranchuk–Migdal (LPM) effect. We revisit the LPM suppression of bremsstrahlung, accounting for quantum disruption of that effect from pair production. We find that there are very large corrections to the LPM bremsstrahlung rate due to the quantum overlap of bremsstrahlung and subsequent pair production. Although it was argued qualitatively in the 1960s that pair production would further reduce the bremsstrahlung rate beyond the already suppressed LPM bremsstrahlung rate, we reach the opposite conclusion: quantum overlap between bremsstrahlung and pair production substantially enhances the bremsstrahlung rate relative to the standard LPM result. We support our qualitative arguments with an analytic calculation of the effect.

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