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Enhancing Dark Matter Annihilation Rates with Dark Bremsstrahlung

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Many dark matter interaction types lead to annihilation processes which suffer from p -wave suppression or helicity suppression, rendering them sub-dominant to unsuppressed s -wave processes. We demonstrate that the natural inclusion of dark initial state radiation can open an unsuppressed s -wave annihilation channel, and thus provide the dominant dark matter annihilation process for particular interaction types. We illustrate this effect with the bremsstrahlung of a dark pseudoscalar or vector boson from fermionic dark matter, $\bar{\chi}\chi \rightarrow \bar{f}f\phi$ or $\bar{f}fZ'$. The dark initial state radiation process, despite having a 3-body final state, proceeds at the same order in the new physics scale Λ as the annihilation to the 2-body final state $\bar{\chi}\chi \rightarrow \bar{f}f$. This is lower order in Λ than the well-studied lifting of helicity suppression via Standard Model final state radiation, or virtual internal bremsstrahlung. This dark bremsstrahlung process should influence LHC and indirect detection searches for dark matter.

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