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An Analytic Theory of Chromatic Emittance Growth in a Plasma Wakefield Accelerator

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Preserving the emittance of an electron bunch as it is accelerated by a plasma wakefield accelerator is one of the major challenges that needs to be overcome for these accelerators to replace conventional techniques. Energy spread in the bunch primarily drives the emittance growth through the process of chromatic phase spreading. The chromatic effects are complicated by the acceleration process; the different particles in the bunch are accelerated at different rates depending on how well the witness beam loads the wake. We present an analytic theory describing this evolution that includes the effects of nonuniformity in the accelerating field, the witness beam's initial energy spread, and mismatch between the beam and the plasma. We discuss some of the interesting features that emerge including the evolution of the longitudinal and energy slices.

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