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Ion motion and hosing suppression in plasma-based accelerators

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Plasma accelerators have been proposed as drivers for the next generation of colliders. Achieving high efficiency while preserving excellent beam quality (low emittance) is critical to realizing this application. High efficiency requires large longitudinal wakefield excitation by the witness beam, and this has an associated large transverse wakefield that will drive the hosing instability. Furtheremore, for high-energy beams with low emittance, the focusing forces in the plasma will pinch the witness beam and increase the beam density, orders of magnitude above the background ion density, leading to ion motion. This results in nonlinear focusing and emittance growth.
We present a solution to mitigate the hosing instability in plasma accelerators that relies on ion motion. The response of the ions to a high-density beam is described, including the coupling to the hosing instability. It is shown that the ion-motion-induced head-to-tail variation in the focusing experienced by the beam suppresses hosing.
A class of initial beam distributions are identified that are equilibrium solutions in the plasma wakefield, including ion motion. Using these beam distributions enables ion motion without emittance growth. Hence, stable acceleration in plasma-based accelerators is possible, while, by using proper bunch shaping, minimizing the energy spread and preserving the emittance.

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