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Stable positron acceleration in self-generated hollow channels

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Hollow plasma channels are promising candidates for the acceleration of electron and positron beams as the transverse forces are nearly vanishing inside the hollow channel. The acceleration is effective as long as the accelerated bunches are perfectly cylindrically symmetric and injected on the axis of the hollow channel structure. Furthermore, the accelerating fields can also be nearly constant provided that the accelerated bunch current profile is appropriately tailored. These features make it fundamentally possible to preserve beam quality during the acceleration. In realistic situations, however, small asymmetries in the beam profile or small misalignments between the beam and the hollow channel axis will seed the growth of the beam breakup instability, thus stopping the acceleration prematurely and degrading beam quality substantially. These beam breakup instabilities are a severe limitation on the use of hollow channels for particle acceleration.

Here, we investigate a new mechanism for stabilization of positron acceleration in hollow channels. Using theory and particle-in-cell simulations with the code OSIRIS, we show that the ion motion associated with the wakefield force can form a hollow plasma channel self-consistently. A second particle beam then drives a nonlinear plasma wave with focusing and accelerating fields for positrons.

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