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Mechanisms for the mitigation of the hose instability in plasma-wakefield accelerators

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The *hose instability* is a long standing challenge for plasma wakefield accelerators (PWFAs). It results from a coherent coupling between transverse phase space asymmetries of beam particles and plasma electrons. According to current models, the beam centroid displacement is amplified exponentially during the beam propagation in the plasma, resulting in an unstable acceleration process or beam-breakup. However, particle-in-cell (PIC) simulations indicate that these models overestimate the hosing growth rates, suggesting that PWFAs intrinsically provide saturation mechanisms for the hose instability [T.J. Mehrling, *et al.* Phys. Rev. Lett. **118**, 174801 (2017)]. In this work we review the theory for the hose instability in order to identify and describe diverse mitigation mechanisms. By means of a self-consistent theoretical model that includes the energy exchange between beam and plasma, we show that the beam energy evolution can significantly mitigate the hose instability. We also discuss other mechanisms which disrupt the coherent coupling between beam and plasma, and thereby lead to a saturation or damping of the beam centroid oscillations. In addition, we examine how the transverse beam asymmetries, which seed hosing, can be reduced. Hence, the presented work reveals crucial mechanisms allowing for stable beam acceleration over long distances in PWFAs.