Hosing instability suppression in self-modulated wakefields

J. Vieira¹, P. Muggli², W.B. Mori³, R.A. Fonseca⁴, L.O. Silva¹

¹ GoLP/IPFN, Instituto Superior Técnico, Universidade de Lisboa, Portugal
² Max Planck Institute for Physics, Munich, Germany
³ UCLA, Los Angeles, CA 90095, USA
⁴ ICTE, Lisbon University Institute, Portugal

With the upcoming plasma wakefield acceleration experiments at CERN, the self-modulation of long charged particle bunches has emerged as a new research direction. The self-modulation instability occurs when a beam much longer than the plasma wavelength propagates in a plasma [1]. As it propagates, the beam excites plasma focusing fields that can periodically focus/diffract beam particles at the plasma wavelength. After saturation, the self-modulation instability results in the generation of a train of beamlets separated by the plasma wavelength. A fully self-modulated bunch can then resonantly excite plasma wakefields that grow secularly along the bunch. Resulting wakefields can then accelerate particles to high energies.

It was recently shown that the hosing instability has nearly the same growth rates as the self-modulation instability [2]. Hosing consists in amplified oscillations of the bunch centroid. Thus, if uncontrolled, it can result in beam break up, seriously compromising self-modulation experiments. In this work we demonstrate that hosing instability suppression occurs once the bunch is fully self-modulated and if wakefield generation occurs in the linear regime. Stable propagation regimes can then be obtained for long propagation distances by seeding SMI, for instance, with an ionising laser pulse. In this case, the propagation is stabilised even for initial tilts (that seed hosing) comparable to the initial bunch radius. The hosing suppression mechanism is analogous to the BNS damping in conventional accelerators. We illustrate our findings with particle-in-cell simulations in Osiris [4] and with analytical modelling [3].

References