PLASMA WAKEFIELD ACCELERATION AND FOCUSING

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High-efficiency acceleration of charged particle beams in the plasma wakefield accelerator was studied experimentally and by numerical simulation (see [1]-[9]). The most impressive experimental results [1] until now in electron accelerating by a wakefield, excited in a plasma, have been achieved using capillary-generated plasma. Plasma-wakefield acceleration provides high accelerating gradients [1,10], promises compact accelerators of high-brightness and high-energy electron beams. Applications of plasma-wakefield accelerators, in particular, particle colliders (see [11]) and free-electron lasers demand low energy spread beams, their small emittance, high current of accelerated bunches, large transformer ratio and high-efficiency operation. Achievement of these requires plateau formation on both the accelerating field for witness-bunch and the decelerating fields for driver-bunch. As it is known plateau formation is possible by controlled beam loading with careful shaping current profile and beam charge selection. We will demonstrate by numerical simulation by PIC code such optimal beam loading in a linear, weakly nonlinear and blowout electron-driven plasma accelerators. Beams for plasma accelerator are prepared with RF linear accelerator with high beam quality. Problems of acceleration of positron bunches in plasma, focusing and stable transport of electron and positron bunches in plasma (see [12]) are important. In the blowout regime the hose instability can appear [13]. Earlier investigations [14]-[15] show that the instability is essentially suppressed if the focusing force is inhomogeneous along the bubble, and radial inhomogeneity can be additional effect. The problem of the instability can be solved in weakly nonlinear regime. In weakly nonlinear regime throughout the areas of the driver and witness bunches the focusing force is inhomogeneous. Radial inhomogeneity of residual plasma electron distribution also leads to bunch stabilization. We will present results of analytical investigation and numerical simulation of hose instability suppression in plasma wakefield accelerator driven by electron bunch in the weakly nonlinear and blowout regimes. We will present in the paper results on: - wakefield passive plasma lenses (due to loading effect) for identical focusing of short or long homogeneous electron or positron bunch or Gaussian bunch depending on its length, charge for stable electron or positron beam propagation in a plasma column; - optimal beam loading for the self-consistent distributions of a decelerating wakefield of plateau type for a driver-bunch and an accelerating wakefield of plateau type for a witness-bunch during all time of acceleration; - control of optimal field shape (by loading effect), accelerating electron or positron bunch in plasma wakefield; - obtaining long electron witness-bunch of good quality (due to loading effect) in plasma wakefield accelerator at high transformer ratio.

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