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Plasma wakefield acceleration and focusing for PETRA IV

The most impressive experimental results (see [1, 2]) until now in electron accelerating by a wakefield, excited in a plasma, have been achieved using capillary-generated plasma. Plasma-wakefield acceleration and focusing provide high accelerating and focusing gradients (see [1, 3, 4]), promise compact plasma accelerators and plasma lenses of high-brightness and high-energy electron and positron beams. Applications of plasma-wakefield accelerators, in particular, particle colliders (see [5]) 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-bunches. 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 and blowout laser-driven and 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 (see [6]), focusing and stable transport of electron and positron bunches in plasma (see [7]) are important.

We will investigate in the project problems:
- serial pair of focusing and defocusing current-carrying plasma lenses for efficient focusing without changing the emittance and ensuring a parallel bunch;
- ideal wakefield plasma lens (due to loading effect) for homogeneous focusing of Gaussian bunches in linear and blowout regimes depending on their lengths, gaps, charges for stable electron or positron beam propagation in a plasma column with emittance decrease;
- optimal longitudinal plasma density inhomogeneity in LPA;
- 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 and positron bunches in plasma wakefield, during all time of acceleration in multy-cell accelerator;
- obtaining long accelerated electron bunch of good quality (due to loading effect) in plasma wakefield accelerator at high transformer ratio and efficiency.

Literature:
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Group

MPA1

Project Category

A6. Theory and computing

Special Qualifications

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