Parametric studies using reduced 3d modeling on plasma scale lengths

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Current modeling for plasma-based accelerators is often performed with the help of particle in cell (PIC) codes. While accurate, these codes require following the smallest spatial/temporal scales, and as a result, are computationally expensive. Reduced models, such as the ponderomotive guiding center solver (PGC) [1, 2] overcome this limitation and provide speedups in order of $\sim(\lambda_0/\lambda_p)^2$, where λ_0 is the laser wavelength and λ_p the plasma skin depth. The speed up is a result of a reduced description of the laser: instead of resolving the fast laser wavelength, PGC captures the evolution of the laser envelope instead. The PGC is thus ideal to explore the effects of ionization seeding for the AWAKE project [3, 4]. AWAKE relies on the self-modulation instability (SMI) to bunch an initially long proton bunch into bunchlets smaller than the plasma wavelength. An ionizing laser co-propagates with the laser, creating a sharp ionization front that seeds the SMI. These simulations are ideal for PGC, because the computational gains, is in excess of $(\lambda_0/\lambda_p)^2 > 10^6$. .We performed parametric studies using the massively parallel, fully relativistic PIC code OSIRIS [5] for the self modulation instability (SMI) as part of the main mechanism for the AWAKE project. The influence of the neutral gas density on the SMI and the injected electrons is discussed. Furthermore, studies on different injection schemes in the plasma scale regime, such as downramp injection and ionization injection is discussed and compared with full 3d PIC and Quasi-3D [6] simulations.

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