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High-Brightness tuneable attosecond bunches with the Resonant Multi Pulse Ionization injection

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Recent advances with the Resonant Multi Pulse Ionization Injection scheme [1,2], which was already proven by simulations to be able to generate few femtosecond long 5GeV beams [3] with beam quality large enough to efficiently drive a FEL [4], move toward the generation of high-brigthness beams with duration of a few hudreds of attoseconds. At the same time, with the aid of an advanced model for the tunnel ionization process in the saturation regime [5], the optimization of the scheme lead to a reduction of the needed number of sub-pulses in the driving train from eight [3] down to two pulses, making the implementation of the scheme more simple and improving its robustness against laser/target imperfections. By just tuning the delay between the wakefield driving train and the ionization injection, it's possible to shape the longitudinal profile of the e-beam, thus adjusting its time duration down to a few hundreds of attoseconds, or even down to 100as if a post-compression technique is employed onto the ionization pulse.
Our test-case FB-PIC q-3D simulations with the simplified two-pulses driving scheme, show that >1GeV e-beam with about 10pC charge, projected energy spread <0.8% and length of about 500as can be generated with a single 200TW Ti:Sa laser system, the e-beam having 5D brightness exceeding 2x10ˆ17 A/mˆ2 and 6D brightness exceeding 2x10ˆ16 A/mˆ2/0.1%. The effect of a passive plasma lens placed right after the plasma downramp is also discussed. Finally, the potentiality of the simplified scheme with the usage of 1PW pulses with the aim of generating >1GeV e-beams will be discussed.

[1] P. Tomassini et al., "The resonant multi-pulse ionization injection", PoP 24, 103120 (2017); https://doi.org/10.1063/1.5000696

[2] P. Tomassini et al., "High quality electron bunches for a multistage GeV accelerator with resonant multi-pulse ionization injection", Phys. Rev. Accel. Beams 22, 111302 (2019)

[3] P. Tomassini et al., "High-quality 5 GeV electron bunches with resonant multi-pulse ionization injection", PPCF 62 014010
DOI 10.1088/1361-6587/ab45c5 (2020)

[4] P. Tomassini et al., "Brilliant X-ray Free Electron Laser driven by Resonant Multi-Pulse injection accelerator", proc. FEL22 conference (Trieste, I)

[5] P. Tomassini et al., "Accurate electron beam phase-space theory for ionization-injection schemes driven by laser pulses", High Power Laser Science and Engineering, (2022), Vol. 10, e15, doi: 10.1017/hpl.2021.56

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