Trapping and Beamloading in hybrid Plasma Wakefield Accelerator schemes

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INHALTSVERZEICHNIS

1. THEORY

1.1 *The history of wakefield acceleration*

Tajima Dawson great Idee, MTV bubble regime, same time PWFA von Rosenzweig... first linear measurements for PWFA

1.2 *Plasma physics*

An introduction into plasma physics is given by starting with chens definition. Topics are

1.2.1 *debye shielding*

1.2.2 *time scales*

scattering can be talked about

1.2.3 *plasma definition*

There are different types of plasmas, but we are only handling with thin, cold weakly coupled plasmas

1.2.4 *electromagnetic waves in plasmas*

dispersion relation needs to be talked about. Especially the dispersion relation of lasers during ionization should get some insight here. One has to look into ionization defocussing.

1.2.5 *fluid model of plasmas*

1.2.6 *waves in plasmas*

So far everything still flows nicely with working along Chen and Mulser. However now the turn needs to be taken. The reason is wavebreaking

1.2.7 *wavebreaking*

Wavebreaking gives us the the ideal way to go from plasma description to blowout description.

1.3 PWFA theory

1.3.1 history of PWFA

A short historic overview is given. Maybe mention landau damping? Then of course, Tajima,Dawson. Also MTV and Rosenzweig should be mentioned.

1.4 The blowout regime

1.5 Descriptions for the blowout regime

Lotov, Suk, breakdown of fluid theory Q-tilde and resonant wake excitation.

1.5.1 Trapping conditions

Basic calculations for the trapping potential are shown. The particle movement must be solved in 3D and in 1D. Make a picture of the comparisons.

1.6 Accelerator physics

Acc. physics should clearly be introduced. Emittance, brightness, twiss parameter need to be defined. Floettmann. A good book should be used here. Don't know which one,yet. TBD.

1.6.1 Panowsky-Wenzel Theorem

$$W_r = \partial_r W_z \tag{1.1}$$

This theorem is so important, it clearly needs a subsection. But where ?

1.7 laser ionisation description

(see diss by Ihar Shchatsinin FU Berlin)

1.7.1 Keldysh Parameter

With E_{bind} being the binding energy and $U_p = \frac{q^2 I}{2 m_e \epsilon_0 c \omega^2}$ being the ponderomotive energy

$$\gamma = \sqrt{\frac{E_{bind}}{2U_p}} \tag{1.2}$$

$\gamma > 1$ -> Multiphoton Ionisation
$\gamma < 1$ tunnel ionisation or BSI

1.7.2 ADK theory

Tunnel ionization is great

2. SIMULATIONS

2.1 Start-to-End simulations for a Trojan Horse at FlashForward experiment

2.2 The trapping potential

2.3 plasma density profile optimisation

2.3.1 Density Downramp facilitated Trojan Horse Acceleration

In wird beschrieben, wie sich ein negativer Dichtegradient auf die in einer Plasmawelle getrappten Elektronen auswirkt. Ausgangspunkt ist dabei die LWFA mit der Annahme, dass bei konstater Elektronendichte der Laserpuls, sowie die Bubble sich mit c bewegen.
Die Welle bewege sich in z-Richtung.
Die Länge der bubble ist Abhängig von der Plasmadichte n. Da sich diese über eine downramp von n_i auf n_f verringert, vergrößert sich auch die bubble über diese Strecke. Sei

$$\xi = z - ct$$

die Position relativ zum Laserpuls. $\xi < 0$ beschreibt die Position eines Elektrons in der Bubble hinter dem Laserpuls. Das Elektron bleibt am gleichen Ort relativ zur Bubblestruktur, aber die Bubble verändert sich. Die Phase der Bubble verändert sich von

$$\Psi_i = \frac{\omega_{pi}}{c}\xi$$

nach

$$\Psi_f = \frac{\omega_{pf}}{c}\xi$$

mit der Phasendifferenz:

$$\Delta\Psi = \Psi_f - \Psi_i = \Psi_i[1 - (\frac{n_f}{n_i})^{1/2}]$$

Die entsprechende Phasengeschwindigkeit errechnet sich aus

$$v_p = -\frac{\frac{\partial\Psi}{\partial(ct)}}{\frac{\partial\Psi}{\partial z}} = \frac{c}{1 + \frac{1}{2\omega_p(z)n(z)}\frac{\partial n(z)}{\partial z}\xi}$$

2.3.2 density transition injection suppression

See paper by Suk

2.4 Laser Beam shaping for optimisation

2.4.1 my beamloading description

2.4.2 beamloading in theory

2.4.3 beamshaping in reality

-pulse-shaping by spatial light modulator(SLM) (Meshulach adaptive real-time fs pulse shaping)

2.5 Magnetic Field facilitated Trojan Horse Acceleration

3. EXPERIMENT

3.1 FACET

3.1.1 The FACET experimental setup

3.2 FlashForwad

3.3 Clara