Quasistatic and PIC simulations of electron self-trapping by the wake of low power laser pulse

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Outline:

QSA and trapping

Parameters

Fast scans with QSA

Full simulation with usual PIC code

Summary
QSA and trapping

No layers interaction → no self-trapping
QSA and trapping

Blue lines — plasma electrons with QSA
Black lines — test electron tracking without QSA

Thresholds for changing model*:
1. Energy ($\gamma > 1.2$)
2. Axis-crossing

Driver parameters:
- $a_0 = 3.5$
- $\tau_0 = 1/\omega_p$
- $r_0 = 2.6/k_p$
- $k_0 = 30k_p$

*WAKE-code team: PHYSICS OF PLASMAS 17, 063106 (2010)
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Summary
Parametrs

**ILP SB Laser System**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (mJ)</td>
<td>300</td>
</tr>
<tr>
<td>Duration (fs)</td>
<td>20</td>
</tr>
<tr>
<td>Waist (mkm)</td>
<td>10</td>
</tr>
<tr>
<td>Power (TW)</td>
<td>14</td>
</tr>
<tr>
<td>Intensity (W/cm²)</td>
<td>$4.5 \times 10^{18}$</td>
</tr>
<tr>
<td>Wavelength (nm)</td>
<td>810</td>
</tr>
<tr>
<td>$a_0$</td>
<td>1.45</td>
</tr>
</tbody>
</table>

- Self-trapping
- Short interaction distance (1 mm)
- Potential users
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Fast scans with QSA

![Graphs showing critical density and mean energy vs. density for 1st bucket and 2nd bucket.](image-url)
Fast scans with QSA

Critical density for self-focusing

Plasma density above $6 \times 10^{18} \text{ cm}^{-3}$ to dense for such laser pulse

Laser pulse envelope after 1 mm interaction

LCODE simulation
Fast scans with QSA

LCODE simulation
Fast scans with QSA

![Graph showing charge and mean energy versus focus point, with two buckets compared.]

- Focusing point at plasma entrance
- Focusing point 300 mkm inside

![Image showing a simulation result with color mapping.]
Plasma density distribution

LCODE simulation
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**Full simulation with usual PIC code**
Summary
Full simulation with usual PIC code
Full simulation with usual PIC code

<table>
<thead>
<tr>
<th>E, MeV</th>
<th>RMS, MeV</th>
<th>$\varepsilon_n$, mm mrad</th>
<th>Q, pC</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>10</td>
<td>1.24</td>
<td>15</td>
</tr>
</tbody>
</table>
Summary

The self-trapping process can be controlled by changing laser pulse focusing point

The generation of good quality quasimonoenergetic beam is possible with moderate power laser pulses

Simulation code with QSA allow one to do fast (~ 450 faster than usual PIC) parametric scans, but fullPIC simulation is still crucial

Further QSA extension developments allow us to carry out global study and optimization of parameters for future experiments

Thank you!