FEW-CYCLE SHADOWGRAPHY OF PLASMA WAVE TRAINS

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Wakefield excitation in 1D fluid theory

Plasma density \( n/n_0 \)

\[ a_0 = 0.5 \]
\[ a_0 = 1 \]
\[ a_0 = 2 \]
\[ a_0 = 3 \]
\[ a_0 = 4 \]

Laser envelope \([a_0]\)

Position \([\lambda_p]\)
Experimental setup

- Vacuum, $10^{-5}$ mbar
- ATLAS, 2 J, 30 fs
- OAP, $f = 2.5$ m
- Hollow core fiber
- Iris
- Lens & CCD
- Nomarski interferometer
- Beam splitter
- Plan-apo objective
- Gas jet
- FROG
- CCD
- Delay stage

Legend:
- Vacuum window
- Glass wedge pair
- Silver mirror
- Flip silver mirror
- Chirped mirror
- Covcave mirror

H. Ding - LPAW 2019
ATLAS main beam

ionisation front

colliding beam

plasma wave train

collision front

not a shock front

S. Schindler's poster
M. Förster's poster
Multiple plasma waves in a single shot

Image of the focus is saturated to show the low intensity satellites.
Laser driven nonlinear plasma wave train

- in-situ density measurement with Nomarski interferometer
- 13% elongation of the main wave train, compared with cold plasma wavelength
- the secondary waves, or low power shots have the cold plasma wavelength
Laser intensity estimate?

- 1D models seem not able to explain the observed wave lengthening
- PIC simulation suggests $a_0 \sim 4$

Influence of the transverse intensity gradient

- a tightly focused spot -> strong transverse ponderomotive force ->
- full cavitation behind the driver
- electrons do not see the intensity peak of the laser pulse
Summary

• we measure lengthening of a nonlinear plasma wave train
• qualitative estimate of the laser intensity
• not only the peak intensity, but also the aspect ratio of the pulse plays an important role
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Thanks !