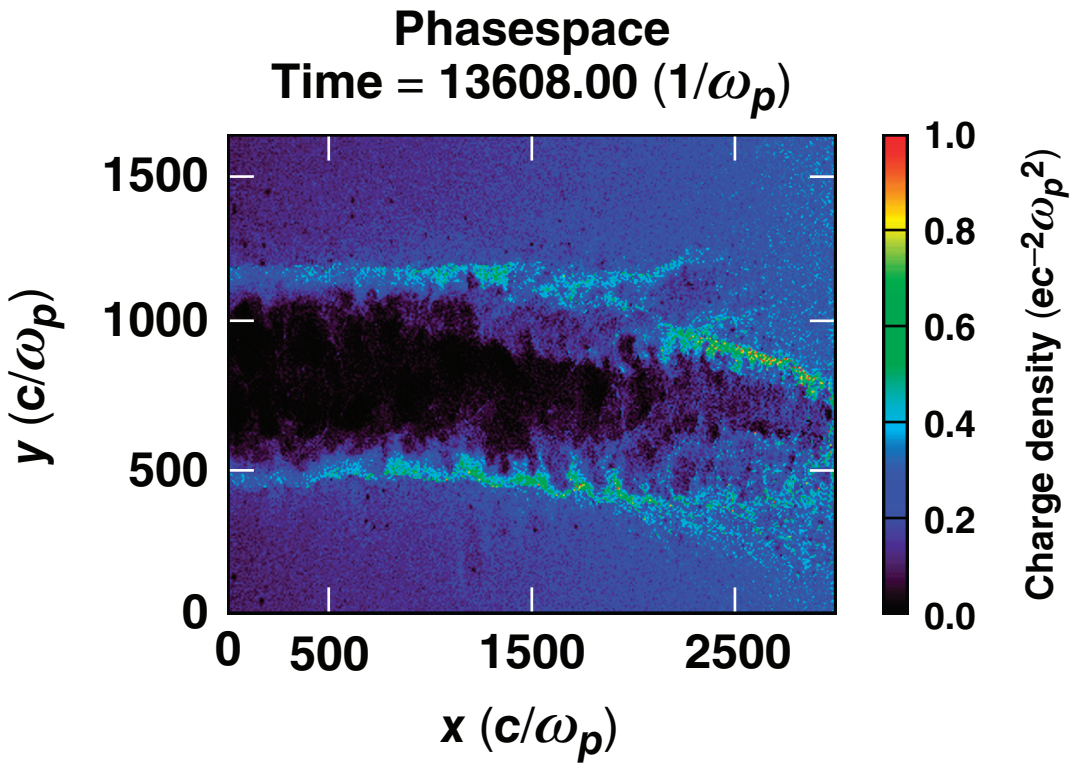
Channeling in the Corona of Fast Ignition Targets



G. Li
University of Rochester
Laboratory for Laser Energetics

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Summary

A clean channel can be established by a high-intensity laser in the underdense plasma of fast-ignition targets

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- The channeling process in millimeter-scaled underdense plasma is studied using 2-D particle-in-cell simulations with realistic density profiles.
- PIC simulations show that channeling is a complicated process involving many nonlinear phenomena.
- The residual density in the channel created by a laser pulse with an intensity of 10^{19} W/cm^2 is about 0.05 n_{cr}.
- The channel advances stochastically and $v \geq 0.1$ c.

Collaborators

C. Ren, R. Yan, and V. N. Goncharov

Laboratory for Laser Energetics
University of Rochester

T. L. Wang, W. B. Mori, and J. Tonge

University of California, Los Angeles

Channeling in the underdense plasma can reduce the energy loss of the ignition pulse

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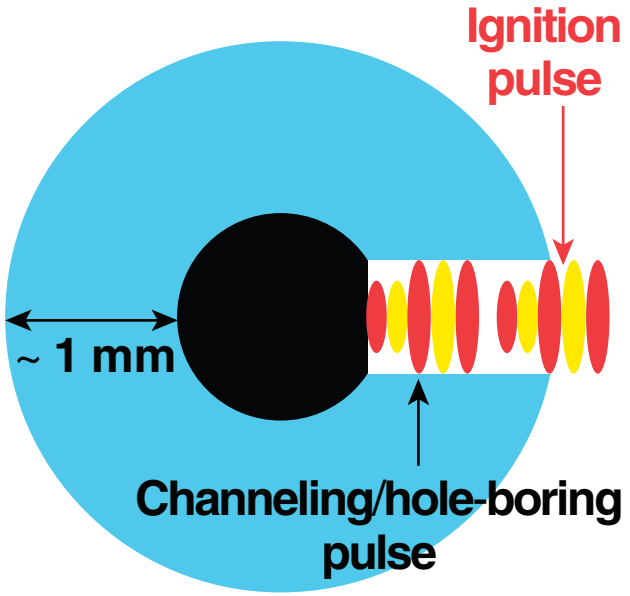
- The ignition pulse needs to propagate around 1 mm in the underdense plasma before reaching the critical surface
- The ignition pulse can be greatly weakened in the underdense plasma due to nonlinear effects

$$\frac{p}{p_c} = 10^6 \times p(PW) \times \frac{n}{n_{cr}} \gg 1$$

- An initial channeling pulse can be used to establish a clear channel to reduce the energy loss of the ignition pulse
  - what is the residue density in the channel?
  - what is the channel-advancing speed?



TC7529

PIC code *OSIRIS* is used to simulate the channeling process in 2-D space

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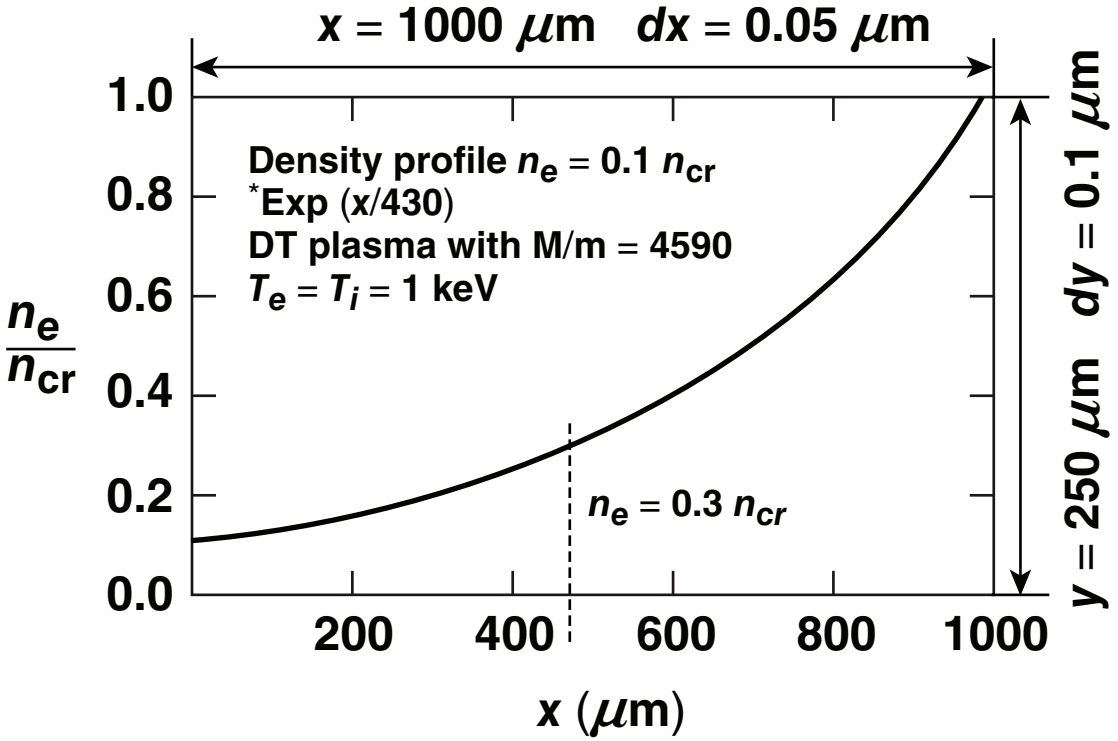
Laser of both
s- and *p*-polarizations
Wavelength $\lambda = 1\ \mu$m
$I = 10^{19}$ W/cm^2,
Spot size 14 μm



Two-step simulation
- **0.1 ~ 0.3 n_{cr}**
- **0.3 ~ 1.0 n_{cr}**

Simulation time $t = 10$ ps
Time step $dt = 0.143$ fs
Total particles number 5×10^8

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A clear channel can be established for 0.1~0.3 n_{cr} and 0.3 ~ 1.0 n_{cr}, respectively

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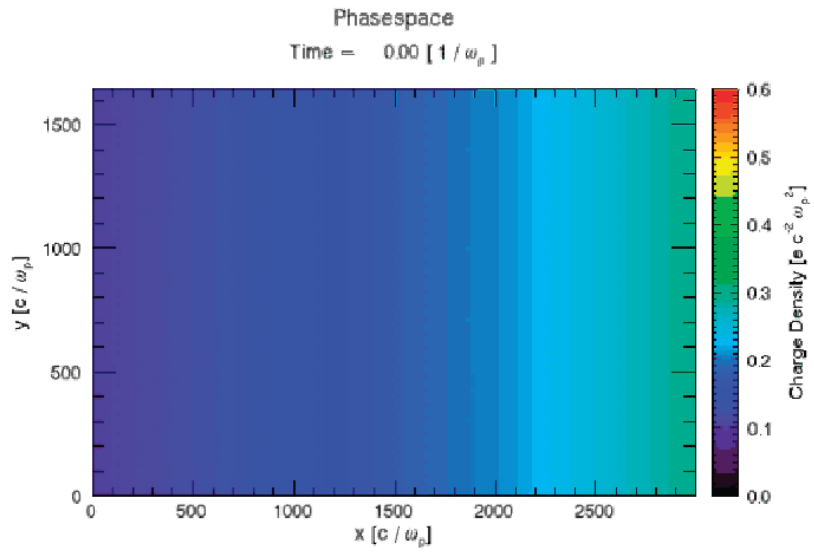
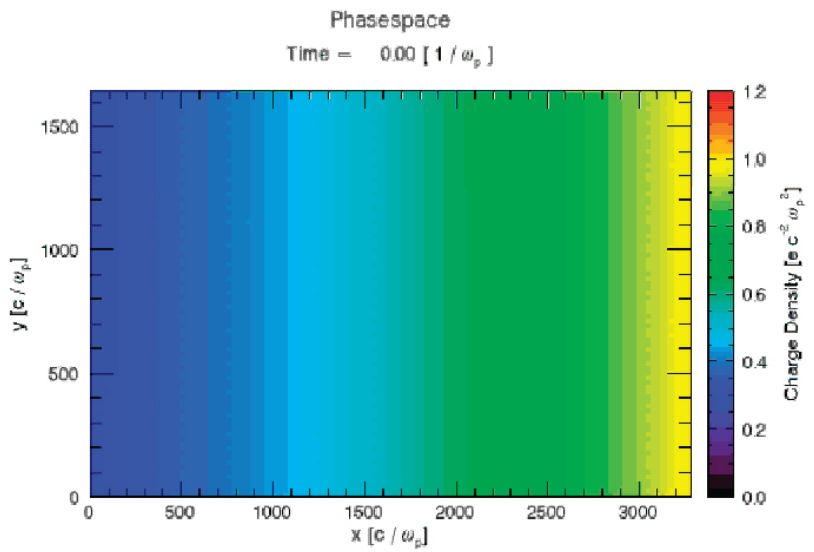
0.1 ~ 0.3 n_{cr}



0.3 ~ 1.0 n_{cr}



Channeling consists of several nonlinear processes

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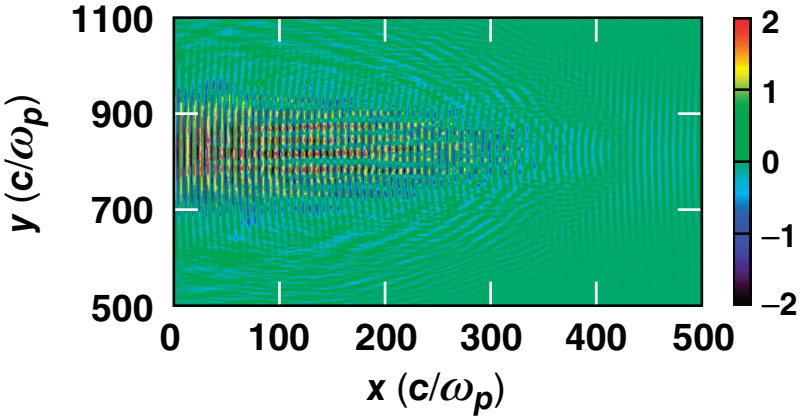
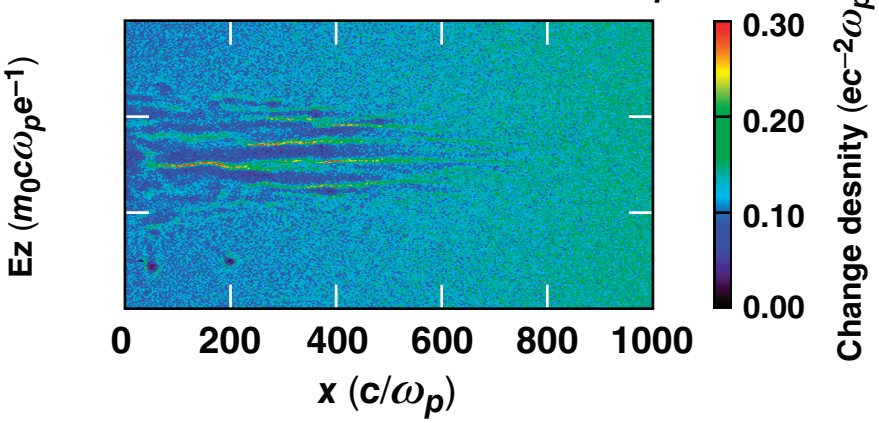
Relativistic SF/filamenting

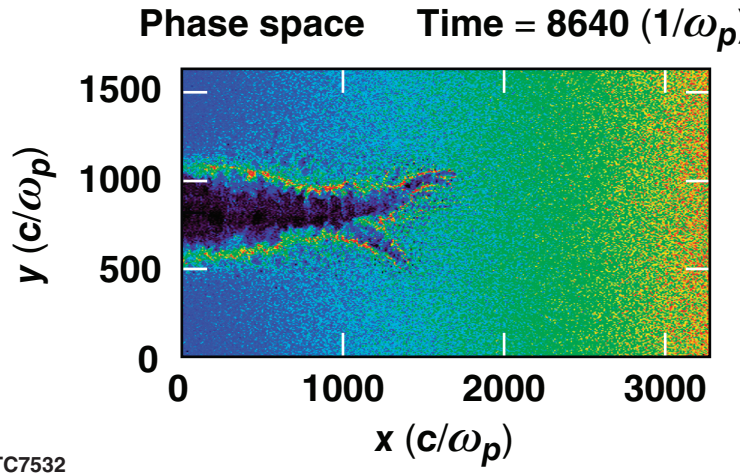


Ponderomotive SF/filamenting

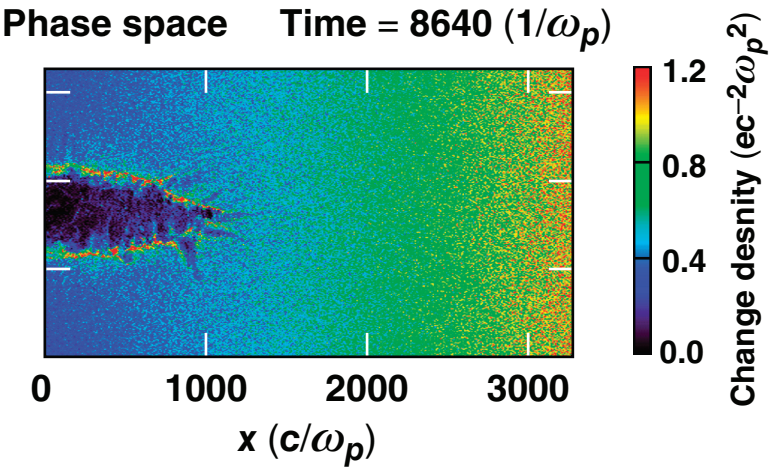


Transverse expansion through shock launching

S-polarzied



P-polarzied



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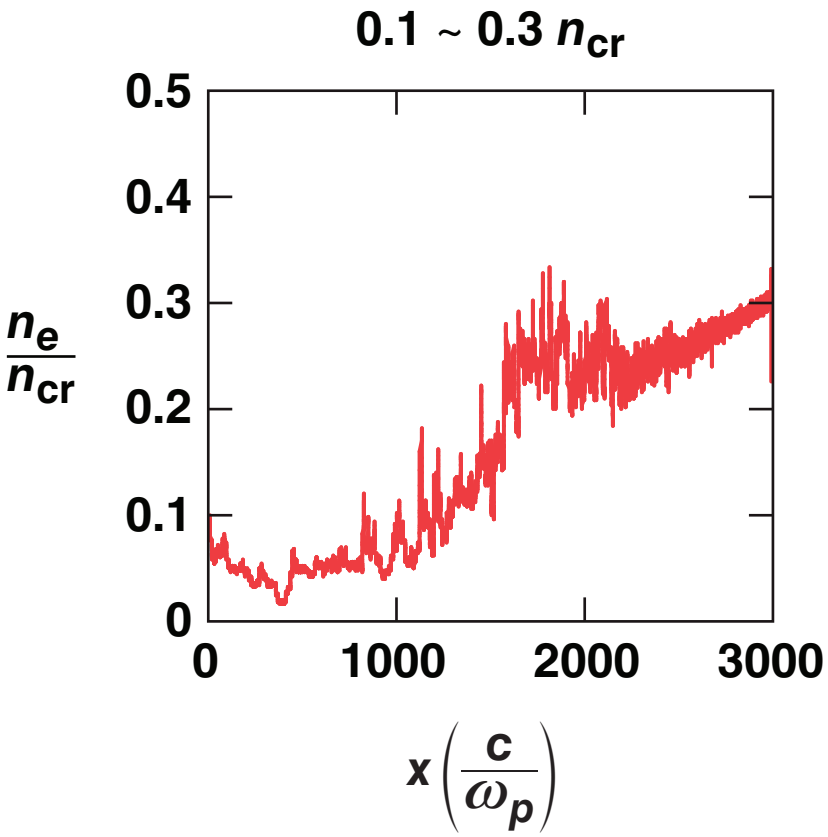
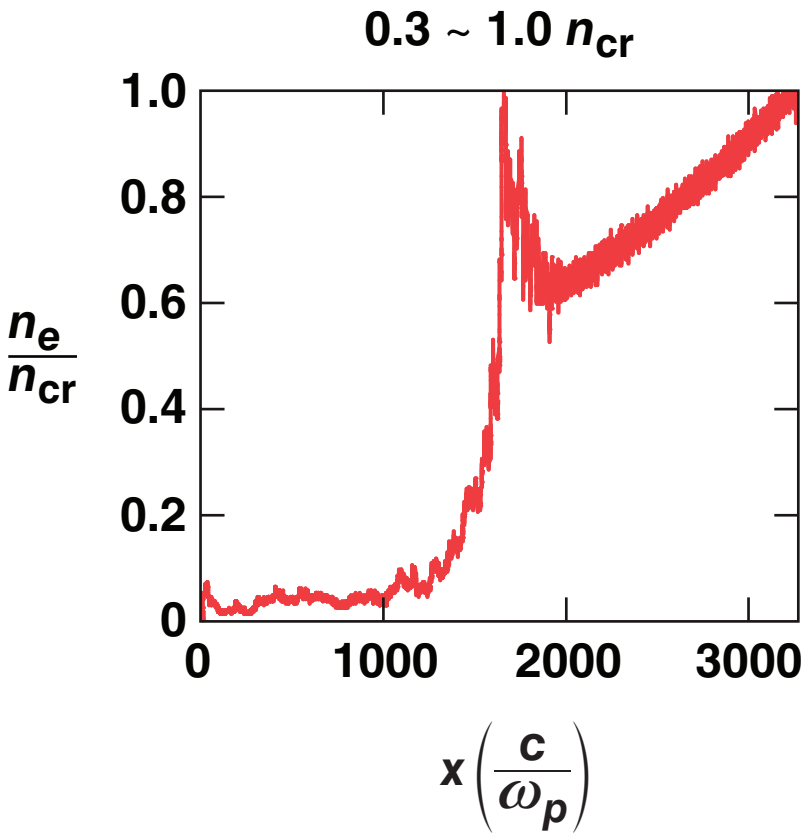
The plasma piles up near the channel front in the longitudinal direction

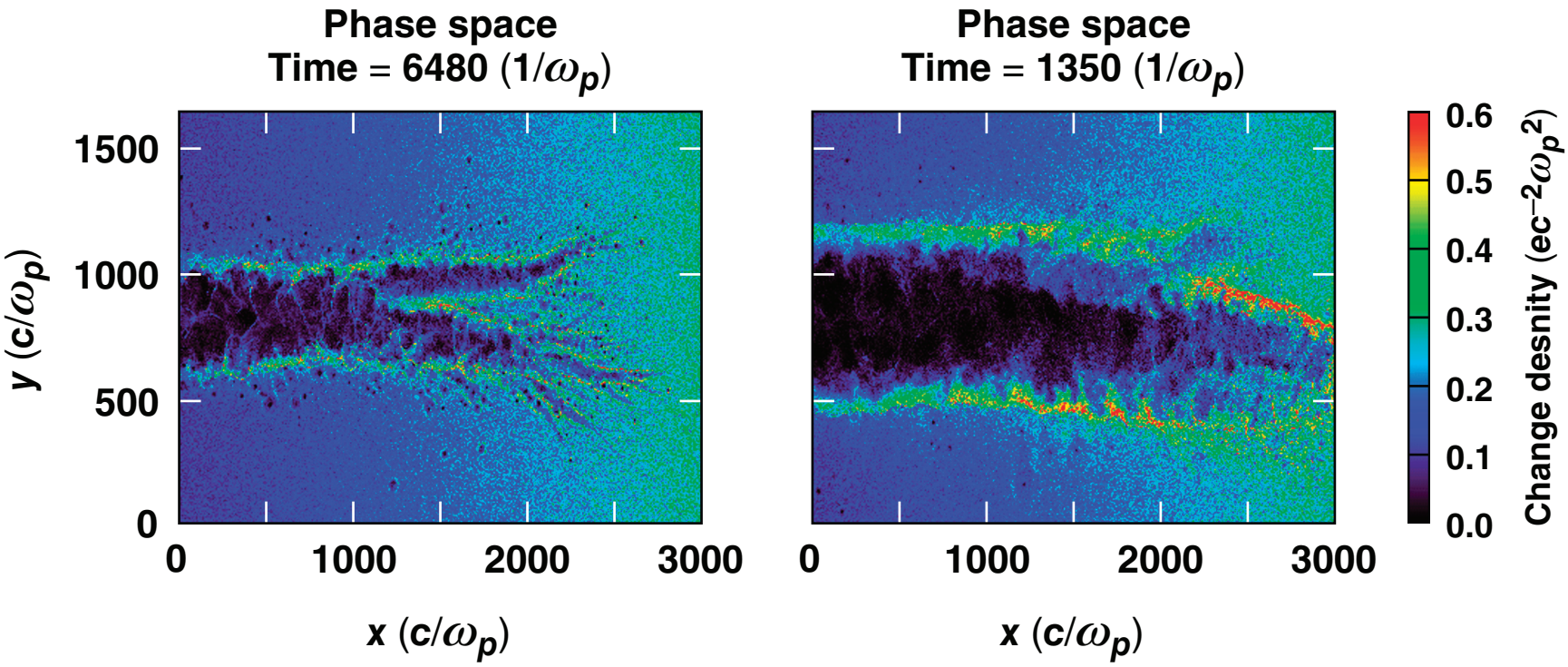




- Residue density ~0.05 n_{cr}
- The piling-up density ~1.0 n_{cr} in the 0.3 ~ 1.0-n_{cr} case

TC7533

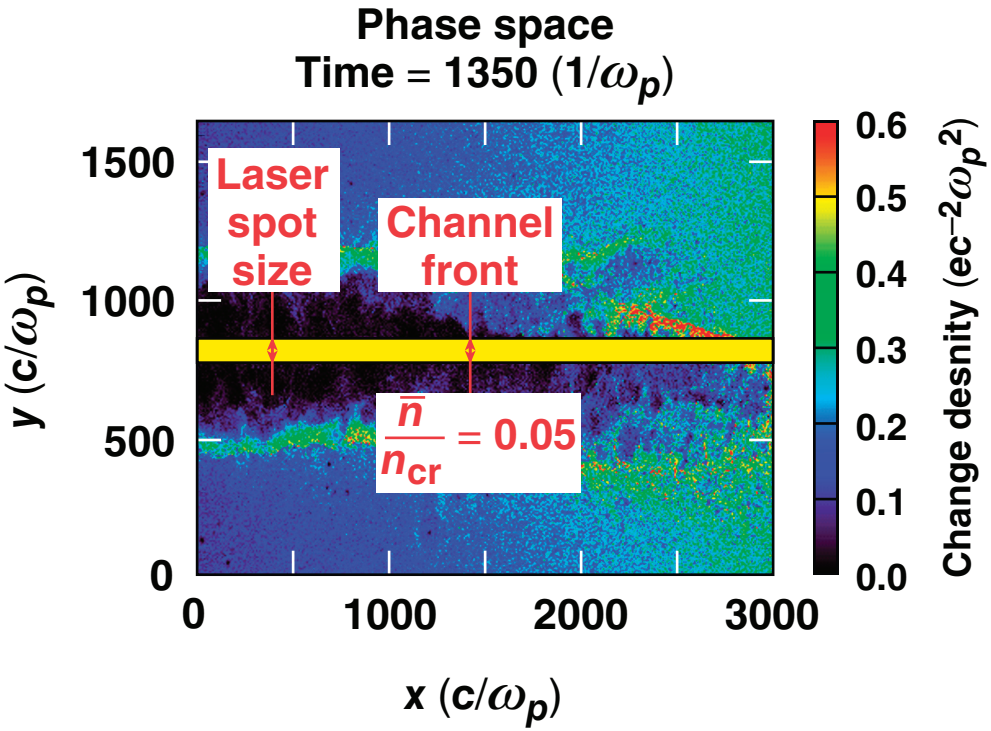
Channel hosing can be self-corrected

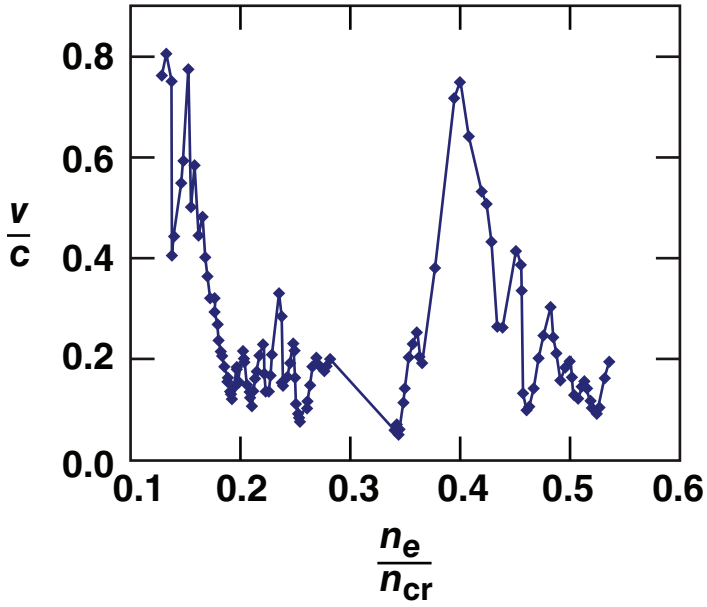


- Laser hosing leads to channel hosing and branching
- Channel branching can be self-corrected

TC7534

The channel advances stochastically





- For v = 0.1 c, it takes 30 ps for the channel front to reach the critical surface

Summary/Conclusions

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