Shock-Wave Acceleration of Ions on OMEGA EP

Plasma density profile for SWA

Space (μm)

Plasma density (×10^21 cm⁻³)

High-power IR pulse

μm thick CH foil

Low-power UV

Ion beam

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Summary

Scaling of the shock-wave acceleration (SWA) mechanism to the 1-\(\mu\)m OMEGA EP Laser System predicts 80- to 150-MeV/amu ions

- Shock wave acceleration experiments at UCLA using
  - 10-\(\mu\)m laser in a H\(_2\) gas jet
  - produced 20-MeV protons with narrow energy spreads
  - normalized vector potential \(a_0 < 2.5\)

- Plasma profiles with a sharp rise to a near-critical peak density and a long exponential decay are key to successful SWA

- Hydro simulations show the appropriate plasma density profile for 1-\(\mu\)m lasers can be produced by preheating a thin 2-\(\mu\)m CH foil
Collaborators

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Lasers incident on overcritical plasmas can create conditions for shock-wave generation.

Counter streaming plasmas lead to shockwave formation.

Electric field (GV/cm)

Plasma density ($n/n_{cr}$)

Space (mm)

Ion reflection $V_{ref} = 2V_{sh} - V_{ion}$
The plasma density profile strongly affects the spectrum of the accelerated ions.

Sheath fields that exist at the sharp plasma vacuum boundary can smear the energy spread of accelerated ions.
To maintain a narrow energy spread, the plasma profile was tailored to reduce the sheath fields.

CO₂ systems are limited in peak power as compared to 1-μm lasers.

*D. Haberberger et al., Nature Phys. 8, 95 (2012).*
Scaling SWA to the 1-μm wavelength range requires a tailored high-density profile.

Hydro simulations

700 to 800 ps after irradiating a 2-μm-thick CH foil, a plasma profile useful for SWA is reached.
Simulations predict strong scaling of the SWA mechanism with laser intensity.

Scaling the SWA mechanism to the 1-μm OMEGA EP Laser System allows for the production of narrow energy spread ion beams in the 100- to 200-MeV/amu range.

Summary/Conclusions

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