Nanostructured Targets For Laser-driven Ion Acceleration And Its Applications

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INTRODUCTION

Enhanced laser-driven ion acceleration via near-critical materials

<table>
<thead>
<tr>
<th>conventional foil</th>
<th>superintense laser</th>
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</thead>
<tbody>
<tr>
<td>• 10^2 – 10^4 µm thickness</td>
<td>• 10^6 – 10^7 TW</td>
</tr>
<tr>
<td>• solid density</td>
<td>• 10^{-10} W/cm²</td>
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hot electrons • thermal spectrum • 1 – 10 MeV temperature

near-critical layer

accelerated ions • exponential spectrum • maximum energy < 100 MeV/A

switch to a smarter target • exploit the strong laser-matter coupling at the critical density

improved acceleration • bigger and hotter electron cloud! • more ions accelerated at higher energies!

Near-critical nanostructured double-layer targets

foam-attached target holder foam material

Particle-In-Cell simulations of laser-driven ion acceleration

methods

Integrated multi-stage and multi-scale approach

1. Nanoparticles in Brownian motion
2. Cluster aggregation by irreversible sticking

RESULTS

Role of the nanostructure & neutron generation

<table>
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<tr>
<th>homogeneous foam</th>
<th>nanostructured foam</th>
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</thead>
<tbody>
<tr>
<td>ion spectrum</td>
<td>electron spectrum</td>
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Neutron angular distribution

Neutron spectrum

Some specific tools: DILCCA model, SPIN, P-segment

laser pulse

- λ = 0.8 µm
- λ = 4
- 10 fs duration
- 4 µm waist
- normal incidence
- P-polarization

foams

- homogeneous foam
- nanostructured foam

neutron spectrum

- no foam
- $n_1 = 1.5n_0$
- $n_2 = 2.3n_0$

- substrate

- $400 \text{ nm thickness}$
- $4\text{ MeV}$

- (p,n) reactions

CONCLUSIONS & PERSPECTIVES

- FOAM-ATTACHED TARGETS: to enhance ion acceleration process
- INTEGRATED APPROACH: to simulate from the interaction to the applications
- ROLE OF THE NANOSTRUCTURE: should be included for a complete description
- NEUTRON GENERATION: promising application that may be enabled by the foam

next steps...

- include in the description other features (e.g. electron bremsstrahlung)
- experimental campaigns on neutron generation
- studies on laser-driven radioisotope production

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