

CONTACT: Szymon Suckewer  
Phone: 609-258-4738

FOR IMMEDIATE RELEASE

## **Super-bright laser uses plasma as amplifier-compressor**

*A compact double-pass ultra-short pulse laser amplifier/compressor achieved very high output intensity of  $3 \times 10^{16}$  W/cm<sup>2</sup> in a beam compressed down to 50-60 femtoseconds.*

ORLANDO, Florida—After forty years of laser research and development, the focus today is on developing high-power, compact lasers. Advances in laser power and reductions in system size and cost continue to foster exploration in many areas of science and engineering, which benefit from the development of ultra-intense and ultra-short pulse sources. Currently, most high-power, ultra-short lasers depend on the chirped-pulse-amplification method, which stretches a short laser pulse to avoid damaging the amplifying medium and then compresses it after amplification. This stretching and compressing at high powers requires large, very expensive gratings to control nonlinear effects and meet the requirement for uniform amplification over a broad bandwidth, which is difficult and technologically challenging.

Using plasma, which can support much stronger electric fields, as the amplifying medium overcomes such limitations. More specifically, in plasma, the resonant interaction between two counter-propagating electromagnetic waves, known as pump and seed waves, excites a plasma wave which converts energy stored in the long pump pulse into the much shorter seed pulse. The output beam undergoes simultaneous amplification and compression, and, since plasma is impervious to optical damage, the power can grow to extraordinary levels.

Such a plasma laser system has been theoretically analyzed and experimentally demonstrated by researchers at the Princeton University, Princeton Plasma Physics Laboratory (PPPL) and the University of California, Berkeley. Schematics illustrating the experimental setup and method are shown in Figure 1. Unprecedented pulse intensity amplification of 20,000 times in a plasma length of just 2 millimeters, has been achieved by using plasma with a significant density gradient and by a novel double-pass design. The intensity of the amplified pulse exceeded the pumping intensity by more than two orders of magnitude. Moreover, this amplification was accompanied by very effective pulse compression, from 500 to 90 femtoseconds, in a single pass. Amplification was increased by another factor of approximately two and the pulse was compressed down to around 50-60 femtoseconds in a two-pass experiment. In addition, a very significant improvement in the efficiency of the energy transfer from the pump to the ultra-short pulses was achieved, which brings this plasma laser closer to becoming a practical device.

Further improvements to the energy transfer efficiency are currently underway, and this very compact, table-top, university-type system is expected to reach output intensities close to  $10^{20}$  Wcm<sup>-2</sup> at the focus in the near future by using approximately 1.5 joule pump channeling into a 250 micrometer diameter of plasma and seed. In fact, by using a much larger pump laser and a much larger plasma (larger diameter and length), intensities of

the order of  $10^{24}$  to  $10^{25}$   $\text{Wcm}^{-2}$  should also be achievable. This high-power plasma laser, with its small size and low cost, will greatly assist the application of fast laser ignition in fusion-energy production, as well as facilitate exciting research in relativistic plasma physics, laboratory astrophysics, and atomic and nuclear physics.

This work was supported by NSF-MRI(ECS-0521037), DOE-NNSA, and DOE(DE-FG02) grants.

**Contact:**

Szymon Suckewer,  
Princeton University,  
609-258-4738,  
suckewer@princeton.edu

[Abstract: CII.00001](#)

**Reduced kinetic descriptions of weakly driven plasma waves**

Invited Session CII:  
Turbulence, Transport,  
and Laser Plasmas

2:00 PM-5:00 PM,  
Monday, November 12,  
2007  
Rosen Centre Hotel -  
Junior Ballroom

[Abstract: CII.00005](#)

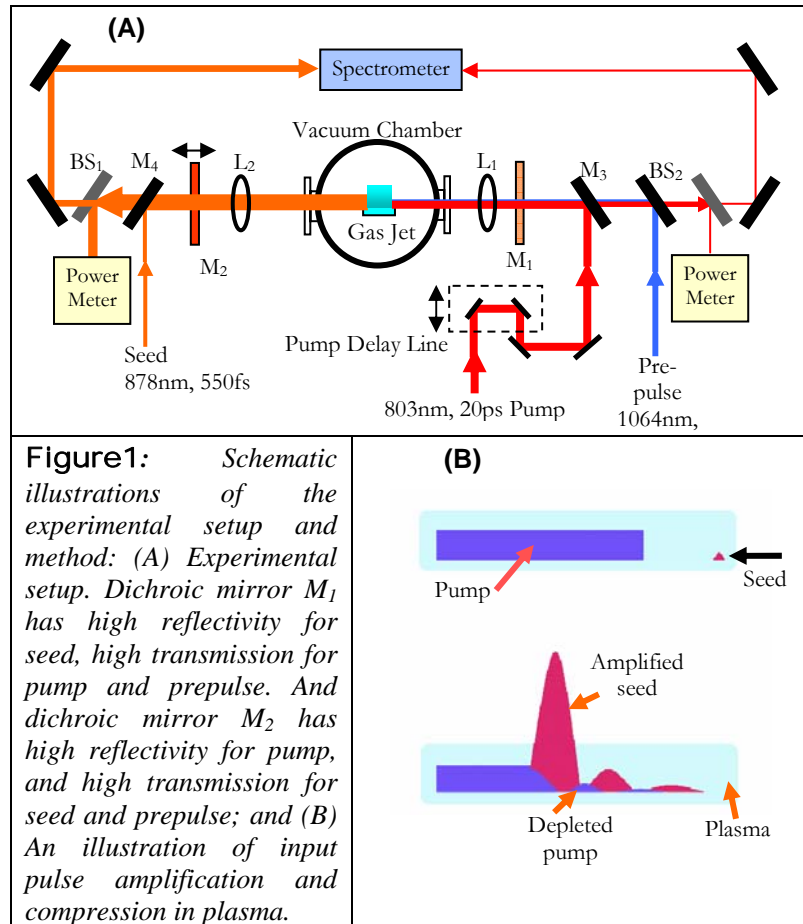
**A Compact Double-pass Raman Backscattering Amplifier/Compressor**

Invited Session CII: Turbulence, Transport, and Laser Plasmas

2:00 PM-5:00 PM, Monday, November 12, 2007  
Rosen Centre Hotel - Junior Ballroom

[Abstract: GP8.00067](#)

**Implementation of a Stimulated Raman Amplifier/Compressor in Plasma**



Poster Session III: Turbulence, Transport, and NL Processes; Fast Ignition and Laser-Plasma Interactions; Divertors, Edge Physics and Fueling; MHD Theory, Heating and Current Drive; Simulation: MHD; Optimal Helicon Source Performance

9:30AM - 12:30PM, Tuesday, November 13, 2007  
Rosen Centre Hotel - Grand Ballroom

**Publication:**

Jun Ren, Weifeng Cheng, Shuanglei Li and Szymon Suckewer. A new method for generating ultraintense and ultrashort laser pulses. *Nature Physics* 3(October):732-736, 2007.