Physics Flash
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INSIDE

Thomas Intrator

Reconnecting with students

By Diana Del Mauro
ADEPS Communications

Tom Intrator has made his mark as a physicist, but he's the kind of guy who isn't satisfied unless he's passing on what he knows. That's why he plans to resurrect the Plasma Physics Summer School this year.

Intrator held the first series of free lectures in 2002, with the ambition of preserving hands-on experimental skills at Los Alamos National Laboratory. "The experimental work we have the students do is not just Mickey Mouse stuff," said Intrator, of Plasma Physics (P-24), who is principal investigator of one of the nation's premier fusion energy experiments. "If I can dangle world-class science in front of them, they'll get interested."

Undergraduate students and graduate research assistants will learn about the history of fusion machines, the nature of plasma, fast x-ray imaging diagnostics, and parametric instabilities, as well as engineering concepts essential to designing complex experiments.

"I grew up in the '60s," Intrator said, sporting a pair of John Lennon style glasses. "I think we should give something back to our culture."

Intrator has nurtured more than 100 undergraduate students and many early career scientists through a variety of activities. And, in turn, they have nurtured him. During the holidays, his home is filled with students. He counts them among his best friends.

Last year, he received the Laboratory's Postdoctoral Distinguished Mentor award, his second student-related award at Los Alamos. "He likes to collaborate with others and to have as many students as he possibly can," Thom Weber (P-24) said of his advisor. "I guess he's got a lot of love to spread."

continued on page 2

Intrator . . . Intrator, who started out as a potter, did a bit of globetrotting before earning a doctoral degree in plasma physics in 1982 at the University of Colorado, Boulder. For more than a decade, he taught engineering physics at the University of Wisconsin-Madison, then he moved on to Los Alamos in 1999 to pursue his research dreams.

"You need to get them before they make too many life choices," he said of emerging scientists.

Erik Hemsing as a P-24 undergraduate student was obviously gifted but he did not have the credentials to enter a first-tier graduate school. Hemsing attended the Plasma Physics Summer School twice, and Intrator invited him to work on the Reconnection Scaling Experiment (RSX), of which Intrator is the principal investigator.

Hemsing spent 18 valuable months at Los Alamos before gaining entrance to the University of California, Los Angeles graduate program, thanks to Intrator's strong letter of recommendation. Now considered a world expert on free-electron lasers, Hemsing is a Stanford University research associate for the Department of Energy's SLAC National Accelerator Laboratory.

"Tom was a great mentor," Hemsing said. "I'm not sure I'd be where I am without that experience. It solidified my desire to become a scientist."

Commonly found in stars and neon signs, plasma is a fluid that takes on definite shape in a magnetic field. RSX, a lab that Intrator's students helped build out of spare parts, incorporates a helical magnetic field similar to a wire made out of plasma. Here, students study plasma current ropes that twist and kink, with applications for solar, space, plasma fusion, and astrophysics research.

"A student could be involved at every level—from building small probes to performing full experiments and presenting work at scientific conferences," Hemsing said.

In a meaningful contribution to the field of astrophysics, Intrator and his students even added something new to a 50-year-old theory that was thought to be well understood.*

For more information about the Plasma Physics Summer School, contact him at intrator@lanl.gov.

* "Current-driven rotating kink mode in a plasma column with a non-line-tied free end," *Physical Review Letters* **97**, 015002 (2006).

Thomas Intrator's favorite experiment

What: The behavior of flux ropes, which are current-carrying plasma columns, the macroscopic realizations of magnetic field lines.
Where: P-24
When: 2010
Why: This experimental study of two flux ropes was dedicated originally to expanding our characterizations of 3D magnetic reconnection.
Who: Xuan Sun, Thomas Intrator, Leonid Dorf, Jason Sears, and Ivo Furno (all in P-24 at the time) and Giovanni Lapenta (Applied Mathematics and Plasma Physics, T-5).
How: We were smashing flux ropes together trying to make them reconnect, as everyone assumed they must. It's a truly 3D experiment, but all our theories are 2D.
The a-ha moment: In certain regimes, we could not make the ropes reconnect; rather, they kept on bouncing. This required some head scratching, and ultimately some explanation, and the simplest one seemed to be that it takes a lot of energy to bend the magnetic field lines sufficiently so that the flux ropes bend toward each other and merge (i.e., magnetically reconnect) at some point along their lengths. We worked out a simple force balance and sure enough it was obvious in hindsight. Less than one year ago, we published it in *Phys Rev Letters*, even though the reviewer was difficult to convince.

First observations of non-ballistic focusing of ultra-high-intensity short-pulse laser-accelerated ion beams using diamond hemi-shells

Studies use Trident laser system

Using the Laboratory's 200-terawatt Trident laser system, a multi-institutional team from Los Alamos, General Atomics, Lawrence Livermore National Laboratory (LLNL) and University of California, San Diego (UCSD) have shown for the first time how laser-accelerated protons are focused and how they are affected by the surrounding structures and geometries of hemi-shell targets.

Recent progress in generating high-energy (>50 MeV) protons from intense laser–matter interactions (10^{18}–10^{21} W cm^{-2}) has opened up new areas of research, with applications in radiography, oncology, astrophysics, medical imaging, high-energy-density physics, and ion-proton beam fast ignition. Given the discovery of proton focusing with curved surfaces, rapid advances in these areas will be driven by improved focusing technologies.

continued on page 3

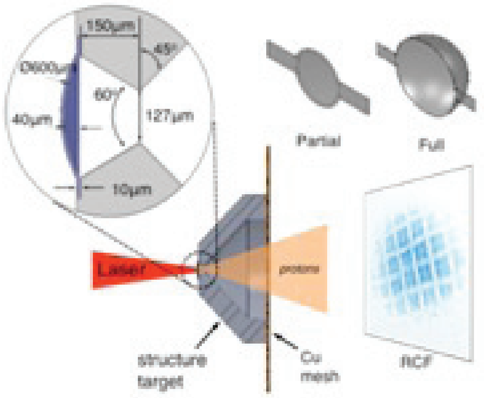

Figure 1. Experimental set-up and targets. The cone targets (expanded) consists of a 10 μm thick spherical substrate, either partial or full (upper right) hemishells, attached to the Al cone structure. A Cu mesh (200 lpi) is positioned 1.5 mm from the apex of the hemisphere and the RCF stack is at 4 cm. Representative RCF data from a cone structure target is shown.

Trident... In research appearing in *Nature Physics*, Kirk Flippo, Dustin Offermann, and Donald Gautier (P-24) and co-authors describe the first investigation of the generation and focusing of a proton beam using a cone-shaped target. Teresa Bartal in her thesis work at UCSD under advisor Prof. Farhat Beg led the work, with simulations performed by Mark Foord (LLNL). A companion paper showing similar focusing behavior for carbon beams was also recently published, as an invited paper, in *Physics of Plasmas* by Los Alamos postdoctoral researcher Dustin Offermann. That work was done on the Trident laser system and the Omega EP (extended performance) laser system at the Laboratory for Laser Energetics in Rochester, NY.

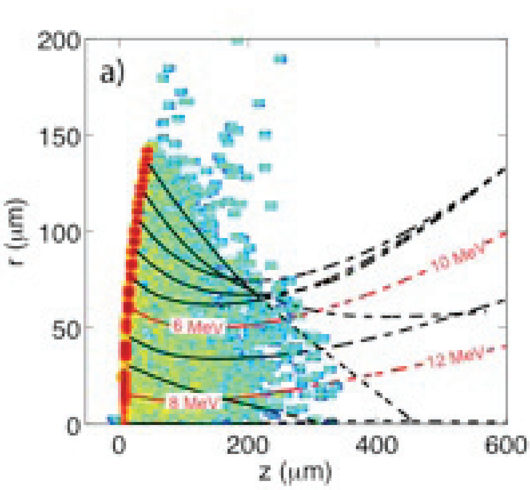

Figure 2. LSP Simulation of probe particles. Proton density map at t = 7.3 ps for the case of a partial hemisphere. The trajectories of test protons are also shown, with solid lines to t < 7.3 ps and broken lines from 7.3 ps < t < 19.2 ps. For comparison, in each plot the kinetic energy gained by two sample particles is also shown (in red), the more energetic protons are emitted closer to the axis.

The team was able to use diamond hemispherical shells irradiated with a laser at an intensity of 2×10^{20} W/cm^2, which is a billion trillion times brighter than the sun's irradiance on Earth. This intense light accelerates protons on the surface of the diamond to tens of millions of electron volts within the space of 1/10th the width of a human hair, thus making these electric fields, at 1 million megavolts/meter, the most intense fields on Earth (for comparison, lightning is 3 megavolts/meter) and rivaling those found elsewhere in the universe, such as in active galactic nuclei, pulsars, accretion disks around black holes, and in supernova shockwaves.

The team has shown that instead of following a purely ballistic path, the accelerated protons and carbon beams have curved geometries resulting from fields within the proton beam (a plasma) and geometric features of enclosed geometries. Their work has significant impact on how these beams can be manipulated and how they will ultimately be used for the various applications.

The Inertial Confinement Fusion (ICF) Program sponsored this study as a potential source for the graceful perturbation of ICF implosions needed to study ICF implosion predictive capability. Mark Schmitt is the project leader for this and other ICF defect implosion studies under the leadership of Steve Batha (LANL ICF Program Manager). The DOE Office of Science funded the work at UCSD and LNLL.

References: "Focusing of short-pulse high-intensity laser-accelerated proton beams," *Nature Physics*, DOI: 10.1038/NPHYS2153. "Characterization and Focusing of Light Ion Beams Generated By Ultra-Intensely Irradiated Thin Foils at The Kilojoule Scale," *Phys. Plasmas*, DOI: 10.1063/1.3589476.

Technical contact: Kirk Flippo

Proton radiography fires 500th shot

On Monday, January 23 the Proton Radiography team fired pRad shot number 500. This landmark shot was the second member of the "HE Gaps" experiment series, which is led by Eric Ferm (DARHT Physics and Pulse Power, WX-5) and James Cooley (XTD Primary Physics, XTD-3) and aims to study the initiation of insensitive HE across a vacuum- or matter-filled gap.

PRAD dynamic shot number 1 was conducted on April 15, 1997, in beam Line B at LANSCE. In the intervening time, the team has recorded 45,111 proton pulse chains into 41,420 series of pictures, ranging from four pictures per series in the earliest days to as many as 2,000 pictures per series for the Moxie camera test shot and 5,000 for a typical cook-off experiment, and a capability of 41 frames per series in typical modern running. Experiments have ranged in size from 100 mg to 10 pounds of high explosives, and have contained

continued on page 4

Proton radiography, invented at Los Alamos National Laboratory, employs a high-energy proton beam to image the properties and behavior of materials driven by high explosives.

500… uranium, plutonium, xenon and many other elements, with densities ranging from a few mg/cc to tens of g/cc. Secondary diagnostics have included (at least) Visar; PDV; temperature probes; visual framing cameras; and piezo, optical, and voltage pins. In the coming weeks, the team intends to supplement the existing HE and powder gun drivers with the PHELIX pulsed power driver. The team is proud to have been able to make 500 contributions to the weapons program and is eager to continue for the next 500.

Technical contact: Andy Saunders

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HeadsUP!

Report slippery spots to 667-6111

With more than 37 slip/trip accidents since December 1, and a cycle of freezing and thawing creating new ice spots every day, safety managers want to remind employees that anyone can and should use the Snow Control hotline to report slippery spots: call 667-6111. Crews from Roads & Grounds will be dispatched as soon as possible to address the problem.

New blog for cost-saving ideas launches

Employees can share ideas for managing LANL costs on a new blog launched recently. The Managing Laboratory Costs blog, blog.lanl.gov/managinglaboratorycosts/, provides a forum for discussing cost-saving ideas and is a new way to get ideas to the Laboratory Integrated Stewardship Council (LISC) and senior managers. You may comment anonymously, but all comments are moderated before posting.

New phone service at Occupational Medicine

Beginning Friday, February 3, LANL workers can call one number at Occupational Medicine for questions about medical issues. The new number - 667-0660 - gives callers a series of prompts they can follow to obtain services from Occupational Medicine medical staff.

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