ISSUE
141
November 24th 2020

Orion news

This issue:

Orion news

The newsletter aims to keep the Orion Team up to date with progress in the experimental campaigns, work programmes and general information of interest.

Editorial Team:
Stefan Parker
James McLoughlin
Colin Danson

Send your comments and news items to our dedicated mailbox orionnews@awe.co.uk

Measuring the Strength of High-pressure Gold and Tin

The first campaign after the COVID shut-down was conducted in Orion investigating the strength of gold and tin at high-pressures.

Our material models need to have knowledge of strength at high pressures. Models are becoming increasingly detailed, and often the models that fit experimental data the best are multiscale physics models. These models contain several length scales, with information being fed up through increasing length scales – so QMD simulations of inter-atomic potentials influence the model for the continuum. Orion's in-situ X-ray diffraction experiments are particularly useful for informing small length scale models – molecular dynamic and crystal plasticity simulations.

Targets were compressed to extreme pressures using Orion's long pulse beamlines and diamond sandwiches. Laser pulses were carefully shaped to provide a gradually increasing pressure wave that propagated through the diamond sandwich sample without shocking it, keeping the sample cool. The driver for the choice of diamond as the 'bread' material for the sandwich is that diamond has a high sound-speed, even at ambient pressures. This means we can reach high pressures without shocking, because the end of the pressure wave doesn't end up overtaking the start of the

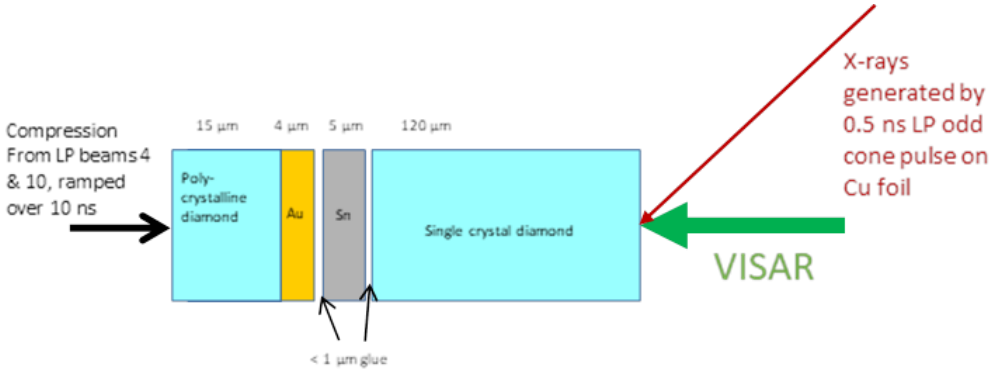


Figure 1: Experimental platform showing how materials are compressed to high pressures in diamond sandwiches.

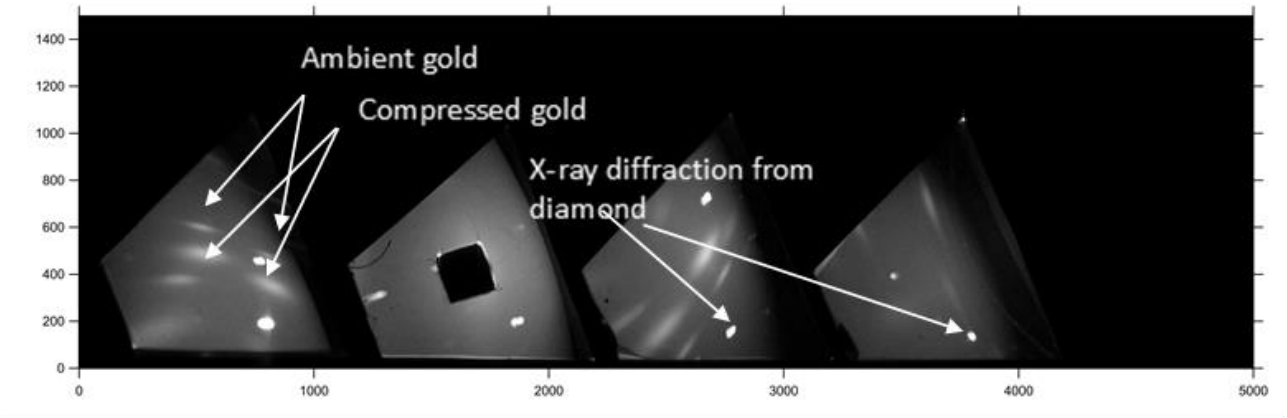


Figure 2: X-ray diffraction data from strongly textured gold.

pressure wave. High-quality X-ray diffraction and VISAR data was gathered at pressures between 0.5 and 1 Mbar. The VISAR system monitored the rear-surface velocity and confirmed how closely the compression route matched simulations.

The experiment was in two parts: gold and tin.

The gold samples exhibited a strong fibre texture – all the grains in the sample were the same way up, and the compression wave propagated along the same crystallographic axis for all grains. This allowed X-ray diffraction data to determine by how much grains rotate as they deformed plastically at high pressures and strain-rates. The rotation of grains can be linked to specific plastic deformation mechanisms. Gold is a good representative FCC material, and the data collected can also give us an insight into the plasticity mechanisms that affect strength in other FCC metals in extreme pressure regimes.

Solid-solid phase changes occur in many materials, and these changes affect material strength. This was our motivation for investigating tin.

Tin changes phase several times as it is compressed to 100 GPa – the pressure at which we recorded X-ray diffraction. Data gathered from ramp-compressed tin shows tin in the BCC phase, as is predicted. Further analysis will aim to extract strength-related information from the data.

The experiment actually started back in March but had to be put on hold due to lockdown restrictions. The break was beneficial though as it allowed a couple of improvements to be made before the campaign was restarted.

Come October, the Orion facility was well-prepared to operate in a safe way, with limited occupancy levels and cleaning stations. The Orion team worked enthusiastically to overcome the many obstacles that cropped up throughout the experiment, all while maintaining the discipline and focus necessary to stay safe. They impressively succeeded in delivering all the shots needed to fulfil the campaign objectives.

A highlight from the campaign was the quality of the VISAR data - alongside drive pulse-shape measurements, it gives us confidence that our compression route was generally well understood.

Emma Floyd

Orion's 10th Anniversary of First Shot to Target

Late in the evening of the 10th of November 2010 there was great excitement in the control rooms of Orion. The laser was ready, the target was in and all began to prepare for the first target shot.

The technicians had manually inserted the target which was being observed through the TVS (target viewing system) as the four-meter diameter chamber was brought to vacuum. As the chamber deformed under pressure the alignment beam wandered across the target but stayed visible and, once working pressure was achieved, stabilised allowing for the first full target alignment under vacuum.

At 11:30pm the team of scientists, engineers and technicians were ready and shot director, Colin Danson, pressed fire. There was no bang or crash, somewhat anticlimactically Orion fired its first target shot. The plasma diagnostics were still not fully commissioned so the technicians went in to confirm that the target had indeed been vaporised.

Firing a single beamline at a low energy (LP02 fired 55J in a 1ns pulse) is now a common occurrence, but then it was the culmination of a decade's worth of work demonstrating that AWE could build and fire a modern laser facility.

What followed was two years of hard work bringing all of the other eleven beamlines online and up to full energy until, following a demonstration experimental campaign, Orion was given its Authority To Operate on the 1/4/2013 and opened to users.

Orion has been used almost continuously ever since that first shot pushing material into warhead relevant conditions and producing cutting edge science. Orion fired its 1000th target shot in early 2015, 2000th in September 2017 and to date a total of 2750. Many of the same staff that were there for that first shot are still firing Orion to this day.

David Hillier

APS Recognises Gianluca Gregori for the Second Year Running

Prof Gianluca Gregori has been awarded the American Physical Society's John Dawson Award for excellence in plasma physics research – for the second year in a row.

Gianluca has very close links to Orion having carried out the very first academic access campaign and is scheduled for a return in 2021. He is an active member of OxCHEDS and supervised several AWE funded DPhil studentships.

The award recognises Gianluca's work generating Weibel-mediated collisionless shocks in the laboratory, impacting a broad range of energetic astrophysical scenarios, plasma physics, and experiments using high energy and high-power lasers conducted at basic plasma science facilities. It establishes laboratory astrophysics as an important tool for discovery science that is complementary to observations and numerical simulations.

He shares this year's award with ten other physicists while last year, he was one of five to receive the award. Since its commencement in 1983, Gianluca is the only physicist to have received this award twice.

'I am absolutely delighted to receive this award for the second time,' comments Professor Gregori. 'Once again, my fellow award winners are peers whom I admire, and respect and it is an honour to stand alongside them as winners of this year's John Dawson award. And, of course, all of this has been made possible by the work and dedication of the many talented graduate students and post-docs who I have worked alongside in the Department of Physics at Oxford.'

OxCHEDS Seminar

A virtual OxCHEDS seminar took place on the 19th October:

'Improved transport coefficients for collisional magnetized plasma.'

James Sadler

Ex-Oxford, and now Los Alamos National Laboratory (LANL)

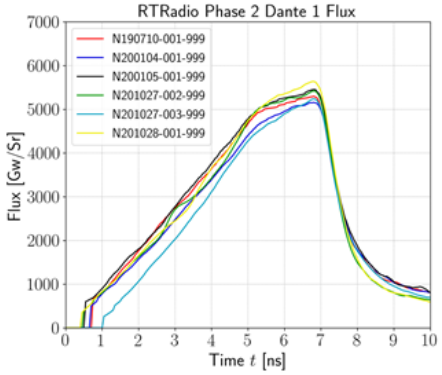
The Braginskii transport coefficients describe the flow of heat and magnetic field in a collisional magnetized plasma. Even if the magnetic pressure is far less than the plasma pressure, magnetic fields can deflect and insulate the heat flow, indirectly altering the hydrodynamics. The magnetic field is also enhanced and advected by the heat flow.

We show that many magneto-hydrodynamic (MHD) simulations have used a set of transport coefficients that yield an unphysical discontinuity in advection velocity. Here we use a kinetic Fokker-Planck approach to find new fit functions that rectify this issue and we describe a new MHD instability that results. It turns out that these re-definitions also bring out the symmetry of the transport coefficients and the thermal and magnetic transport that they describe.

AWE Successfully Field Shots at NIF

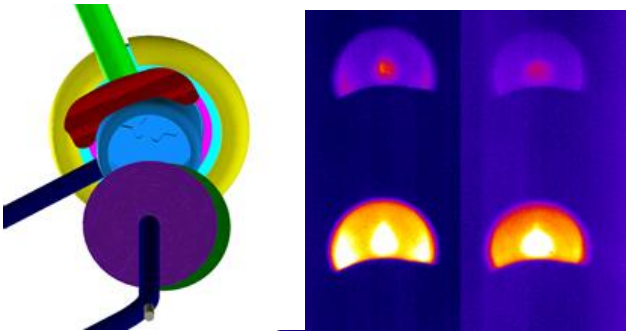
Earlier in October AWE fielded three shots on the National Ignition Facility (NIF), LLNL as part of the current radiation transport campaign. These experiments demonstrate continued delivery by the experimental and target fabrication teams amidst Covid restrictions.

The shots used radiography to image evolution of different complex 3D target designs, which includes a layer of CRF (carbon foam). All shots returned good imaging data, despite the loss of a NIF backlighter quad on one of the shots. Preliminary Dante data and SXI (Static X-ray Imager) images show consistent data across the set of shots.

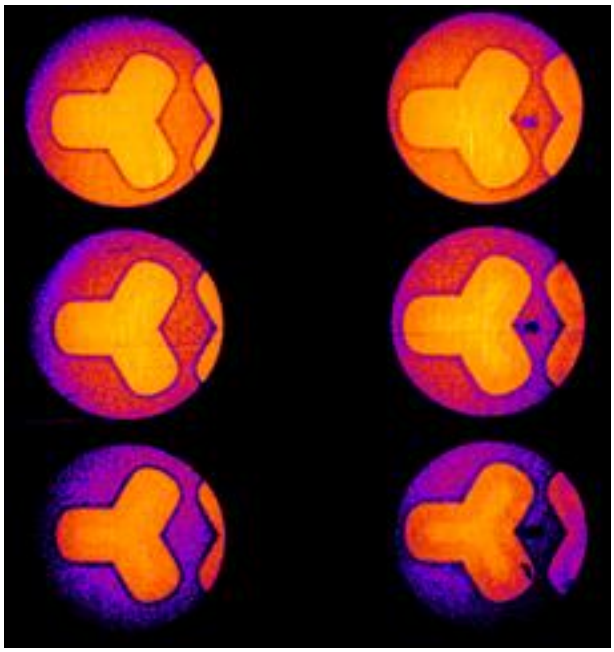


Preliminary Dante flux unfold for shots N201027-002, N201027-003 and N201028-001, compared to previous shots.

The alignment of the other shot was affected by loss of the alignment fiducial, during transit of the delicate targets. This meant some of the drive beams were dropped to satisfy facility constraints. For this shot the Dante1 measurement of x-ray flux, used to infer hohlraum drive, is reduced at early time. The reduced drive energy does not entirely account for the observed reduction, with the cause now being investigated.

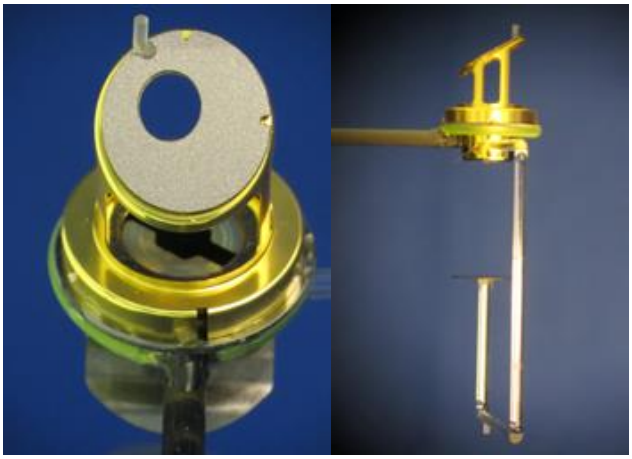


SXI diagnostic view from beneath the target, and SXI images from N201028-001



Low resolution quick scan of radiography image for N201028-001.

The radiography data, which was the primary measurement for these shots, shows a clear evolution in behaviour for the different target types. The shots used AWE-manufactured physics packages and the targets were assembled by AWE using both AWE and LLNL supplied components, before being shipped to LLNL. LLNL Target Fab provided support in final target preparation and a metrology cross-check at NIF. Thanks go to both AWE and LLNL Target Fab in successfully delivering these targets.



Target images

The targets were fielded by Mike Rubery and Lauren Hobbs, with support from the LLNL NIF team, and designed by John Morton and Peter Graham.

Warren Garbett

ELI-NP Autumn School 2020 - ELIAS2020

On 9-13 November 2020 the inaugural ELI-NP Autumn School, ELIAS2020, was held virtually organised by the ELI-NP facility in Magurele, Romania. The school was attended by ~60 students. Experts from around the world, including Colin Danson, were invited to give lectures on a broad range of subjects.

Overview: The field of photon–based nuclear science and applications is rapidly evolving being driven by the major worldwide development of ultrahigh intensity lasers and brilliant quasi-monochromatic gamma beam systems. The School aims at introducing PhD students and young post-doctoral researchers to the field of high power lasers and nuclear photonics and also to present recent experimental and theoretical advances in the field. The School will consist of a number of lecture courses given by experts in the field, starting from a basic level, but also including more advanced seminars. The lectures will be held in the new Conference Center and online. Students are invited to contribute to the school by short oral presentations on their own research.

Following an introductory presentation by Prof Nicolae Victor Zamfir, Project Director ELI-NP and an ELI-NP Scientific overview by Prof Kazuo Tanaka, ELI-NP Scientific Director, Colin Danson gave the opening international presentation on 'Petawatt and Exawatt Class Lasers Worldwide'.

There were many excellent presentations covering diverse fields, some of the highlights included talks from:

- Olivier Chalus, Thales, France '10PW laser system at ELI-NP: Challenges and achievements.'
- Julien Fuchs, CNRS, France 'Laboratory Astrophysics with high-power lasers.'
- John Kline, Los Alamos National Laboratory, USA 'Alternate capsule designs and approaches to ICF.'
- Heinrich Hora, University of New South Wales, Australia 'Million degrees C for igniting fusion is no longer needed: use no-thermal ps-CPA-laser pulses.'

The hosts organised an excellent virtual tour of the facility, which was played during coffee breaks.

Ioan Dancus, Head of ELI-NP Laser Systems, said after the workshop 'Thank you very much for your participation in the ELI-NP Autumn School. Our audience received your presentation with a lot of interest, and for myself, it was a great pleasure to see you again. All of us much appreciate your view of the High Power Laser field, based on your experience and lifelong contribution to it.'

Colin Danson

The control room of ELI-NP following the firing of their first 10PW shot in August 2020

Inaugural 10PW Laser and Users Symposium

A virtual symposium was attended by Colin Danson at the ELI-NP facility, Romania on the 17th November 'Moving into unchartered territories'. Over 200 participants attended the hosted from the control room of ELI-NP including Gerard Mourou and Donna Strickland 2018 Nobel Physics awardees.

Overview: *The ELI-NP (Extreme Light Infrastructure - Nuclear Physics) in Magurele, Romania, hosts a unique and unprecedentedly high-intense laser system. The laser system has an output capability of 10 PW (= 1016 Watt) supplied individually by two beamlines, which correspond to around 12 % of the total power received by the Earth from the Sun. This output can be repeated every one minute. We have to thank Professors Gerard Mourou and Donna Strickland, who were awarded the Nobel Prize in Physics in 2018 for their groundbreaking invention of the chirped pulse amplification technique that enabled the construction of our laser system.*

If we can produce this fraction of instantaneous sunlight power in a laboratory, what do scientists do with it? According to Albert Einstein, energy corresponds to a mass, implying that if we concentrate tremendous energy into a small volume, a finite mass may be created from vacuum. The scientists are eagerly awaiting the opportunity to reach this guiding light and a manifold of other concepts in experimental physics and related applications. Therefore, it is our great pleasure to host this inaugural symposium for our users.

ELI-NP is funded with the structural fund by the European Commission since 2012 and has been intended to serve European and international research communities.

The symposium was opened by an introduction from Nicolae Zamfir, Project Director ELI-NP highlighting the current status of the facility. This was followed by words from Donna Strickland, University of Waterloo, Canada. She described the early days of CPA and how far it has come and that no one at the time could have dreamed, even Gerard Mourou, of 10PW laser capability.

A current facility status was given by Kazuo Tanaka, ELI-NP Scientific Director followed by virtual tours of the facility presented by Ioan Dancus, Head ELI-NP Laser Systems Department and Catalin Ticos, Head ELI-NP Laser Driven Experiments. The highlight was live shots of the facility demonstrated by Olivier Chalus, Thales. A series of shots were fired at 1 minute intervals ramping up to shots at 10.7PW (251J in 23fs). While waiting between shots he apologised at how slow the repetition rate was!! Gianluca Sarri, Queen's University Belfast gave the final technical presentations with an overview of the exciting scientific possibilities offered by lasers at the 10PW level.

The symposium was concluded by a presentation from Gerard Mourou, IZEST, France. He congratulated the facility on achieving such a significant goal and then wanted to postulate where we would be going next with PW scale facilities. He discussed two possible compression schemes. The first using self-phase modulation in thin plates at the output of the system followed by compression to achieve single fs pulses. The second scheme discussed the possibility of getting even shorter pulses using relativistic compression on target leading to Joule level pulses at an attosecond: a true exawatt laser which would lead to exciting new applications.

Colin Danson

Remembrance Day

Orion's resident artist produced a wonderful collage of poppies that helped us to remember the fallen on Remembrance Day:

'They shall grow not old,
as we that are left grow old:
Age shall not weary them,
nor the years condemn.
At the going down of the sun and in the morning,
We will remember them.'

Louise Small

AWE Celebrates 70 Years

2020 sees AWE celebrate 70 years of service to our national safety and security.

To mark this anniversary an e-book has been produced containing a mixture of archive footage, historical milestones and facts, plus insight into what makes us a unique workplace and community. The e-book can be found online within the 'about us' section of AWE's website:

https://www.awe.co.uk/about-us/our-history/

Some notable visitors feature in the e-book with rare footage of a speech from then Prime Minister, Harold Macmillan, whilst visiting AWRE in 1957 and on-site pictures of the royal visit from Her Majesty the Queen and HRH the Duke of Edinburgh in 1979.

The e-book also showcases some of AWE's innovation – from supercomputers to 3D virtual imagery – and includes a time-lapse video showing the Orion laser facility being built, and the importance of our STEM learning with local schools to inspire future generations.

A recurring theme in the e-book is the importance of communities. These include our MDP colleagues, local schools and Skills Academy – there's even some amazing black and white footage showing apprentices being tasked with making a set square, which is something that still happens to this day. Our work with local charities, inclusive organisations and recreational groups is also highlighted.

Staff News

Welcome to Orion's three new technicians:

Orion operations would like to welcome three new trainee laser technicians to the team. Liam Colegate, Cameron Komba and Ryan Charles have joined us over the past few months, and we would like to wish them all the very best in their new roles.

My name is Liam Colegate, I have joined Orion as one of the new laser technicians but have worked with AWE for just over 4 years as health physics across the business. It's been refreshing seeing Orion after having spent my time generally in crumbling facilities, painted open windows and mouse traps everywhere. I am an avid reader and keen cyclist when the weather permits!

My Name is Ryan Charles, I am one of the new laser technicians here at Orion. Before joining the Orion team, I worked at Mercedes as a car mechanic for 8 years. I decided I would change career paths and start something new here at Orion because I felt like I needed a new challenge, I am very much enjoying learning about every element involved in the Orion

facility. I'm excited to see my progression over the many years I hope to be here.

My name's Cameron Komba, I recently joined the Orion family in early September for the laser technician role. Prior to AWE I worked for Virgin media as a field technician. I'm really excited to continue to learn new things with Orion every day as it's a new challenge and I also look forward to working with my good team.

Farewell to Mark:

At the end of October Mark Lightfoot retired from his role as target assembler with the Target Fabrication Group at AWE. He had been part of the team for 8 years and helped to develop the use of augmented reality target assembly via the use of OGP video CMM's. This type of assembly aid overlays guidelines and angles onto the live image of the target to ensure correct alignment of components and is vital to the production of targets for US campaigns and has also helped increase the quality of complex Orion targets.

Mark also helped ensure the transition of Target Fab in to Orion went as smoothly as possible for assembly through an agile response to target demands and building stocks ahead of a moving move date, to ensuring we met as many of our delivery commitments as possible during this time. He also helped in the layout of the new assembly area to make return to operations as easy as possible. If you look closely Mark also has a starring role on the corporate video on the external website home page.

At his leaving presentation, Mark, thanked everyone he had worked with and said how much he had enjoyed working in TF with the different challenges that assembly provided. Mark was looking forward to spending some more time exploring with his wife and the dogs in their caravan and finding the time for more fishing.

Farewell to Samantha:

Sam Tombs, who has been on the Orion Mitie housekeeping team for two years has moved on to a position in Health Physics. All in Orion want to wish her well in her exciting new role.

Sam said on leaving 'I'd like to thank the whole of the Orion team for making my time there so pleasurable. I was given a lot of support within the facility to move forward from housekeeping, to my new position in Health Physics. I will most certainly miss everyone, but certainly hope our paths cross again. I would also like to thank the team from Mitie.'

What's in a Name?

People are once again spotting unusual Orion's:

Jon Cooney spotted this scene from the 1990's TV sitcom 'Bottom':

Have you seen any unusual Orions' on your travels?