Australian ITER Forum Website News Update 10/17

B.J.Green (12/10/17)

1. PPPL and General Atomics team up to make TRANSP code widely available

By
John Greenwald
October 6, 2017

http://www.pppl.gov/news/2017/10/pppl-and-general-atomics-team-make-transp-code-widely-available

Plasma transport analysis, the study of how plasma particles, heat and momentum drift across magnetic field lines, is a necessary first step for understanding how well fusion reactors are performing. Teams of scientists from the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) and General Atomics (GA) have joined forces to bring PPPL's premier transport code, TRANSP, to beginning users and experts alike.

Using the workflow manager OMFIT developed by GA scientists, the team has created a TRANSP module that streamlines data preparation for TRANSP analysis and couples TRANSP to other widely used software. While TRANSP analysis of international tokamak experiments has been available for more than 30 years, the new interface through OMFIT has produced a new user base, modern visualization and increased productivity.

Expanding the global community

The result has been expansion of a global community. "From a technical point of view, OMFIT is a workflow manager that can couple physics codes, execute them in complex workflows, and provide them with streamlined interfaces," says Orso Meneghini, a GA physicist. "Perhaps more importantly, OMFIT is a growing community effort, which is gathering the contribution of many physicists across domestic and international institutions, and is supporting the research of over two hundred scientists worldwide."

In recent years, the number of TRANSP users on DIII-D, the National Fusion Facility that GA operates for the DOE, has expanded from a handful to nearly 40 researchers by the end of 2016. While most are new users, legacy users have also migrated to the OMFIT platform. "What used to be a complex and cumbersome process to generate TRANSP runs that was mastered by only a few has now become available to all users with powerful and intuitive drivers and visualizations," says physicist Brian Grierson, a PPPL researcher on DIII-D who developed the TRANSP module in OMFIT with PPPL physicists Shaun Haskey and Nikolas Logan.

Logan points out the utility of the module. "Through OMFIT, we have created a community-based platform for developing scientific analysis software, where expert users can develop and oversee critical physics analysis with results available for the wider community," he says.

Benchmarked on U.S. tokamaks

Researchers have used the new TRANSP interface in OMFIT to study fusion plasmas in three U.S.-based tokamaks: DIII-D; the National Spherical Torus Experiment (NSTX) at PPPL prior to its recent upgrade; and Alcator C-Mod at MIT, which ceased operation at the end of 2016. The interface was benchmarked on the U.S. experiments and is now being used to analyze data gathered from domestic and international tokamaks.

Multiple scientists presented TRANSP analysis results obtained through OMFIT at the 2016 International Atomic Energy Agency (IAEA) Fusion Energy Conference in Kyoto, Japan. "I used the new OMFIT workflow to efficiently analyze transport in an ITER-like DIII-D discharge with TRANSP," says Chris Holland of the University of California, San Diego. ITER is an international tokamak under construction in France.

"The TRANSP output and uncertainty analysis was then used as input for massively parallel multiscale GYRO simulations" that model plasma turbulence at the microscopic scale in fusion reactors, Holland said. Results of the simulations, published in the journalNuclear Fusion in May, matched experiments showing that turbulence caused by electron transport takes place at multiple scales of time and space.

PPPL, on Princeton University's Forrestal Campus in Plainsboro, N.J., is devoted to creating new knowledge about the physics of plasmas — ultra-hot, charged gases — and to developing practical solutions for the creation of fusion energy. The Laboratory is managed by the University for the U.S. Department of Energy's Office of Science, which is the largest single supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time. For more information, please visit science.energy.gov(link is external).

2. How machine learning can predict and prevent disruptions in reactors

October 11, 2017

https://phys.org/news/2017-10-machine-disruptions-reactors.html

Robert Granetz has been a research scientist in MIT's Plasma Science and Fusion Center for more than 40 years. He recently gave a talk hosted by the MIT Energy Initiative (MITEI) on using machine learning to develop a real-time warning system for impending disruptions in fusion reactors. A specialist in magnetohydrodynamic instabilities and disruptions, Granetz discussed how research in this area is bringing us one step closer to creating a stable, net-energy-producing fusion device.

Q: What makes plasma different from other states of matter? What are the challenges of working with plasma as an energy source?

A: In a gas at normal temperatures, the negatively-charged electrons and positively-charged nuclei are tightly bound into atoms or molecules, which are electrically neutral. Therefore, there are no forces exerted between particles unless they happen to actually collide. (The gravitational force acts between all masses, but gravity is much too weak to be relevant.)

When gas particles do collide, the collisions only involve a pair of particles at a time, and the kinematics of the collision are very simple, just like billiard ball collisions. So we can easily calculate the behaviors of gases. However, at the high temperatures that we need for fusion, the thermal energy of each atom or molecule is much, much greater than the binding energy that holds the electrons and nuclei together, so the neutral particles break up into their constituents, i.e. electrons and nuclei, which we call the "plasma state."

Therefore, in a plasma, all the particles are charged, and there are long-range electric and magnetic forces acting between the particles. A single electron or ion influences the motion of about a billion other electrons and ions simultaneously, and all of those billion other particles are simultaneously influencing every other individual particle. In addition, the electrons and nuclei have extremely different masses, so their velocities are very different. Also, since all the particles are charged, they can interact strongly with electromagnetic radiation. All of these complicating properties mean that in practice, we can't accurately calculate the detailed behavior of plasmas from the basic equations of physics.

Q: In the context of fusion reactors, what's a disruption?

A: To date, the tokamak concept for a steady-state fusion reactor outperforms all other concepts in terms of energy confinement. The tokamak relies on driving a large current—of the order millions of amperes—through the plasma to produce the magnetic field structure required to obtain good energy confinement. However, this large plasma current is somewhat unstable, and is subject to sudden termination, usually with very little warning. When a disruption occurs, the considerable thermal and magnetic energy contained within the plasma is suddenly released very quickly, which can lead to damaging thermal and electromagnetic loads on the reactor structure.

The whole goal of fusion energy is to develop large power plants to generate electrical power on the grid, and replace today's fossil-fueled utility power plants, and even replace fission nuclear power plants. But if a fusion power plant is subject to disruptions, its electricity output would suddenly turn off. Even if the most damaging consequences can be avoided, it could be hours or days before the plant can recover and get back online, only to be subject to another disruption at some later time. No utility would want to use fusion energy if that were the case. If we're going to rely on the tokamak concept for fusion reactors, we need to avoid or mitigate disruptions.

Q: How can machine learning address this problem?

A: The signs that a disruption is imminent are often quite subtle. Fusion researchers continuously measure a number of characteristic plasma parameters during a plasma discharge, and we have reason to believe, both from empirical experimental evidence and from theoretical understanding, that some of these measured plasma parameters may provide indications that a disruption is about to occur. But this information is not straightforward to interpret, not just with respect to the occurrence of an impending disruption, but also with regard to the timing of an impending disruption.

In an attempt to solve this problem, my team—which consists of myself, postdoc Cristina Rea, graduate students Kevin Montes and Alex Tinguely, and a dozen scientists at other U.S. and international labs—has built up large databases of measured parameters which we believe are relevant to disruptions, from several years' worth of experiments on several different tokamaks around the world. We are now applying machine learning techniques to these data to see if we can discern any patterns that would accurately predict whether or not a disruption will be occurring at a specific time in the near future. When dealing with large, complicated datasets, machine learning may be a powerful way of finding subtle patterns in the data that elude human efforts.

3. Wendelstein 7-X: Second round of experimentation started

First plasmas in the upgraded device / "It's now getting exciting", says Project Head Thomas Klinger

September 11, 2017

http://www.ipp.mpg.de/4254576/08_17

The plasma experiments in the Wendelstein 7-X fusion device at Max Planck Institute for Plasma Physics (IPP) in Greifswald have now been resumed after a 15-month conversion break. The extension has made the device fit for higher heating power and longer pulses. This now allows experiments in which the optimised concept of Wendelstein 7-X can be tested. Wendelstein 7-X, the world's largest fusion device of the stellarator type, is to investigate this type's suitability for application in a power plant.

Besides new heating and measuring facilities, over 8,000 graphite wall tiles and ten divertor modules have been installed in the plasma vessel since March last year, i.e. the scheduled end of the first experimentation phase. This cladding is to protect the vessel walls and allow higher temperatures and plasma discharges lasting 10 seconds in forthcoming experiments.

A special function is exercised here by the ten sections of the divertor: As broad strips on the wall of the plasma vessel, the divertor tiles conform exactly to the twisting contour of the plasma edge. They thus protect especially those wall areas to which particles escaping from the edge of the plasma ring are specifically directed. Along with unwanted impurities the impinging particles are neutralised and pumped off.

The divertor is thus an important tool for regulating the purity and density of the plasma.

The smaller predecessor, the Wendelstein 7-AS stellarator at IPP in Garching, had already yielded encouraging results in divertor tests. But not till the much larger successor, Wendelstein 7-X at Greifswald, did the geometry conditions come up to power plant size, particularly the ratio of the divertor area to the plasma volume. “We are therefore very excited that we are now able for the first time to investigate whether the divertor concept of an optimised stellarator can really work properly”, says Project Head Professor Thomas Klinger. These tests will play a major role: Many detailed investigations will carefully check how to guide the plasma and what magnetic field structures and heating and replenishing methods are most successful.

Newly enlisted measuring instruments will also allow observation of turbulence in the plasma for the first time: The small eddies entailed influence how successful magnetic confinement and thermal insulation of the hot plasma are, these being important parameters for a future power plant, because they determine the size of the plant and hence its economical merit. “We shall be able for the first time to check whether the promising predictions of theory for a completely optimised stellarator are correct. In comparison with previous devices, Wendelstein 7-X is expected to yield quite new, possibly even better, conditions”, says Thomas Klinger.

As all ten microwave transmitters for the microwave heating of the plasma are meanwhile ready for use, this will allow a higher energy throughput and plasmas of higher density. It will now be possible to raise the energy to 80 megajoules once all versions of the microwave heating have been tackled and tested, as compared with 4 megajoules in 2016. The rather low plasma density hitherto can now be more than doubled to attain values meeting power plant requirements.

This has significant consequences: First the density of the plasma has to be sufficient to allow electrons and ions to exchange energy effectively. Previously, the microwave heating had only been able to heat essentially just the electrons. Instead of hot electrons with 100 million degrees and cold ions with 10 million degrees as hitherto the electrons and ions in the new plasma will have almost equal temperatures of up to 70 million degrees. This should also enhance the thermal insulation of the plasma. Whereas it was hitherto just upper average in relation to the size of the device, the effect of optimising Wendelstein 7-X should now become visible: “It’s getting very exciting”, states Thomas Klinger.

Background

The objective of fusion research is to develop a power plant favourable to the climate and environment. Like the sun, it is to derive energy from fusion of atomic nuclei. As the fusion fire does not ignite till temperatures exceeding 100 million degrees are attained, the fuel, viz. a low-density hydrogen plasma, ought not to come into contact with cold vessel walls. Confined by magnetic fields, it levitates inside a vacuum chamber with hardly any contact.

The magnetic cage of Wendelstein 7-X is formed by a ring of 50 superconducting magnet coils about 3.5 metres high. Their special shapes are the result of sophisticated optimisation calculations. Although Wendelstein 7-X is not meant to produce energy, the device should prove that stellarators are suitable for power plants. For the first time the quality of the plasma confinement in a stellarator is to attain the level of competing devices of the tokamak type.

For this purpose, further stages of modification are being planned. For example, the graphite tiles of the divertor are to be replaced in a few years by carbon-fibre-reinforced carbon elements that are additionally water-cooled. This will allow discharges lasting up to 30 minutes in which it can be tested whether Wendelstein 7-X will achieve its optimisation targets in the long run: In this way the device is to demonstrate the essential advantage of stellarators, viz. their capability for continuous operation.

Isabella Milch

4. Research led by PPPL provides reassurance that heat flux will be manageable in ITER

By
John Greenwald
September 26, 2017
http://www.pppl.gov/news/2017/09/research-led-pppl-provides-reassurance-heat-flux-will-be-manageable-iter

major issue facing ITER, the international tokamak under construction in France that will be the first magnetic fusion device to produce net energy, is whether the crucial divertor plates that will exhaust waste heat from the device can withstand the high heat flux, or load, that will strike them. Alarming projections extrapolated from existing tokamaks suggest that the heat flux could be so narrow and concentrated as to damage the tungsten divertor plates in the seven-story, 23,000 ton tokamak and require frequent and costly repairs. This flux could be comparable to the heat load experienced by spacecraft re-entering Earth’s atmosphere.

New findings of an international team led by physicist C.S. Chang of the U.S. Department of Energy’s (DOE) Princeton Plasma Physics Laboratory (PPPL) paint a more positive picture. Results of the collaboration, which has spent two years simulating the heat flux, indicate that the width could be well within the capacity of the divertor plates to tolerate.

Good news for ITER

"This could be very good news for ITER," Chang said of the findings, published in August in the journal Nuclear Fusion. "This indicates that ITER can produce 10 times more power than it consumes, as planned, without damaging the divertor plates prematurely."

At ITER, spokesperson Laban Coblentz, said the simulations were of great interest and highly relevant to the ITER project. He said ITER would be keen to see experimental benchmarking, performed for example by the Joint European Torus (JET) at the Culham Centre for Fusion Energy in the United Kingdom, to strengthen confidence in the simulation results.

Chang's team used the highly sophisticated XGC1 plasma turbulence computer simulation code developed at PPPL to create the new estimate. The simulation projected a width of 6 millimeters for the heat flux in ITER when measured in a standardized way among tokamaks, far greater than the less-than 1 millimeter width projected through use of experimental data.

Deriving projections of narrow width from experimental data were researchers at major worldwide facilities. In the United States, these tokamaks were the National Spherical Torus Experiment before its upgrade at PPPL; the Alcator C-Mod facility at MIT, which ceased operations at the end of 2016; and the DIII-D National Fusion Facility that General Atomics operates for the DOE in San Diego.

Widely different conditions

The discrepancy between the experimental projections and simulation predictions, said Chang, stems from the fact that conditions inside ITER will be too different from those in existing tokamaks for the empirical predictions to be valid. Key differences include the behavior of plasma particles within today's machines compared with the expected behavior of particles in ITER. For example, while ions contribute significantly to the heat width in the three U.S. machines, turbulent electrons will play a greater role in ITER, rendering extrapolations unreliable.

Chang's team used basic physics principles, rather than empirical projections based on the data from existing machines, to derive the simulated wider prediction. The team first tested whether the code could predict the heat flux width produced in experiments on the U.S. tokamaks, and found the predictions to be valid.

Researchers then used the code to project the width of the heat flux in an estimated model of ITER edge plasma. The simulation predicted the greater heat-flux width that will be sustainable within the current ITER design.

Supercomputers enabled simulation

Supercomputers made this simulation possible. Validating the code on the existing tokamaks and producing the findings took some 300 million core hours on Titan and Cori, two of the most powerful U.S. supercomputers, housed at the DOE's Oak Ridge Leadership Computing Facility and the National Energy Research Scientific Computing Center, respectively. A core hour is one processor, or core, running for one hour.

Researchers from eight U.S. and European institutions collaborated on this research. In addition to PPPL, the institutions included ITER, the Culham Centre for Fusion Energy, the Institute of Atomic and Subatomic Physics at the Technical University of Vienna, General Atomics, MIT, Oak Ridge National Laboratory and Lawrence Livermore National Laboratory.

Support for this work comes from the DOE Office of Science Offices of Fusion Energy Sciences and Office of Advanced Scientific Computing Research.

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5. PPPL physicist Francesca Poli named ITER Scientist Fellow

By
John Greenwald
September 21, 2017
http://www.pppl.gov/news/2017/09/pppl-physicist-francesca-poli-named-iter-scientist-fellow

Physicist Francesca Poli of the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) has been appointed an ITER Scientist Fellow. She will join a network of researchers who have achieved international recognition and will work closely with ITER, an international tokamak under construction in France, to develop the scientific program to be carried out during the fusion device's lifetime.

Poli will facilitate installation of TRANSP, the PPPL-developed computer code that is used throughout the world to analyze and predict fusion experiments. Included in her role will be the design of scenarios for the ITER research plan and the training of young researchers on operation of the code.

"I'm pretty excited," Poli said of the appointment, which was approved by ITER Director-General Bernard Bigot. "This will allow us to promote TRANSP for ITER and will be good for the Laboratory," she said. "It will enable us to improve TRANSP by developing new capabilities."

For ITER, Poli previously coupled a reduced model of neoclassical tearing modes, a type of plasma instability, to the large and complex TRANSP code. She continues to work with the International Tokamak Physics Activity Integrated Operation Scenarios (ITPA-IOS) topical group on the modeling of ITER with TRANSP.

Poli will remain at PPPL during the three-year renewable fellowship, which includes the opportunity for frequent travel to ITER. Among benefits of the fellowship will be a graduate student to assist in research and support for travel expenses for extended visits to work with ITER scientists on-site in Cadarache, France.

Poli, a PPPL physicist since 2010, is an expert in simulating the evolution of tokamak plasma discharges. She applies her expertise to interpreting existing experiments, predicting and designing new experiments, and predicting plasma performance in ITER.

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6. Science & Technology

https://lasers.llnl.gov/news/science-technology

LOS: Newest Fast Camera in the West

A multi-organization partnership has developed a new ultrafast diagnostic called the Single Line of Sight, or SLOS, camera that brings a 60-fold increase in full-frame shutter-speed capability to the National Ignition Facility. Researchers are hailing the new high-speed imaging technology as a much-anticipated breakthrough for high energy density and inertial confinement fusion (ICF) experiments.

LLNL led the SLOS camera development in collaboration with Sandia National Laboratories (SNL), San Diego-based General Atomics (GA), and UK-based Kentech Instruments Ltd. The new capabilities it brings to NIF include:

- Using advanced sensor technology for full-frame time sequencing of imaging for the first time; and
- Shutter speeds as short as 35 picoseconds (trillionths of a second).

The new SLOS sensor introduces a burst-mode capability similar to a motor drive on a standard camera. It can take images in rapid-fire sequence with a two-nanosecond gate integration of time, said Arthur Carpenter, a NIF diagnostics engineer and the responsible system engineer for the SLOS camera. It then uses a “time microscope” to divide these time slices down by a factor of 60, resulting in gate widths of 35 picoseconds.

“This is a marvelous example of an international collaboration,” said NIF Scientific Diagnostic Leader Joe Kilkenny, a longtime leader in the effort to develop the SLOS and other next-generation imaging cameras.

The SLOS innovation merges two recent high-speed imaging technologies: the DIXI (Dilation X-ray Imager) currently used in NIF, and an advanced double-layer hybrid complementary metal oxide semiconductor sensor, or h-CMOS, developed by SNL. Equipped with the h-CMOS sensor, SLOS increases shutter speed by a factor of three over traditional framing cameras used in NIF.

Expectations are high for SLOS in the wake of the camera’s successful commissioning in September. It is expected to compliment DIXI, which is considered the world’s fastest two-dimensional x-ray framing camera. DIXI can capture images of NIF implosions at 200 billion frames a second, but it can’t record images over the same area on the image plane multiple times.

Understanding Implosions

The advantage that SLOS brings is the ability to image NIF shots with full-frame time sequencing; researchers expect that capability to enable greater understanding of the implosions they record, Carpenter said. “The major limitation of microchannel-based framing cameras like DIXI and hGXD (the hardened gated x-ray detector) can be overcome with this system,” he said.

DIXI uses the centuries-old pinhole photography concept to generate an image. With the new SLOS sensor for NIF, Carpenter notes, researchers can now couple advanced x-ray optics technology that can focus images down to get significantly better spatial resolution with ultra-fast timing to sharpen clarity.

“With SLOS you can look at a sequence of full-frame images,” he said. “There’s been a lot of excitement in the community about this technology.”

The SLOS technology is considered a transformational diagnostic under the National Nuclear Security Administration’s 2016 Inertial Confinement Fusion Program Framework.

SLOS also offers some radiation resistance, with the capability of handling medium-yield shots. Development of the SLOS camera electronics also allowed real-world testing of radiation-hardening techniques for the next generation SLOS system currently under development, Carpenter said.

Armed with its sophisticated sensors, SLOS will provide two full frames per shot; a planned upgrade in 2018 is expected to allow SLOS to capture four frames per shot. With the next-generation version on NIF, the SLOS 2, researchers plan to gain 16 frames on a radiation-hardened version of the camera built to handle high-yield shots.

“SLOS 2 might have the first small-scale active electronics that will operate during a high-yield shot inside the Target Chamber,” Carpenter said.

At the inaugural commissioning experiment on Sept. 21—the 400th NIF shot in Fiscal Year 2017—a crowd of researchers from NIF and General Atomics gathered to watch the successful fielding of the dilation-aided diagnostic. The experiment was led by Carpenter and LLNL physicist Sabrina Nagel, who served as principal scientist for DIXI and worked on the development of the SLOS diagnostic.

“We have data!” Nagel called out when the shot went off at 7:30 p.m., and immediately dove into analyzing the data. She describes the pulse-dilation process as similar to pacing cars coming off a highway ramp and onto the freeway. Stop-and-go lights accelerate the autos along the highway, placing fast cars out front and slower cars in the rear so they don't bunch together. After some time on the freeway their spacing will increase; in the same way, pulse dilation allows a relatively slow detector to pick out a set of electrons, leading to a faster effective shutter speed.

With that increased control of the SLOS, Nagel said, comes the ability to get more images from a single line of sight recorded per shot of the laser—like a camera being able to take more photographs of the same scene.

"You can think of it as getting more frames with your camera," she said. "Instead of one frame or a bunch of frames but with blurred images, you can get four all spaced out evenly."

The other advantage of the SLOS system is the "gates," or timing limitations between frames (snapshots), are flexible; depending on the experiment, researchers can control the time between images—an impressive amount of control considering the time-gate measurements are in trillionths of a second.

A Marriage Made in Heaven

"This will for the first time give you actually improved temporal resolution of these single line-of-sight CMOS detectors because we have the dilation part in front," Nagel said. "Now we will have multiple images, from a real single line-of-sight image, with a 40-picosecond temporal resolution from any x-ray source you want to image."

Kilkenny highlighted the importance of the SLOS technology to ICF research: "A true single-line-of-sight camera is enabled by a marriage made in heaven between the pulse-dilation technology, which Sabrina has demonstrated on NIF, with the 10-to-20 picosecond gate time of DIXI and the ability to record four gated images with nanosecond gating with hybridized CMOS focal plane arrays."

One of the developers of both the DIXI and the SLOS fast cameras is Terry Hilsabeck of GA. He noted that when DIXI, using pinhole imaging, was unable to achieve the higher spatial resolution the researchers sought, the collaborating team pursued the method of capturing more frames from one image on a single line of sight, allowing the use of higher-performance x-ray optics.

Hilsabeck worked on the problem with scientists from Sandia, GA, Kentech and Livermore. The collaboration faced technical challenges in trying to develop a way to use a digital chip to record and store enough images of a laser shot in a series, or time sequence. The burst-mode h-CMOS sensors were developed to achieve nanosecond-scale, multi-frame image recording by storing data locally in pixels during the event, so it could hold multiple images in sequence. The physics of signal propagation on the chip, however, limit the gate speed to about a nanosecond—too slow for time-resolved core imaging.

The h-CMOS sensor has 160 electrical connections that must penetrate the vacuum barrier of the electron tube. The sensor's photodiode array originally was designed to detect visible light and 6 keV (6,000 electron-volt) x-rays. Detecting electrons would require tripling the electron energy in the tube. The team needed to develop adequate radio-frequency shielding, because the photocathode at the input end of the SLOS instrument is excited at the kilovolt level, while the sensor—which sits only 50 centimeters away—is recording millivolts.

"The biggest risk we had," Hilsabeck noted, "was that in that tube, you're pulsing kilovolts on one end and you're sensing millivolts on the other. That's a million time stronger, so you worry about noise, and the question was whether that sensor would work in that 'noise' environment. So we put up enough shielding around it and it ended up working well."

What does this new SLOS diagnostic ultimately bring to NIF? "If we get better data quality," Hilsabeck said, "then we get more understanding of how the implosions are performing—and hopefully that will lead to higher yields. That's the goal."

7. HAPLS Featured in *Optics & Photonics News*

https://lasers.llnl.gov/news/science-technology

For the second straight month, the LLNL-developed High-Repetition-Rate Advanced Petawatt Laser System (HAPLS) graces the cover of a scientific research publication.

HAPLS is the cover feature story in the October issue of *Optics & Photonics News*, published by the Optical Society of America (OSA). It also was highlighted in the July/August issue of the Laboratory's *Science & Technology Review* in an article titled, "Advanced Laser Promises Exciting Applications."

In the *Optics & Photonics News* article, "High-Average-Power Ultrafast Lasers,"LLNL physicists Tom Spinka and Constantin Haefner, NIF & Photon Science program director for Advanced Photon Technologies, discuss the role of HAPLS in the context of a new generation of petawatt (quadrillion-watt) peak-power lasers.

"When tightly focused," they wrote, "PW-peak-power lasers can generate intensities of greater than 10^{21} W/cm^2 and electromagnetic fields more than 100 times stronger than the field that binds electrons to atomic nuclei. This opens a range of interesting and potentially useful laser–matter interactions.

"However," they continue, "these lasers still have one weakness: a very low pulse repetition rate. Many of them fire only once every few minutes, and even the advanced PW laser at the Lawrence Berkeley National Laboratory's Berkeley Lab Laser Accelerator facility fires only once per second."

By contrast, HAPLS, which was designed and constructed by LLNL for the European Extreme Light Infrastructure (ELI) Beamlines project, "is poised to increase the repetition rate of PW-peak-power laser pulses by an order of magnitude." HAPLS is designed to deliver petawatt laser pulses with energy of at least 30 joules and durations less than 30 femtoseconds (quadrillionths of a second) at a repetition rate of 10 Hz (10 times a second).

"At ELI Beamlines," the authors write, "the ability of new lasers to produce extreme intensities on targets—in multiple pulses per second—should drive forward new discoveries in high-intensity laser science and transform laser-driven particle and radiation sources from scientific curiosities into viable tools."

HAPLS is currently being integrated into the ELI Beamlines facility, which is expected to be ready for use by the international scientific community in 2018.

8. Pressure vessel in place at Karachi 2

11 October 2017

The reactor pressure vessel (RPV) has been hoisted into place at Karachi unit 2 in Pakistan. All of the main reactor components - the RPV and three steam generators - have now been installed at the Chinese-designed Hualong One unit.

http://www.world-nuclear-news.org/NN-Pressure-vessel-in-place-at-Karachi-2-1110177.html

The operation to lift the RPV into place was completed on 30 September, China National Nuclear Corporation (CNNC) said yesterday.

Lifting of the four main components took just under three weeks to complete, starting with the installation of the first steam generator on 10 September. The operation marks the first time that a "pre-introduction" construction method - with the main reactor equipment installed before the dome of the containment building is put in place -

has been employed in this type of nuclear power plant, CNNC said. This approach can significantly reduce construction time, compared with the traditional method of installing equipment through a hatch in the containment.

Two Hualong One units are under construction at Karachi. Work began on unit 2 in 2015 and unit 3 in 2016, with commercial operation planned for 2021 and 2022, respectively. The units are the first export of the Hualong One pressurised water reactor design, which is also being promoted for use at the Bradwell site in the UK.

A single unit pressurised heavy water reactor, Karachi 1, has been in operation at the site since 1972.

Researched and written
by World Nuclear News

9. Robot deployed into Magnox Swarf Storage Silo

10 October 2017

A robot has been sent into Sellafield's most hazardous nuclear waste store for the first time. The Avexis will help dislodge and clear waste from the Magnox Swarf Storage Silo, Sellafield Sites announced today.

http://www.world-nuclear-news.org/WR-Robot-deployed-into-Magnox-Swarf-Storage-Silo-10101701.html

The Magnox Swarf Storage Silo was built in Cumbria, England in the 1960s to store waste from the UK's earliest nuclear reactors. It closed in 2000 and has now been prioritised for clean-up by the Nuclear Decommissioning

Authority. It is the first time a remotely operated vehicle (ROV) has been deployed inside the building. Sellafield Sites said.

The robot - which can 'see' inside the silo via cameras attached to its body and also clear away small bits of waste clinging to the silo wall - was developed by Cumbrian firm Forth Engineering with support from the University of Manchester. Maryport-based Forth Engineering specialises in remote tooling, deployment methods, and sensor systems.

The company's founder, Mark Telford, said: "The site needs innovative methods for undertaking engineering tasks in harsh environments underwater. Other industries like marine and oil and gas are also looking for similar products. Successfully deploying our technology at Sellafield means we can transfer it to these other industries and grow our customer base."

Rebecca Weston, strategy and technical director for Sellafield Ltd, said the Avexis shows how the supply chain can help reduce the UK's nuclear hazard "faster, cheaper and more safely". It also shows how companies can use Sellafield as a "springboard into international export markets", she added.

The Avexis, which is small enough to fit through spaces of 150mm, is the first robot of its kind "to go from concept to market" within five years, Sellafield Sites said. And, at £10,000 ($13,177), it is also the cheapest of its kind, it added.

Researched and written
by World Nuclear News

10. South Korea's AP1400 clear for European export

09 October 2017

European Utility Requirements (EUR) has approved modifications Korea Hydro & Nuclear Power Co Ltd (KHNP) has made to its APR1400 reactor design, according to *Reuters*. The approval by EUR - a technical advisory group for European utilities on nuclear power plants - means South Korea's state-run nuclear operator can further expand its export markets.

http://www.world-nuclear-news.org/RS-South-Koreas-AP1400-clear-for-European-export-09101702.html

Gaining the EUR approval will allow KHNP to build the European compliant model in countries that require EUR certification outside of Europe such as South Africa and Egypt, KHNP said today. The changes modify how the APR 1400 cools itself in the case of an emergency.

KHNP, which is owned Korea Electric Power Co (Kepco), operates all of South Korea's 24 nuclear power plants. Construction of the first pair of APR1400 reactors - Shin Kori 3 and 4 in South Korea - was authorised in 2006, although the actual construction licence was not issued until April 2008. First concrete for Shin Kori 3 was poured in October 2008, with that for unit 4 following in August 2009. Unit 3 was originally scheduled to enter commercial operation at the end of 2013, with unit 4 due to start in September 2014. However, their operation was delayed by the need to test safety-related control cabling and its subsequent replacement. Unit 3 eventually reached first criticality in December 2015, was connected to the grid in January 2016 and entered commercial operation in December. Unit 4 is now expected to start up in September 2018.

Two further APR1400 units had been planned for both the Shin Kori and Shin Hanul sites. However, KHNP announced in May that it had suspended design work for the planned units 3 and 4 at the Shin Hanul until South Korea's new government announces its policy on the construction of new reactors. Last month it also decided to temporarily suspend construction of Shin Kori 5 and 6.

Four more APR1400s are under construction at Barakah in the United Arab Emirates. All four are scheduled to be in operation by 2020.

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11. Milestones for Vogtle construction

09 October 2017

The Vogtle AP1000 construction project in Georgia has marked multiple construction milestones including a concrete "super placement" for unit 3 and the lift of the 237-tonne CA03 module for unit 4.

http://www.world-nuclear-news.org/NN-Milestones-for-Vogtle-construction-0919178.html

The placement of 1844 cubic yards (1410 cubic metres) of concrete in four key areas of unit 3's containment vessel required a continuous operation lasting 71 hours. Concrete was placed in the unit's refuelling cavity, the bottom of the in-containment refuelling water storage tank, the west steam generator cubicle walls and the pressuriser cubicle walls.

The CA03 module placed in unit 4 is part of the unit's 75,300 cubic feet (2132 cubic metre) in-containment water storage tank, which will be filled with borated water to provide a passive heatsink for the operating reactor and backup cooling for the reactor vessel. The CA03 is one of the structural steel modules known as super modules because they are too large to transport and require on-site assembly.

As well as the concrete placement and the CA03 module, the past month has seen placement of the 35-tonne CA33 floor module at unit 3 and placement of unit 4's deaerator inside the turbine building. The deaerator, which is 148 feet (45 metres) long and weighs 300 tonnes, will remove dissolved gases, such as carbon dioxide and oxygen, from feedwater, preventing corrosion and helping to reduce plant maintenance and operating costs.

Georgia Power owns 45.7% of the project to construct two AP1000 units at the Vogtle site, near Waynesboro, with co-owners Oglethorpe Power (30%), MEAG Power (22.7%) and Dalton Utilities (1.6%). Following constructor Westinghouse's Chapter 11 bankruptcy filing earlier this year, Georgia Power in August filed a recommendation with the Georgia Public Service Commission to complete construction of the two AP1000 units as the most economic choice for customers. The commission is expected to review the recommendation and make a decision on the future of the project as part of its 17th Vogtle Construction Monitoring proceeding.

Project management and control at the site transitioned to Southern Nuclear after a services agreement between Westinghouse and Vogtle's co-owners became effective on 27 July and, in August, Georgia Power contracted with Bechtel to manage daily construction efforts under the direction of Southern Nuclear. US Energy Sercretary Rick Perry announced on 29 September further support of up to $3.7 billion in loan guarantees to the owners of the Vogtle project, to which the Department of Energy has already guaranteed $8.3 billion in loans.

Vogtle unit 3 is expected to start commercial operation in November 2021 and unit 4 in November 2022.

Researched and written
by World Nuclear News

12. EDF on track with Flamanville performance testing

09 October 2017

EDF is preparing for the next stage of system performance testing at the Flamanville EPR, with a view to the fuel loading and reactor start-up at the end of the fourth quarter of 2018. The company has thus confirmed its roadmap for Flamanville 3 drawn up in September 2015 and that the project cost is set at €10.5 billion (2015 rate, excluding interim interest).

http://www.world-nuclear-news.org/NN-EDF-on-track-with-Flamanville-performance-testing-09101701.html

he system performance tests - which confirm and test how all the EPR circuits are working - began in the first quarter of this year and, having completed the so-called '*chasse en cuve*' (vessel flushing operations) during the summer, EDF is now preparing for two new phases. These are the cold tests, which will start in the second fortnight of December, and the hot tests, which will start in July 2018.

The cold tests will include water tightness tests in the reactor's primary circuit at a pressure of over 240 bars (higher than the pressure of the circuit when it is operating). The hot tests will involve checking the equipment under similar temperature and pressure conditions to those under which it will operate. More than 1000 engineers and technicians working for EDF and industry partners have been mobilised to carry out these system performance tests, the company said.

Construction work began in December 2007 on the 1650 MWe unit at the Flamanville site in Normandy – where two reactors have been operating since 1986 and 1987. The dome of the reactor building was put in place in July 2013 and the reactor vessel was installed in January 2014. The reactor was originally expected to start commercial operation in 2013, but owing to delays this is now expected in late 2018.

The French nuclear regulator, Autorité de Sûreté Nucléaire (ASN), provisionally ruled in June that the unit could start up safely next year, but that the head of its reactor pressure vessel (RPV) would need to be replaced by the end of 2024. Areva NP revealed its discovery of an anomaly in the composition of the steel in certain zones of the RPV's closure head and bottom head in April 2015. The engineering group started a test program to demonstrate that the mechanical strength of the steel is sufficient in all operating situations. Its conclusions were sent to ASN in December last year.

ASN's approval of the start of operations at Flamanville 3 is a European Commission precondition for approving EDF's planned takeover of Areva's reactor business.

Researched and written by World Nuclear News

13. Olkiluoto 3 commercial operation rescheduled

09 October 2017

Regular electricity production at Finland's Olkiluoto 3 is now expected to start in May 2019, the first-of-a-kind EPR unit's supplier consortium has told Finnish utility Teollisuuden Voima Oyj (TVO). Regular production had previously been scheduled to begin at the end of 2018.

http://www.world-nuclear-news.org/NN-Olkiluoto-3-commercial-operation-rescheduled-0910177.html

TVO said the plant's supplier had been preparing a schedule review for the project completion "for some time". Work has now reached a stage where the supplier can confirm the main milestones, the company said. The previous schedule was provided in September 2014.

The latest schedule sees grid connection taking place in December 2018 with the start of regular electricity production in May 2019. The unit's ramp-up program will see it produce 2-4 TWh of electricity, at varying power levels between those dates.

TVO's Olkiluoto 3 (OL3) project director Jouni Silvennoinen said the company was "very disappointed" by the additional delay.

"There is still substantial work to be accomplished in the OL3 EPR project and it is essential that all the necessary technical, human and financial resources are allocated to the project. The restructuring of the French nuclear industry must not compromise this," he said.

Cold functional tests began at Olkiluoto 3 in June, with hot functional tests scheduled for later this year. TVO said that although the testing program was progressing many important tests remain to be carried out.

"Our objective remains the prompt completion of the OL3 EPR project. TVO continues to be committed to supporting the turn-key plant supplier," Silvennoinen said.

The consortium of Areva GmbH, Areva NP SAS and Siemens AG began construction of Olkiluoto 3 in 2005 under a turnkey contract signed with TVO in late 2003. Completion of the 1600 MWe reactor was originally scheduled for 2009, but the project has suffered various delays and setbacks.

TVO in September filed an appeal against the European Commission's approval for the French government to inject €4.5 billion ($5.4 billion) into Areva as part of the group's restructuring. TVO claimed the plan does not provide sufficient guarantees that the Olkiluoto 3 EPR project will be completed. Bernard Fontana, CEO of French engineering company Areva NP subsequently said that the Commission's approval in January had been made on the understanding there would be no changes to the Olkiluoto 3 project.

Researched and written
by World Nuclear News

14. Elon Musk's big battery for South Australia already half complete

T https://www.theguardian.com/australia-news/2017/sep/30/elon-musks-big-battery-for-south-australia-already-half-completeesla boss said the project is a great example of how to replace fossil fuels with renewables

https://www.theguardian.com/australia-news/2017/sep/30/elon-musks-big-battery-for-south-australia-already-half-complete

The clock is ticking on entrepreneur Elon Musk's promise to build the world's largest lithium-ion battery in South Australia within 100 days or provide it for free.

But with the facility already half finished, the US billionaire looks set to get paid.

Musk travelled to Jamestown, in SA's mid-north, on Friday where construction of the 100-

megawatt battery is well advanced. Construction of the battery was announced in July.

Elon Musk's big battery brings reality crashing into a post-truth world

Tim Hollo

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“To have that [construction] done in two months … you can’t remodel your kitchen in that period of time,” Musk told an audience in Jamestown.
The Tesla boss said the South Australian project was an example of how to replace fossil fuels with renewables.

“This is a great example to the rest of the world of what can be done,” he said.
“When this is done in just few months, it will be the largest battery installation by a factor of three.”
The SA battery will be paired to a neighbouring wind farm run by renewable energy company Neoen in Hornsdale to bring added reliability and stability to the state’s power supplies.

It is thought to be costing taxpayers about $50m and forms part of the state government’s $550m energy plan.
Other elements of the energy plan include installing emergency generators at two sites in Adelaide, a push for more gas-fired power generation and a solar-thermal power plant near Port Augusta.

It was prompted by a series of power problems, including a statewide blackout when a freak storm brought down transmission lines a year ago and another event last summer when heavy demand and a lack of electricity flowing through the interconnector with Victoria cut services to thousands of properties.