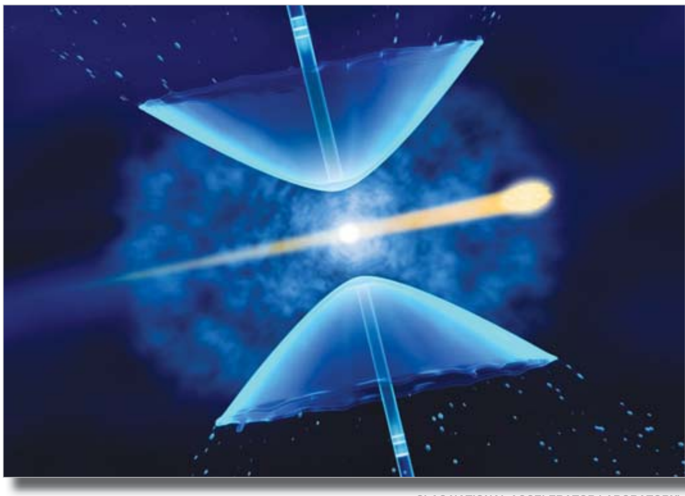
Footprints of baby planets

New analysis of the ALMA data for a young star HL Tauri provides yet more evidence of baby planets around the star. Two gaps were uncovered in the gas disk around HL Tauri.

First movies of droplets getting blown up by X-ray laser



SLAC NATIONAL ACCELERATOR LABORATORY)
This illustration shows how an ultrabright X-ray laser pulse (orange beam) vaporizes part of a liquid jet (blue), creating umbrella-shaped films of liquid and sending shock waves through the jet (bright stripes at top and bottom).

Researchers have made the first microscopic movies of liquids getting vaporized by the world's brightest X-ray laser at the Department of Energy's SLAC National Accelerator Laboratory. The new data could lead to better and novel experiments at X-ray lasers, whose extremely bright, fast flashes of light take atomic-level snapshots of some of nature's speediest processes.

"Understanding the dynamics of these explosions will allow us to avoid their unwanted effects on samples," says Claudiu Stan of Stanford PULSE Institute, a joint institute of Stanford University and SLAC.

"It could also help us find new ways of using explosions caused by X-rays to trigger changes in samples and study matter under extreme conditions. These studies could help us better understand a wide range of phenomena in X-ray science and other applications."

According to Phys.org, liquids are a common way of bringing samples into the path of the X-ray beam for analysis at SLAC's Linac Coherent Light Source (LCLS), a DOE Office of Science User Facility, and other X-ray lasers. At full power, ultrabright X-rays can blow up samples within a tiny fraction of a second. Fortunately, in most cases researchers can take the data they need before the damage sets in.

The new study, published in Nature Physics, shows in microscopic detail how the explosive interaction unfolds and provides clues as to how it could affect X-ray laser experiments.

Stan and his team looked at two ways of injecting liquid into the path of the X-ray laser: As a series of individual drops or as a continuous jet. For each X-ray pulse hitting the liquid, the team took one image, timed from five billionths of a second to one ten-thousandth of a second after the pulse. They strung hundreds of these snapshots together into movies.

"Thanks to a special imaging system developed for this purpose, we were able to record these movies for the first time," says coauthor Sébastien Boutet from LCLS. "We used an ultrafast optical laser like a strobe light to illuminate the explosion, and made images with a high-resolution microscope that is suitable for use in the vacuum chamber where the X-rays hit the samples."

The footage shows how an X-ray pulse rips a drop of liquid apart. This generates a cloud of smaller particles and vapor that expands toward neighboring drops and damages them. These damaged drops then start moving toward the next-nearest drops and merge with them.

In the case of jets, the movies show how the X-ray pulse initially punches a hole into the stream of liquid. This gap continues to grow, with the ends of the jet on either side of the gap beginning to form a thin liquid film. The film develops an umbrella-like shape, which eventually folds back and merges with the jet.

Based on their data, the researchers were able to develop mathematical models that accurately describe the explosive behavior for a number of factors that researchers vary from one LCLS experiment to another, including pulse energy, drop size and jet diameter.

They were also able to predict how gap formation in jets could pose a challenge in experiments at the future light sources European XFEL in Germany and LCLS-II, under construction at SLAC. Both are next-generation X-ray lasers that will fire thousands of times faster than current facilities.

"The jets in our study took up to several millionths of a second to recover from each explosion, so if X-ray pulses come in faster than that, we may not be able to make use of every single pulse for an experiment," Stan says.

"Fortunately, our data show that we can already tune the most commonly used jets in a way that they recover quickly, and there are ways to make them recover even faster. This will allow us to make use of LCLS-II's full potential."

The movies also show for the first time how an X-ray blast creates shock waves that rapidly travel through the liquid jet. The team is hopeful that these data could benefit novel experiments, in which shock waves from one X-ray pulse trigger changes in a sample that are probed by a subsequent X-ray pulse.

This would open up new avenues for studies of changes in matter that occur at time scales shorter than currently accessible.

Euro Soyuz rocket launches two Galileo satellites

A Europeanized Russian Soyuz rocket successfully placed two European Galileo positioning, navigation and timing satellites into medium-Earth orbit — the 13th and 14th in a series of 26 Galileo spacecraft, with more to come.

According to space.com, operating from Europe's Guiana Space Center in French Guiana, on the northeast coast of South America, the Soyuz rocket's Fregat upper stage released the two 733-kilogram spacecraft into their 22,522-kilometer-altitude orbit some three hours and 48 minutes after liftoff.

Launch operator Arianespace confirmed the accurate orbital injection, and European Space Agency officials said both satellites were healthy and sending signals.

In addition to four in-orbit-validation satellites — one of which is no longer functioning correctly — the European Commission ordered 22 spacecraft from a consortium led by OHB SE of Bremen, Germany, with the payloads provided by SSTL of Guildford, England.

Specially modified heavy-lift Ariane 5 rockets are scheduled to launch the remaining 12 satellites, four at a time. The first of the three was scheduled for Nov. 17, with the other two set for 2017 and 2018.

With another successful Soyuz launch performed to expand the Galileo satellite navigation system, Arianespace today reaffirmed the company's important role in supporting European governments and institutions with independent, reliable and available access to space.

The Galileo constellation, with many of the same performance goals as the US GPS, Russia's Glonass and China's Beidou networks, is considered fully operational at 24 satellites. But European officials have always said they would launch 30 satellites to provide sufficient in-orbit backup.

Paul Verhoef, director of navigation at the 22-nation European Space Agency, said an invitation to tender to industry for eight more Galileo satellites, plus up to six options, had been issued earlier this month.

A contract decision is expected by the end of the year and will present ESA and the European Commission — the executive arm of the 28-nation European Union and the owner of the Galileo program — with a difficult choice.

The least-expensive decision ostensibly would be to order recurrent models from the OHB team to take advantage of the scale economies that have already brought down the satellites' cost.

New method for doping single crystals of diamond

Along with being a girl's best friend, diamonds also have remarkable properties that could make them ideal semiconductors. This is welcome news for electronics; semiconductors are needed to meet the rising demand for more efficient electronics that deliver and convert power.

SWAMIBU
This is a collection of 0.02, 0.03 and 0.04 carat solitaire diamonds weighing in total 5.36 carats.

The thirst for electronics is unlikely to cease and almost every appliance or device requires a suite of electronics that transfer, convert and control power. Now, researchers have taken an important step toward that technology with a new way to dope single crystals of diamonds, a crucial process for building electronic devices, phys.org wrote.

"We need the devices to manipulate the power in the way that we want," said Zhengqiang (Jack) Ma, an electrical and computer engineering professor at the University of Wisconsin-Madison. He and his colleagues describe their new method in the Journal of Applied Physics.

For power electronics, diamonds could serve as the perfect material. They are thermally conductive, which means diamond-based devices would dissipate heat quickly and easily, foregoing the need for bulky and expensive methods for cooling. Diamond can also handle high voltages and power. Electrical currents also flow through diamonds quickly, meaning the material would make for energy efficient devices.

But among the biggest challenges to making diamond-based devices is doping, a process in which other elements are integrated into the semiconductor to change its properties. Because of diamond's rigid crystalline structure, doping is difficult.

Currently, you can dope diamond by coating the crystal with boron and heating it to 1,450˚C. But it's difficult to remove the boron coating at the end. This method only works on diamonds consisting of multiple crystals stuck together. Because such polydiamonds have irregularities between the crystals, single-crystals would be superior semiconductors.

You can dope single crystals by injecting boron atoms while growing the crystals artificially. The problem is the process requires powerful microwaves that can degrade the quality of the crystal.

Now, Ma and his colleagues have found a way to dope single-crystal diamonds with boron at relatively low temperatures and without any degradation. The researchers discovered if you bond a single-crystal diamond with a piece of silicon doped with boron, and heat it to 800˚C, which is low compared to the conventional techniques, the boron atoms will migrate from the silicon to the diamond. It turns out that the boron-doped silicon has defects such as vacancies, where an atom is missing in the lattice structure. Carbon atoms from the diamond will fill those vacancies, leaving empty spots for boron atoms.

Coral bleaching 'lifeboat' could be just beneath surface

A report commissioned by the United Nations and coauthored by the University of Sydney's UNESCO Chair in Marine Science offers a glimmer of hope to those managing the impact of bleaching on the world's coral reefs, including the Great Barrier Reef.

Coral bleaching has affected virtually the entire Great Barrier Reef and many other coral reef systems globally, a result of the continuing rise in global temperatures and exacerbated by the summer's major El Niño event, sciencenewsline.com reported.

The 35 authors of the United Nations Environmental Program report — including the University's Professor Elaine Baker in the School of Geosciences — say as the world's surface reefs are being threatened, part of the ecosystem may survive in these barely known deeper environments, known as mesophotic coral ecosystems (MCEs).

Shallow coral reefs from the water's surface to 30-40 meters depth are the tip of the iceberg that comprises the ocean's extensive coral ecosystem. MCEs are intermediate depth reefs starting at about 40 meters depth and continuing to around 150 meters. The report — 'Mesophotic Coral Ecosystems A lifeboat for coral reefs?' — looks at the role MCEs could play in the preservation of shallower reefs.

The report asks if MCEs can provide a refuge for the species under threat in shallower reef ecosystems and whether they can provide the stock to re-populate shallow reefs if they continue to decline.

"Mesophotic coral ecosystems are a seed bank for some organisms," said Baker.

"More research needs to be done to firmly establish the role of MCEs in preserving our reefs; they aren't a silver bullet but they may be able to resist the most immediate impacts of climate change — thereby providing a refuge for some species and potentially helping to replenish destroyed surface reef and fish populations.

"It may be that the cooler, deeper water in MCEs could be more hospitable to many species than the warmer surface water," she said. "They also are less prone to waves and turbulence, therefore potentially offering a more stable environment."

JOHN REED
In shallow waters, the Caribbean coral Montastraea cavernosa exhibits a boulder-like morphology, shown at 5m.

The review brought together information on the geology, biology, distribution and socio-economic aspects of mesophotic reefs in order to examine their potential resilience.

The report found some deep mesophotic coral ecosystems may be less vulnerable to the most extreme ocean warming, but others may be just as vulnerable as their shallow counterparts and cannot be relied on to act as life boats.

The full report and UN media release will be available via UNEP/UNEA-2 as well as from the University of Sydney.