ETH zürich

NO. 2/2015

GLOBE

LIGHT

VISIBLE–INVISIBLE

From X-rays to microwaves

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FUNDAMENTAL AND VERSATILE

Lino Guzzella
President of ETH Zurich

The United Nations has declared 2015 to be the International Year of Light and Light-based Technologies, reminding us that light isn't just a basic necessity of life for humans, plants and animals – it is also an essential component of science and culture. At ETH, too, scientists make use of the entire spectrum of light in their research. Some are using infrared light to study how our universe began; some are increasing the capabilities of X-ray diagnostic techniques in medicine; still others are developing new optical technologies that make telecommunication not just faster, but also more powerful and more energy efficient. This issue of *Globe* showcases five examples of the wide-ranging research on light taking place at ETH. You can read about them in our special focus section on light starting on page 16.

A series of photographs placed throughout the Focus section bring the ETH main building into the spotlight, exploring various perspectives on this issue's central theme.

Further insights into light as a research topic will also be on display during the Scientifica 2015, which is taking place from 5–6 September. There, the University of Zurich and ETH will present selected research higlights to the general public.

I hope you will find this issue of ETH's *Globe* illuminating and I'm looking forward to meeting you at the Scientifica 2015!

Lino Guzzella
President of ETH Zurich

Globe, the magazine for ETH Zurich and ETH alumni.

ETH zürich

Cover image: Craftt / Editorial: Giulia Marthaler

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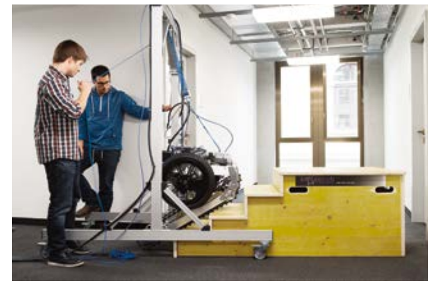

Up the steps in a wheelchair – page 38

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Picture credits: Marco Carocari; Annick Ramp; Daniel Winkler

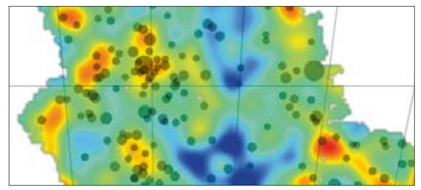
NEW AND NOTED

Bumblebee genome

FEW IMMUNE GENES

Research spearheaded by ETH has discovered the reasons behind bumblebees' sensitivity to environmental pollutants such as pesticides. To do this, they unlocked the genome of two agriculturally important bee varieties – and found that only around 150 out of the 20,000 total genes are actually involved in the immune response. Similarly, only a few genes regulating body detoxification were identified.

Unlocking the bumblebee genome



Galaxies (the grey spots here) tend to gather where dark matters is of a high density (yellow to red areas).

Dark matter distribution

NEW MAP

An international team including members from ETH has succeeded in mapping dark matter over the largest-ever contiguous region. While dark matter is invisible, its mass makes it possible to observe its gravitation. This feature also enables it to influence the paths of galaxies – and the distribution of light, which is why images of distant galaxies appear slightly distorted. This distortion gave the researchers an insight into how dark matter is distributed.

Extreme weather

CLIMATE CHANGE LOOMS LARGER

Extreme weather events are still rare, making any localised changes in their frequency very difficult to prove statistically. Collating data from every measuring station around the world, on the other hand, makes the picture much clearer. The period since the 1950s has charted a global trend towards more frequent and intense extremes of heat, and the number of stations experiencing a lean towards heavy precipitation is greater than those seeing the opposite.

Now, ETH Zurich climate scientists in Reto Knutti's team have looked at the proportion of all world extremes of heat and precipitation that are attributable to global warming. Their work has shown that it is spurring on more than half of global heat extremes and just under a fifth of extreme precipitation events today. It is not possible to pin any single event on global warming alone, but the man-made greenhouse effect is increasing the frequency with which extremes occur. Not only that, but the rarer and more extreme a heat or precipitation event, the more prominent the man-made contribution to it. As global warming grows, world extremes of heat and precipitation are set to become rapidly more frequent. At a temperature rise of 2 degrees Celsius, experts expect twice the number of extreme heat events compared with a rise of 1.5 degrees Celsius. Half a degree may seem a miniscule difference at first glance, but climate researchers are convinced that these figures – themselves the subject of climate negotiations – can make a huge impact on the frequency of extreme events.

Image sources: Sciencephoto; Vikram et al, 2015

NEW AND NOTED

Time lapse

THE ORIGINS OF SHANGRI-LA

The furthest south-east corner of the Tibetan highlands is home to dizzying peaks and rushing currents, but also high valleys with rolling hills and meandering rivers. It was these landscapes that inspired novelist James Hilton's mysterious fictional place Shangri-La. Less romantic are earth scientists' previous explanations of where the high valleys came from, which claim that the collision of tectonic plates and the resulting increase in the land's height were the causes.

Now, researchers working with ETH Professor Sean Willett have simulated the geological processes of the last 50 million years using a new model – and drawn a different conclusion. In their simulation, the north-easternmost corner of the Indian plate pushes against the Asian plate, deforming the Earth's surface. This cuts off river courses from their basins, resulting in less water flowing through them. Erosion slows down along their banks and the adjacent slopes, they become less steep – and high valleys with rolling hills are formed amidst the mountains over millions of years.

Earth Surface Dynamics:
→ www.esd.ethz.ch

Picture credits: © iStock.com/lolapi

ETH GLOBE 2/2015

Structural engineering

The way forward for hardwood construction

With its House of Natural Resources, ETH Zurich is blazing a trail in the field of sustainable building. This innovative structure is a showcase for the more intelligent use of hardwood in construction.

It's early June, and ETH Zurich's Hönggerberg campus is holding an inaugural ceremony for a new office building. A small annexe-like structure spanning two storeys, it's hardly a headline-maker. Or is it? Look closer and you'll see the House of Natural Resources – not just any office building, but a research laboratory for sustainable construction and the site where ETH Zurich is testing technologies and components that have never been put to use anywhere else.

Erected in a flash
At the heart of the new building is its skeleton support structure, which – unlike most timber constructions – is composed largely of hardwood rather than softwood. "Nowadays, hardwood is mainly found in interior design and furniture construction, or put to direct use in energy applications because it is inherently more difficult to process than softwood," explains Andrea Frangi, professor at the Institute of Structural Engineering and a driving force behind the project. Ecologically speaking, this is bad practice. Global warming has led to growing numbers of deciduous trees in Swiss forests, creating a pressing need to put their wood to better use. The CO_2 balance, too, stands to benefit from hardwood starting off in high-quality applications like timber construction, being recycled and then only being incinerated after retracing this route a few times.

The structure that is the subject of the ETH building's new experiment contains beams made from softwood and hardwood, as well as ash columns. The lack of supporting walls allows the floor plan to be rearranged as required, and each element was prefabricated to enable the support structure to be erected at the site in no time at all. Instead of screws connecting the elements to one another, there are prestressing tendons (cables) holding the beams together. Frangi is proud of what has been achieved: "It's a great example of how quickly timber buildings can be put up nowadays." Donning his researcher cap, he will now be interested to see how the prestressing force in the tendons changes over time. "Going by our model calculations, we shouldn't have to stress the tendons again at any point over the life of the building," he says. "But the data will tell whether that actually bears out in practice. We'll be measuring it using instruments we have permanently installed at the site."

Concrete and hardwood united
The building's other key innovation is the beech and concrete floor on the first storey. "Wood is excellent at absorbing tensile forces," explains Frangi. "But floors have a lot of static, fire protection and soundproofing requirements to contend with, so concrete floors are still a very common sight." In fact, the new structure at the House of Natural Resources benefits from both materials – and therefore the best of both worlds. Here too, Frangi is keen to find out whether the floor will behave as expected over time.

The new building is opening its doors to academics from other disciplines too, offering a proving ground for new forms of technology. One example is Professor of Architecture and Building Systems Arno Schlüter from the Department of Architecture, who is trialling a new type of adaptive solar façade on part of the building envelope. Consisting of modules made up of thin-film solar cells, the system also features pneumatically driven actuators that adapt the position of the cells in line with the location of the sun and the amount of heat and light the building requires. With this installation, Schlüter hopes to show how a building can incorporate systems that not only save and generate energy, but are also more effective at taking the needs of occupants into consideration.

Encouragement for the industry
It is now a matter of experiencing the new technology day by day to see whether it will stand the test of time. "We will be documenting exactly how satisfied users are with the building," explains Frangi. The novel approach has attracted wide attention, with the project receiving support from not only the Swiss National Science Foundation and the Swiss Commission for Technology and Innovation, but also the Swiss Federal Office for the Environment and the EU's Climate-KIC initiative. On Frangi's list of hopes is that the local wood-processing industry will benefit from the project too. "Timber construction has huge potential in Switzerland," he states. "It would be fantastic to see companies adopting our strategies in other projects." – Felix Würsten

House of Natural Resources:
→ www.honr.ethz.ch/en

1 Prestressed hardwood frame
The heart of the building is the prestressed hardwood frame forming the support structure for the floor systems on the upper two storeys. It consists of glued-laminated timber, with columns made from ash and beams from ash and spruce. Prestressing creates a semi-rigid connection that is able to centre itself and can even stand up to the kind of vibrations that would be experienced in an earthquake, for example.

2 Wood and concrete composite floor
The wood and concrete composite floor on the first storey consists of beech boards topped with a layer of concrete. In addition to absorbing tensile forces, the wood also provided a formwork element for the concrete. This meant that, unlike a conventional concrete floor, no additional expense was required. Notches were milled into the wood to create a strong mechanical connection.

3 Hardwood floor
The novel hardwood floor structure is installed on the second storey. The beech cross-laminated timber boards in the top section are connected by beech slats installed at right angles to one another. Unlike conventional timber floors, the new structure is therefore able to bear loads in two directions.

4 Monitoring
Numerous sensors will record how the building behaves over time. Sixteen load cells monitor the prestressing force in each stressed cable. Two optical measuring systems record strain in the timber frame, while additional sensors monitor the displacement between the beech boards and concrete in the composite floor. Even the system deformation and the moisture in the timber frame are recorded.

5 Façade
The building's façade is also a proving ground for new technology. Part of the building envelope features an adaptive solar façade that automatically regulates energy demand. The individual elements are equipped with drives controlled by compressed air. On the roof there are also solar modules, the positions of which are aligned by special wooden elements whose shape changes over the course of the day.

Picture credits: Marco Carocari; ETH Zurich

NEW AND NOTED
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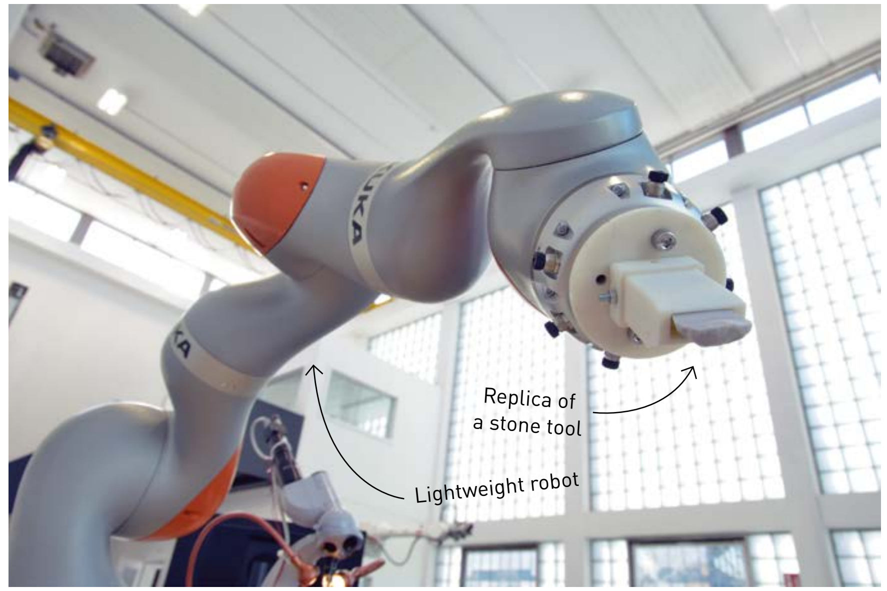


Archaeology

USING ROBOTS TO TRAVEL THROUGH TIME

ETH researchers have developed a robot system that, in future, will help archaeologists create databases of archaeologically relevant information on materials and the signs of wear and tear they show. The robot's abilities can be demonstrated by affixing a replica of a stone tool to its arm and having it rub this against a piece of leather. Automated analyses of the abrasion marks are produced, and under the microscope they provide an insight into how the tool would have been used.

Materials research

CREATING A SENSOR FROM TOBACCO PLANTS

Scientists working with ETH Professor Chiara Daraio have constructed a thermometer that is at least a hundred times more sensitive than its predecessors. The process involved manipulating temperature-sensitive tobacco plant cells in order to create a hybrid material containing not only the cells themselves, but synthetic components too.

The researchers experimented with tobacco cells in a cell culture environment, exploring how they can be transposed to a lifeless, dry material without losing their temperature-sensitive properties. The answer came when the scientists grew cells in a medium containing extremely small carbon tubes – electrically conductive nanotubes that formed a network between the tobacco cells and were able to penetrate their cell walls. When cells cultivated in this way are dried out, the result is a strong material akin to wood – leading the researchers to dub it "cyberwood". Unlike normal wood, the new material conducts electricity thanks to its nanotubes. Interestingly, this conductive property is both dependent on temperature and highly sensitive; the same as is found in living tobacco cells in cell cultures.

Even at a distance, the innovative sensors are able to detect the presence of warm objects – like a hand approaching them from a few dozen centimetres away. In this case, their level of conductivity would be dictated by exactly how far away the hand is. The researchers have now applied to have the sensor patented.

A researcher examines unripe coco de mer fruit.

Coco de mer

FIERCE COMPETITION

Found inside fruit weighing 18 kg, coco de mer seeds are the largest in the world. ETH Emeritus Professor of Plant Ecology Peter Edwards and his team have shown that competition is one of the factors that encourages the plant to produce increasingly large seeds. This approach makes the plant a more likely winner in the race to pass on its genes to the next generation – because a larger seed means a greater supply of nutrients for their potential offspring.

Picture credits: ETH Zurich; www.seychelles.ethz.ch

Immune system

VITAMIN E IN THE FIGHT AGAINST VIRUSES

For cold sore sufferers, a day of blazing sunshine has the potential to end in a breakout. The higher UV radiation levels release free radicals, putting the body under oxidative stress. This weakens the immune system and encourages herpes viruses to reproduce.

Now, ETH Zurich researchers have hit on a phenomenon that explains the impact of oxidative stress on immune cells. A study they conducted worked with laboratory animals whose immune cells were missing an enzyme responsible for repairing oxidative damage to the cell membrane. To their surprise, they were able to prevent cell death by mixing a high dose of vitamin E into the animals' food. Providing antioxidants at this level was enough to protect the membranes of certain immune cells against damage, enabling the cells to reproduce and successfully stave off the viral infection. The quantity of vitamin E added to the food was ten times higher than what is found in standard food.

The ETH scientists' work has shown that even a genetic defect in a key component of the body's antioxidant mechanisms can be offset by administering a high dose of vitamin E.

Geologists venture to the bottom of Lake Neuchâtel.

Lake Neuchâtel

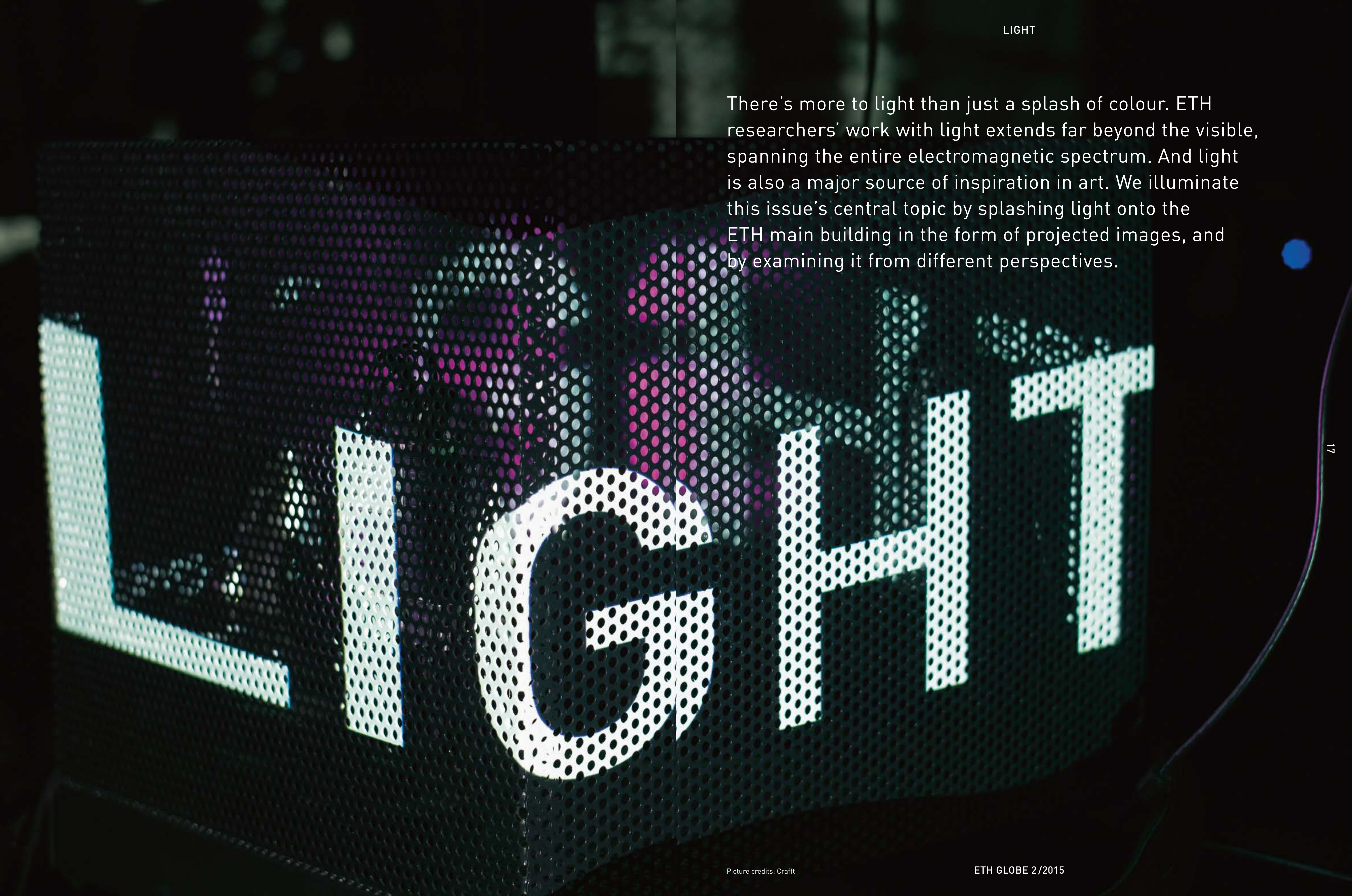
GIANT CRATERS ON A LAKE BED

A routine measurement-taking trip on a research vessel resulted in an extraordinary, unexpected find for ETH Zurich geologists: huge craters at the bottom of Lake Neuchâtel. The research team discovered four in total, all by the northwest shore and more than 100 metres down. The craters measure between 80 and 160 metres in diameter and are 5.5 to 30 metres deep – making them some of the world's largest underwater craters found in any inland lakes.

At the bottom of the largest crater, the researchers have created a mud covering over a vent that measures 60 metres in depth and is filled with a thick suspension of water and sediment. Among the results that the ETH scientists' measurements have revealed is that the crater suspension is a few degrees Celsius warmer than the sediment surrounding the crater – a clear sign that the two bodies of water have different properties and that the craters' origins lie in giant sources of water, rather than phenomena like volcanic activity. The likeliest explanation, the earth scientists believe, is that the craters are linked to the karst systems of the neighbouring Jura Mountains. The water that seeps into the ground here flows below ground and under Lake Neuchâtel's bed, seeking out the path of least resistance to the surface. In doing so, it penetrates the several metres of sediment layers that have been deposited on the lake bed over millennia.

Sediment Dynamics Group:
→ www.sedimentdynamics.ethz.ch

Picture credits: Anna Reusch/ETH Zurich



There's more to light than just a splash of colour. ETH researchers' work with light extends far beyond the visible, spanning the entire electromagnetic spectrum. And light is also a major source of inspiration in art. We illuminate this issue's central topic by splashing light onto the ETH main building in the form of projected images, and by examining it from different perspectives.

Picture credits: Crafft

Renaissance of X-rays

ETH Professor Marco Stampanoni played a major role in advancing X-ray microscopy. Now, scientists can even shoot three-dimensional and extremely high-resolution films.

TEXT Fabio Bergamin

These film images drew worldwide attention: powerful muscles hidden within the thorax of a fly, which flex and relax 120 times a second – magnified using a microscope and displayed in incredible detail. By way of joints that are among the most complex in the natural world, these muscles power the insect's wings. The films also show additional tiny steering muscles, which precisely control each wingbeat to determine the direction of the fly's flight. These three-dimensional, extremely high-resolution moving pictures of the bluebottle's flight apparatus are the results of a collaboration between Marco Stampanoni, professor at ETH Zurich and group head at the Paul Scherrer Institute (PSI) in Villigen, and research colleagues at Imperial College London and the University of Oxford. Stampanoni counts this as one of his personal research highlights of the past year.

3D movies with a resolution of just a few micrometres are an excellent example of what researchers can achieve with X-rays today, 120 years after they were discovered by Wilhelm Conrad Röntgen. They still bear his name in German: Röntgenstrahlung, or "Röntgen rays." Stampanoni belongs to a group of scientists that have made definitive strides over the past few years in advancing X-ray microscopy. Today, the 41-year-old native of Ticino spends most of his working hours at the Swiss Light Source (SLS) at PSI – where he can produce high-resolution 3D images of the interior of essentially anything he is putting under his microscope.

The SLS produces extremely intense light known as synchrotron radiation, which makes it possible to take such precise measurements – and even film footage – of moving objects like blow-flies. "A very intense X-ray radiation strikes the object under study each second," explains the ETH professor, "and this allows us to take measurements with extremely short exposures. All we need is a few milliseconds for a high-resolution image."

Generating the synchrotron radiation requires a large-scale facility like the SLS. "This radiation is also produced by CERN's Large Hadron Collider (LHC) in Geneva, for example, but there it's an unused by-product, since the LHC was built for a different purpose," Stampanoni explains, adding: "The SLS, by contrast, was built specifically to use synchrotron radiation."

Although the synchrotron radiation is highly intense, it is invisible to the human eye – it lies in the same part of the spectrum as X-rays and short-wave UV radiation. The reasons why scientists call this radiation "light", and consequently why SLS stands for "Swiss Light Source", are historical but also physical. One is that X-rays "shine through" objects. Another is that electromagnetic radiation is essentially the same across the entire spectrum – from gamma rays to X-rays, visible light to microwaves and radio waves. All these types of radiation differ only in wavelength.

MARCO STAMPANONI
Marco Stampanoni is a professor of X-ray imaging. He heads the X-ray imaging and microscopy division at the Institute for Biomedical Engineering of ETH Zurich and the University of Zurich. He also leads the X-ray tomography group at the Swiss Light Source of the Paul Scherrer Institute.

Conventional X-rays taken further

In addition to their intensity, the X-rays produced at the synchrotron light source offer another advantage: they are coherent, meaning they consist of waves with a constant phase difference. This coherence is a crucial requirement for what's known as phase-contrast X-ray imaging, a refinement to conventional X-rays that is currently the subject of intense research. Phase-contrast X-rays can provide an even more detailed view of the interior of the object under study. This is another area where Stampanoni focuses his research.

In conventional absorption imaging, X-rays are directed at an object and a measurement is taken of how many penetrate through to the other side. Bones, for example, significantly absorb X-rays, whereas soft tissues allow them through. If structures inside an object absorb X-rays to a much greater or lesser degree than their surroundings, conventional X-ray techniques can make them visible.

Phase-contrast sensitive devices, in addition to the conventioal absorption signal, detect whether X-rays are slightly deflected in the object's interior as a result of scattering and refraction phenomena. "We can use that to generate very sharp, high-contrast images and map structures in the tissue that would be blurred or even invisible using conventional X-ray technology," Stampanoni explains.

Possible use in mammography

Until recently, scientists who wanted to work with coherent radiation that is so essential for phase-contrast imaging had to rely on large-scale synchrotron research facilities. Researchers at PSI, however, managed a few years ago to use conventional X-ray tubes like those found in doctor's surgeries and hospitals for the same purpose, even though they produce incoherent radiation. To do this, the scientists use a trick involving a series of specially made gratings with extremely thin slits arranged in parallel. The first micrograting, made of gold and placed between the X-ray tube and the test object, makes the X-rays coherent. A second grating made of silicon splits the electromagnetic waves into multiple overlapping waves. A third micrograting, again made of gold, helps the scientists to determine changes in the resulting superposition pattern, which they use to calculate how much the radiation was absorbed, refracted and scattered.

"This technique looks promising as a way to improve the early detection of breast ›

"We can map structures that would appear blurry on a conventional X-ray image."

MARCO STAMPANONI

SWISS LIGHT SOURCE
The SLS is a large-scale research facility at the Paul Scherrer Institute. Researchers at the Institute plus those from around the world use the synchrotron radiation produced by the SLS for their experiments. The core of the SLS is a particle accelerator 90 metres in diameter, situated in an impressive circular hall. Electrons race around the accelerator at nearly the speed of light. Synchrotron radiation is produced when these electrons are deflected, a process that uses magnets placed at regular intervals.


Tunnel that houses the electron beam

Picture credits: Giulia Marthaler

Picture credits: PSI

cancer in mammography," Stampanoni says. Preliminary tests on resected breast tissue samples indicate that the technique might be used to distinguish different types of microcalcifications in the female breast – a feat that was impossible with conventional X-rays. These microcalcifications are an indication of an early-stage tumour, which is why the technique could help doctors to better detect malignant breast lesions in the future using non-invasive methods. Stampanoni names this as another highlight of his research last year: "It's a very good example of how we can take knowledge derived from fundamental research at a large-scale facility and make it available to everyone."

So far, Stampanoni and his group have been working with a prototype that's not yet suitable for clinical work, and they have been testing samples of breast tissue, not actual patients. "However, our next step is to develop a device that can be used in a clinical setting. We would also then be able to use it for conducting initial clinical trials," says Stampanoni.

Detecting plastic explosives

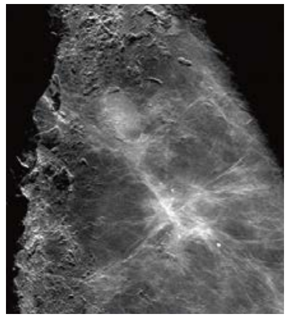
Phase-contrast imaging could be used in further applications one day, such as for improved baggage scanning in airports. Today's scanners can't really tell the difference between, say, plastic explosives and cheese, since both absorb X-rays to a similar degree. Yet they have different scattering and refractive properties, so phase-contrast X-ray imaging would confer distinct benefits.

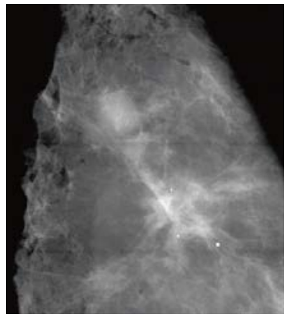
Meanwhile, Stampanoni is hard at work on his next microscopy projects. One aims at using a non-invasive approach to create a 3D map of the brain of a mouse, including even the tiniest of blood vessels, with an unprecedented resolution of less than one micrometre. In comparison, today's conventional computed tomography in a hospital generates brain images at a resolution that is about one thousand times lower. A major challenge in this project will be to handle the huge amount of data that will be generated and also to interrogate such data appropriately to extract the desired information. Another project in the pipeline is to examine the lungs of a living, breathing mouse under the X-ray microscope, right down to the smallest alveoli. The speed of the SLS microscope makes it particularly suitable for observing the motion of the lungs.

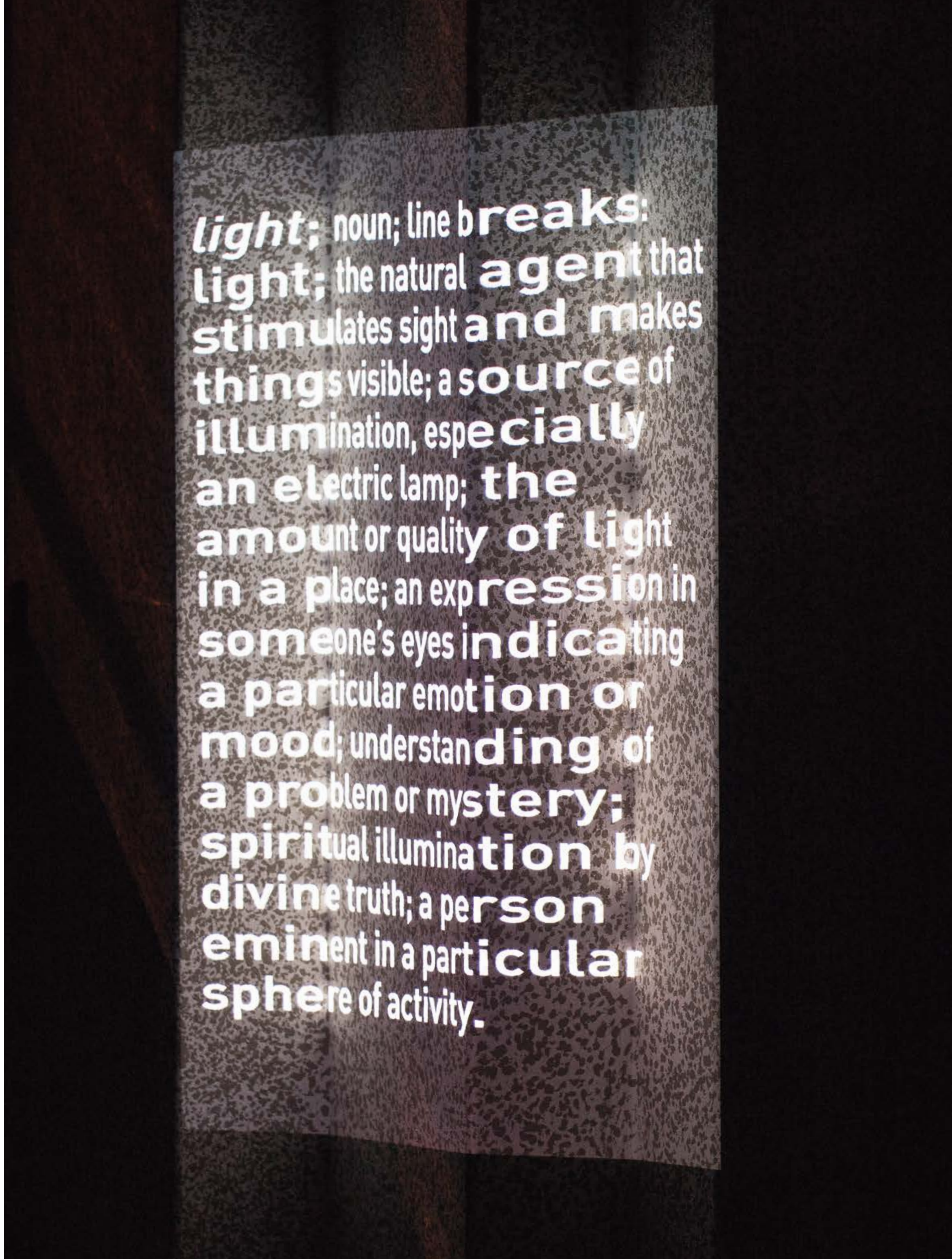
According to Stampanoni, "The time is ripe for making advances like these, since X-rays are currently experiencing something of a renaissance." Phase-contrast imaging has made such huge strides over the past few years that it is now becoming an attractive technology for medical diagnostics. Anyone wishing to generate a comparable high-resolution, 3D image of the insides of a bluebottle ten years ago would have had to take measurements over several hours, Stampanoni says. A film sequence of ten 3D images per second would have been completely unthinkable. ○

Division of X-ray Imaging and Microscopy:
→ www.biomed.ee.ethz.ch/research/x-ray_imaging

PHASE-CONTRAST IMPROVES MAMMOGRAPHY
Phase-contrast X-ray imaging (top) provides clearer, crisper images than conventional mammography (bottom). It also makes the extensions of a tumour (bright areas) much easier to spot.







Picture credits: PSI / KS Baden; Crafft

Exciting molecules

Chemist Frédéric Merkt uses UV light to illuminate the hidden world of molecules.

TEXT Corinne Hodel

"Light is the key to many processes in chemistry and molecular physics," says Frédéric Merkt, professor of physical chemistry. He uses laser light to study the structures of molecules and the dynamics of chemical processes. When the molecules under study are exposed to light, they usually absorb some of it. That absorption triggers further processes that Merkt and his group measure. The resulting spectra are unique and specific to the molecules studied.

Merkt and his group obtain these spectra using radiation in the far ultraviolet range, with a wavelength under 200 nanometres. They use short-wavelength radiation in their experiments because it acts on the electrons of the molecules and transfers them from their ground state to highly excited states. In order to keep the UV radiation from being absorbed by the surrounding air, this radiation has to be generated in vacuum chambers where it also interacts with beams of the molecules they study. The researchers have to build their UV laser sources and their spectrometers themselves because they are not commercially available. On Merkt's desk is a molecular spectrum stretching over several pages that have been attached together. His research group has just recorded the UV spectrum of the He_2 molecule, and he's thrilled: "Helium is a noble gas, which means it isn't normally found in molecules." The researchers excited the He_2 molecule with UV light to increasingly higher energy levels. As a result, one electron moved farther and farther away from the positively charged core of the molecule. "The electron shell can expand to sizes of up to several micrometres, which is larger than unicellular organisms," explains Merkt. When the scientists extrapolate this process, they can also study the positively charged He_2^+ ion. This ion is supposed to have been one of the first molecules created in the universe, but thus far no one has really managed to characterise it in the lab. "This spectrum has enabled us to discover extremely precise information about He_2^+ for the first time," says Merkt. "It also helps us gaining a better understanding of how an excited electron behaves in a molecule such as He_2."

FRÉDÉRIC MERKT
Frédéric Merkt received his degree in Chemistry from ETH Zurich and his PhD in 1992 from the University of Cambridge (UK). After completing post-doctoral work in Orsay and at Stanford and Oxford, he was appointed assistant professor at ETH Zurich in 1995. Since 1999, he has been a full professor at the Physical Chemistry Laboratory.

To make such measurements possible in the first place, the researchers had to use a trick. Since light particles such as He_2 typically move at speeds of several hundred metres per second, they fly through the light beam too quickly for precise measurements. "We had to find a way to slow down the molecules," says Merkt. Using very strong pulsed magnetic fields, the researchers are able to bring the molecules almost to a standstill – which means the molecules spend more time in the light beam and can be measured more accurately. This method was first developed at ETH and is now applied in laboratories around the world.

Enthusiasm and reward

Over the years Merkt has received multiple national and international honours for his outstanding fundamental research, most recently the Otto Bayer Award in 2014.

"It is wonderful to wake up in the morning with the prospect of shedding light on the unknown," says Merkt. "My group is driven by curiosity, and the technical challenges we have to overcome constantly stimulate new ideas." It is the combination of precise observations with the dedication to answering the questions these observations raise that has brought Merkt and his group such success. His findings have great significance for his field, "but the main benefit for society are the well-educated and creative scientists who later take on positions in research or industry," Merkt emphasises. Having the privilege to accompany his students and coworkers in their professional development makes him as happy as discovering a new spectrum. ○

Molecular Physics and Spectroscopy Group:
→ www.xuv.ethz.ch

Picture credits: Crafft; Giulia Marthaler

Lightning-fast communications

Light is a medium that allows for efficient data transmission at the highest data rates. Jürg Leuthold, head of the Institute of Electromagnetic Fields, explains how researchers continue pushing the boundaries of the possible.

INTERVIEW Martina Märki

In his laboratory, Jürg Leuthold works with the "fastest light switches in the world".

"Home users will soon be surfing at 10 Gbit/s," says Jürg Leuthold.

I remember as children we used to play in the dark, flashing our torches to send each other messages in Morse code. How do things stand now?
Actually, this operation principle has uniquely been used until recently. Up to the year 2005, optical communication technology operated on basically that principle: if the signal – that is to say, light – is present, then that corresponds to a value of "one"; otherwise, the signal or light is absent, corresponding to a value of "zero". The only thing that really changed prior to 2005 was the switching speed, which got faster and faster.

Am I right in thinking that the use of fibre optic cables was an important step en route to ever-higher data transmission speeds?
Absolutely. Instead of sending electrons down copper cables the old-fashioned way, we now drive photons – tiny particles of light – through fibre optic cables. This makes it possible to transmit much more information per unit of time. It was in 1996 that a data rate of one terabit per second was achieved for the very first time using the familiar light on and off technique. That means switching a trillion, or 10^{12} times a second. This represented a real breakthrough.

But there was still plenty more to come, wasn't there?
In 2001, specialist magazine *Nature* published an important theoretical paper addressing the maximum possible transmission capacity of fibre optic cables. The paper suggested that the maximum possible transmission capacity of a fiber optic cable should be around 100 terabits per second. However, this was reckoned unachievable in practice. It was estimated that the best possible data transmission rate would be around 10 terabits per second. However, that very year, we realised that, in optics too, it was possible to encode light signals in a new way. Prior to 2001, we had access only to the signal intensity – i.e. the light was on or the light was off. Now, we had new components that allowed for improved encoding – or phase encoding as we call it.

What exactly do you mean by that?
Light is a wave. A wave's phase indicates at what point in time the wave's peak and its valley are transmitted. That means that for a given wave you could either transmit the peak first and then the valley, or vice versa. That in itself is information. The difficulty is that the light waves we are talking about oscillate some 200 trillion times a second. To identify the absolute phase of such a waveform is something that many at the time viewed as impossible. >

Picture credits: Marvin Zilm; Crafft

What was your part in this development?
At the time, I was working at Bell Labs in the US. A colleague of mine and I were fortunate in that we weren't familiar with the theories surrounding the presumed impossibility of phase coding in optical fiber communications. We happened to work on the idea of measuring not the absolute phase but rather the relative phase from one bit to the next. This is much easier to do. The encoding technique is known as differential phase-shift keying. I built a special receiver for the purpose.

And your plan worked?
It allowed us to beat the then world record in data transmission by a factor of two straight off the bat. Since 2005, we've seen the first networks to feature differential phase-shift keying entering service. Since then, the big network operators have increasingly been turning to phase encoded signals to transmit data – and it looks like the "light on-light off" era is drawing to a close. About four years ago, we reached a data transmission rate of 100 terabits per second in a single fibre optic cable for the first time. Not only have we achieved what was considered theoretically possible but practically beyond reach ten years ago – by now we've even exceeded that benchmark.

How does that help me as a private user?
Think back 15 years – at this time you were lucky to get 128 kilobits a second from your desktop computer. These days, you can easily get a gigabit per second with a fibre optic connection. Private users today have around 10,000 times the bandwidth they had 15 years ago. Now imagine the same thing happening in a different context: how about asking car companies to make their cars 10,000 times faster or 10,000 times more energy efficient.

What are you working on at the moment?
In communications technology, we start off with electrical signals. To be used in optical communications, these need to be converted into an optical laser signal. This is where modulators come in, converting the electrical signal into an optical one. Standard optical telecommunications modulators are about 10 centimetres long and 2 centimetres wide. They work at speeds of up to 40 gigabits a second and consume five picojoules of energy per bit encoded. That may not sound like much, but when you repeat the operation 40 billion times a second it quickly adds up – especially when you have up to a thousand modulators in a single room. What we've done is develop new modulators, reducing their size to a millimetre or even less. The latest generation of modulators are just a few micrometers in length and operate twice as fast with way less power consumption.

How did you manage to make the modulators so small and energy efficient while delivering such performance?
We no longer work so much with light as with plasmons. The only time the information is in the form of a light signal is in the fiber optic cable itself. As soon as the signal arrives on the chip, we convert it into a plasmon. Plasmons are oscillations of electrons at the frequency of optical light signals. It's much easier to manipulate plasmons than light because you're dealing with electrons, not photons. These plasmons are switched, then converted back into an optical signal a fraction of a picosecond later and fed into the fibre optic cable, now carrying information.

What's the advantage of this miniaturisation?
It now seems conceivable that we could combine optics and electronics on the same chip. Before, this was out of the question because of the discrepancy in the size of the components involved. Generally speaking, high-performance optic components are still comparatively large. A terabit transmitter, for instance, takes up a lot of room. If we wanted to house 1,000 of them in a central data exchange, we would need an entire building. And with all the additional components involved, energy consumption would simply be too high. That's why it's so important we work on miniaturising the components.

The bulk of data traffic seems to be transferring to mobile communications. How can your research help in this context?
It will take new approaches in the mobile communications sector, too, to deal with the huge amount of data that customers will demand in future. Similar to optics, where we have very high frequencies, mobile communications will soon have to move to higher frequencies. More precisely, mobile communications will soon be moving from conventional microwaves to waves that oscillate around 100 to 1,000 times faster. Experts envision that a new era – the terahertz area – will start. And of course we want to be right at the forefront. ○

TINY BUT EFFICIENT
New modulators to convert electrical signals into optical ones: conventional modulators are 10 centimetres in size and encode 40 gigabits per second. The new generation of modulators developed by Jürg Leuthold and his team measure a few micrometers and operate at higher speeds with lower power consumption.

Picture credits: Antal Thoma

Planet-hunting

ETH astrophysicist Michael Meyer has a big dream: to obtain an image of an Earth-like planet. But his wait is not over yet.

TEXT Felix Würsten

Ask Michael Meyer about his hopes and dreams, and you can't miss the passion he brings to his research. The astronomy professor is firm in his mission: "In a few years' time we'll have a whole new generation of telescopes to work with, and I'm convinced they will help us to take the first direct images of an Earth-like planet." What he is also seeking are answers to an extensive list of questions he has compiled: How common are planets on which life could exist? What do these celestial bodies look like? How are they created?

Meyer is in for a little more waiting before he gets all his answers, however: there are still another nine or so years to go before the opening of a research facility involving the European Extremely Large Telescope, which will search for direct evidence of Earth-like planets. A successor to the Very Large Telescope at the European Southern Observatory in Chile, and featuring a mirror diameter of 39 metres, it is set to be the world's largest telescope and will produce images at a previously unmatched level of resolution. Ultimately, the telescope should yield direct evidence of not only planets that are on a massive, Jupiter-like scale, but smaller celestial bodies, too. In other words, planets which have a similar size and, potentially, a similar chemical make-up to Earth – and which could be sustaining life. The presence of molecular oxygen in the atmosphere of planets like these could be an indication of extraterrestrial life. "Here on Earth, plants are the only reason molecular oxygen exists in the atmosphere," explains Meyer. "It's a highly chemically reactive element, so it would dissipate quickly without them."

Two kinds of light

For the moment, Meyer has to settle for images produced by existing telescopes, although these still provide ample fuel for his research. Recently, a new camera was put into operation at the Very Large Telescope. Meyer's research group was heavily involved in its construction, and it is now delivering spectacular image data. "It's just amazing what this instrument is showing us," he enthuses. "These new images have helped us discover two new planets on a Jupiter-like scale."

Meyer's group uses two kinds of light in its hunt for planets. The scientists working with Hans Martin Schmid, a titular professor in the group, focus on evaluating visible light reflecting from planets. Meyer and his team, on the other hand, specialise in the infrared range. Infrared light has a longer wavelength than visible light, plus two key attributes that make it particularly interesting to astronomers. Firstly, it can be used to identify cold objects because the spectrum of light waves emitted shifts further towards the infrared range the colder an object is. Secondly, the infrared range reveals more objects because cosmic dust between the Earth and the object being observed scatters visible light, but less so infrared light. ›

MICHAEL MEYER
Michael Meyer is a professor of astronomy in the Department of Physics. His research considers how stars and planets are created, and which celestial bodies could support life. The most important tool helping him to answer these questions is infrared light, and he also uses equipment such as cameras that he and his group have developed themselves.

Picture credits: Giulia Marthaler

While his fellow professors at the Institute for Astronomy are concerned with the way in which galaxies come into being, as well as black holes and dark matter, Meyer's work is entirely focused on the origins of stars and planets. "By comparison, the objects we're looking at are pretty small," he says. "That's why we're also restricting our investigations to an area relatively close to Earth. All the images we take come from our own galaxy, the Milky Way."

How to recognise a planet?
Meyer is particularly intrigued by what exactly makes a planet different from a brown dwarf – a bone of contention in expert circles, even when it comes to setting definitions. Many astronomers distinguish brown dwarfs from planets on the basis of their mass: this approach holds that an object can be classified as a brown dwarf if its mass is at least 13 times that of Jupiter. This is the point at which deuterium is able to fuse into helium inside the object.

Meyer is brief in his dismissal of this theory, however: "This limit is something we have decided on. It's not something celestial bodies pay attention to." Instead, he is making the case for brown dwarfs and planets to be distinguished on the basis of their genesis. "A brown dwarf is formed like a star when the pull of gravity compresses a gas and dust cloud into a large object," he explains. "Planets are created through a totally different process, however. When a new star arises, a disk of dust forms around it; in this, particles cluster gradually until they create larger objects that ultimately grow to the size of planets."

Meyer knows that identifying how a small object was formed is no mean feat. He remains convinced, however, that brown dwarfs and planets can be differentiated in this way. As part of PlanetS – one of the latest additions to Switzerland's National Centres of Competence in Research and an initiative that involves ETH academics as well as planetary scientists from the Universities of Bern, Geneva, Zurich and EPFL – he is embarking on a project that will pay close scrutiny to processes taking place in the disks of dust surrounding stars. "These disks are often distributed as concentric circles with different levels of density. Planets are located in the ones that are less dense, because the planets captured the material in these areas," he says.

Slow and steady Europe wins the race
Together with his group, Meyer is participating in a range of international projects. In addition to the European Extremely Large Telescope, Meyer was also involved in the early planning of the James Webb Space Telescope, the Hubble Telescope successor that is to be launched into an orbit close to Earth in 2018 and will record images in the infrared range.

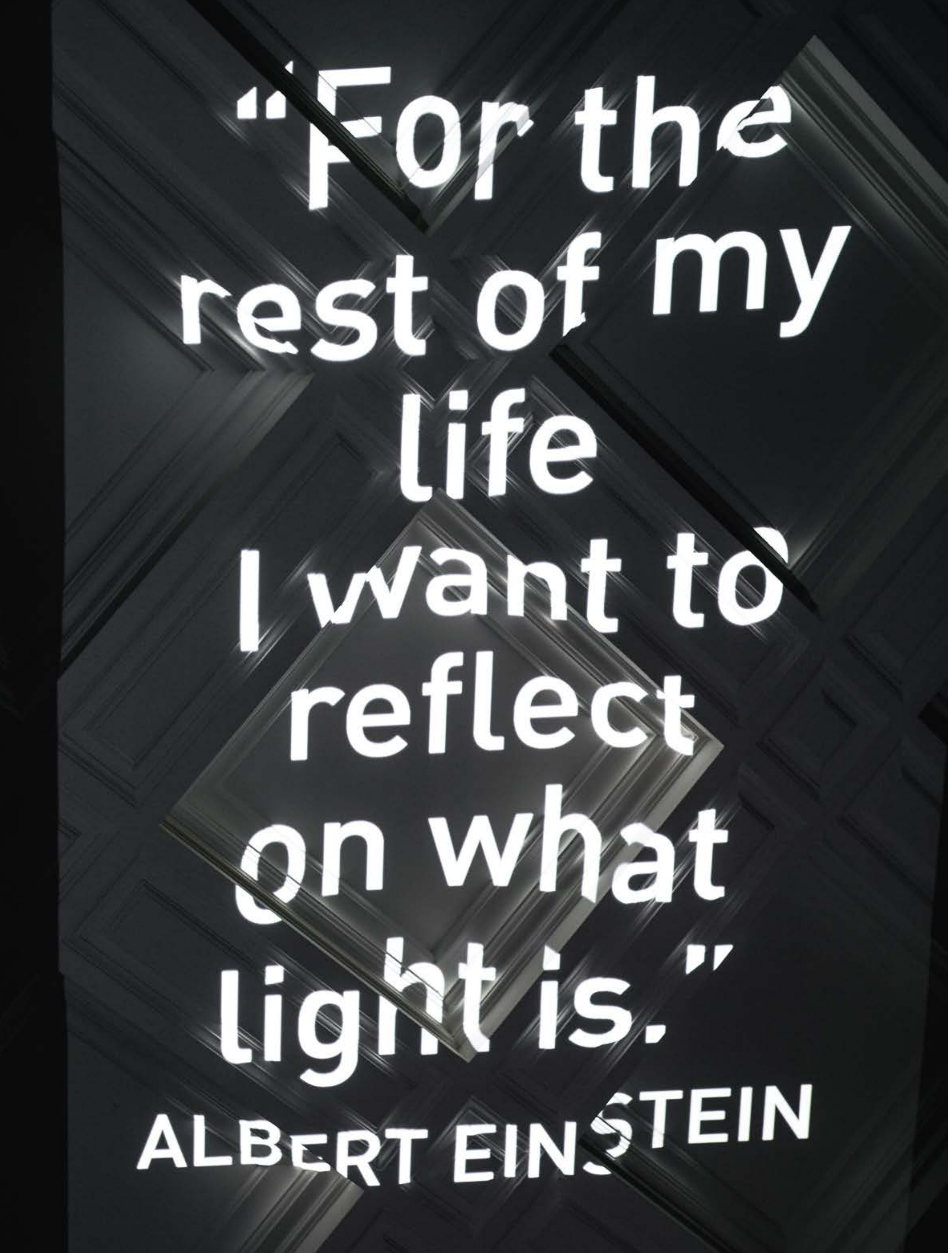
Meyer is not just playing the role of astronomer in these large-scale projects: he is acting as a developer of measuring instruments too. "It's much better if we, as a research group, develop a piece of equipment like an infrared camera for a telescope ourselves. Not only do we gain a better understanding of how the instrument works – something that's useful when it comes to analysing data – but as developers we're also given a certain amount of guaranteed time to use the telescope for our own research, without having to submit any applications."

The academic admits that participating in European projects on such a large scale is highly labour-intensive. "If you want to get your project off the ground, there is a lot of convincing to do among groups of experts and political bodies," he explains. Meyer also developed measuring instruments himself back when he was working as a researcher in the US – but found a vastly different approach on those shores. "If everything went exactly to plan, it was possible to get a new camera onto the telescope within one year. The whole process is much slower in Europe." As he explains, however, this quick-fire American approach was not without its pitfalls, and he remembers many instances where instruments had not been properly thought through. "Twenty years ago, the US had the upper hand in the approach it was taking. But today we're dealing with much more complicated telescopes, and the European process lends itself better to that." ○

The Star and Planet Formation Research Group:
→ www.astro.ethz.ch/meyer

EUROPEAN EXTREMELY LARGE TELESCOPE
The European Southern Observatory developed the initial concept for constructing a new, extremely large telescope back in 2005, and its work is now set to come to fruition by the middle of the next decade. The European Extremely Large Telescope (or E-ELT for short) will begin operating in Chile. Featuring a main mirror measuring 39 metres in diameter, it will be the world's largest telescope for visible light and the infrared range. Not only will the E-ELT be extremely powerful, capturing 13 times more light than the largest telescope currently in existence, but it will also deliver exceptionally sharp images, with an anticipated resolution that is 16 times higher than those taken by the Hubble Space Telescope. Research in the field of astrophysics is set to make huge strides with the E-ELT. It is hoped that it will not only provide the first images of an Earth-like planet, but also contribute to cosmology studies by investigating the properties of the first stars and galaxies as well as dark matter and dark energy.

Picture credits: ESO/L. Calçada; Crafft



Measuring forests with radar

To find out more about the Earth's biomass, Irena Hajnsek is collecting data from the air.

TEXT Roland Baumann

Irena Hajnsek has recently returned from Africa – Gabon, to be exact – where the professor of Earth observation and remote sensing was looking into airport usage charges and permits for transmitting signals. In February 2016, she hopes to return to this central African country as part of a team expedition, flying into the jungle with the other researchers and using airborne radar provided by the German Aerospace Center to collect data that they can use to calculate forest biomass.

"Our aim is to find out more about the properties that are specific to the tropical rainforest in Africa, gain some experience with the sensors and test out the algorithms that we use to calculate biomass," explains Hajnsek. This particular expedition, however, marks just one step in a much larger mission known as Biomass. Set up by the European Space Agency (ESA), its goal for 2020 is to launch a space satellite that will then record data from the world's forests once a year. "Climate research really needs to know more about terrestrial biomass – forests account for roughly 50% of the carbon held in terrestrial plants" says Hajnsek, who will be acting as scientific director of the upcoming airborne survey. "And CO_2 trading certifications are another area where it's vital to have accurate information about terrestrial biomass and how it changes over time."

So how exactly do you measure a forest? The 45-year-old expert explains: "First, we transmit electromagnetic signals from an aircraft or a satellite to Earth. These hit different types of structures, sending a range of different signal strengths bouncing back to us." She uses the strength and path length of the received signal to calculate height-related data – how tall a treetop is, for instance. "If we want to calculate the mass of the forest, however, we also need information on how high the forest floor is. That requires electromagnetic waves that can penetrate through the forest all the way to the ground," continues Hajnsek, who is also involved in two satellite missions as scientific coordinator.

IRENA HAJNSEK
Irena Hajnsek has been associate professor of Earth observation and remote sensing at ETH Zurich's Institute of Environmental Engineering since 2009. In 2002, she also took up a position as head of the Polarimetric SAR Interferometry (Pol-In-SAR) research group at the German Aerospace Center.

The last mission commenced in 2012 and was given the name TanDEM-X in reference to several aspects: the two satellites working as a pair, the digital elevation measurement or DEM for short, and the three-centimetre radar wavelength represented by X for X band. Researchers are using the data to generate a global, digital terrain model that is accurate down to the metre. It's an achievement Hajnsek is very proud of: "This kind of unified height model that covers the entire globe is a real first. Scientists across the world can use it to do things like create map data. It will also provide a springboard for several other areas worth exploring."

Despite their other uses, X band wavelengths are too short to penetrate dense forest and hit the ground: "This is where the 23-centimetre L band and the 80-centimetre P band come in." Germany has already proposed the idea of launching a new satellite mission using longer wavelength Tandem-L, something the Japan Aerospace Exploration Agency is also keen to participate in, and which would also involve measuring biomass – albeit several times a year in order to look at the effects of the changing seasons. It is another project in which Hajnsek has a stake, although she states that it has not yet secured the funding it needs.

Returning to the Biomass project, the ESA has decided that its next step should be to take measurements from space using a P-band system – another first. This will require an initial round of testing. "We've already explored typically northern boreal forests in Sweden, and temperate forests in Germany," says Hajnsek. "What we're now missing is information about tropical forests. That means highly dense tropical rainforests, mangrove forests and savannah forests." This is exactly what she is going to measure early next year in Gabon. ○

Chair of Earth Observation and Remote Sensing at ETH Zurich:
→ www.ifu.ethz.ch/EO/index_EN

Picture credits: Giulia Marthaler

Plans for Dübendorf's Innovation Park are coming together, and the project is soon ready for take-off.

Dübendorf Innovation Park

SOON READY FOR TAKE-OFF

After last autumn's approval by the Swiss Federal Council, Dübendorf air base is on course to provide the 70 hectares required for Zurich Innovation Park. Part of the national Swiss Innovation Park, the site will afford established companies the opportunity to fuse their research and development activities with those of ETH Zurich, the University of Zurich and the country's network of Universities of Applied Sciences.

In early March, the Federal Council took a step further in creating the framework for the Innovation Park by submitting for Parliament's approval the design concept and support measures developed in recent months. These include a temporary framework credit to act as surety and the ability to release federal land to the Canton of Zurich with planning permission. Another event at the start of March was the founding of the Swiss Innovation Park Foundation, something that also involves the Canton of Zurich and has laid the foundation for getting the Swiss Innovation Park up and running.

The Innovation Park project is feeling the momentum of the canton's efforts too. Zurich's Commission for Energy, Transport and the Environment is recommending that the Cantonal Council accept the partial revision of the cantonal structure plan, which will impose the basic conditions that the Innovation Park needs to get off the ground, in a way that authorities are expected to adhere to.

New Vice-Rector Paolo Ermanni

Executive Board

NEW VICE-RECTOR

ETH now has four vice-rectors thanks to the Executive Board's appointment of Professor of Structure Technologies Paolo Ermanni as the new Vice-Rector for Continuing Education. A Ticino native and Director of the Congressi Stefano Franscini, he takes up his post alongside Vice-Rector for Study Programmes Joachim Buhmann, Vice-Rector for Doctoral Studies Thomas Vogel and Vice- Rector for Curriculum Development Andreas Vaterlaus.

Architecture

FRONT AND CENTRE

The Shenzhen Bi-City Biennale of Urbanism/Architecture is the most significant biennale with a focus on urban development and architecture. This year's exhibition, due to open on 4 December 2015 in the Chinese cities of Shenzhen and Hong Kong, will explore the theme of Re-living the City. Among this year's four curators are Alfredo Brillembourg and Hubert Klumpner, two Professors of Architecture and Urban Design, bringing ETH Zurich front and centre on an illustrious stage.

Image/Picture credits: Canton of Zurich; Giulia Marthaler

10 years of D-MTEC

Where technology meets business

The Department of Management, Technology and Economics (D-MTEC) is celebrating its tenth anniversary. Head of Department Gudela Grote looks back at its history, and considers what the future holds.

INTERVIEW Adrian Ritter

Gudela Grote, what will you be celebrating on the occasion of D-MTEC's tenth anniversary?
Our department carries out research and provides education at the interface of technology and business with a focus on major societal topics – such as the best ways to promote innovation in individuals and organisations, choices among energy sources that we should rely on in the future, and offsetting the risks associated with complex systems such as healthcare. One thing we are always concerned about in our research is the sustainable use of both natural and human resources.

The scientific community holds our work in high regard, as reflected in our position in various rankings. We are attractive cooperation partners for companies and public institutions. We are educating future decision-makers to understand the interplay of technology, organisations, and society, which renders them highly sought-after candidates on the job market. All this is worth celebrating.

What led to the department being founded?
The immediate predecessor of D-MTEC was the Department of Industrial Management and Manufacturing. But D-MTEC's roots can be traced all the way back to the 1920s. At that time, ETH had set up an Institute of Industrial Engineering and Management whose main purpose was to give

Gudela Grote is a professor of work and organisational psychology, and has been head of the Department of Management, Technology and Economics since August 2014.

Picture Credits: Craftt

ETH engineers the knowledge and skills needed for managing large-scale production systems.

When D-MTEC was founded, it integrated teaching and research in economics and management in a single department, and expanded significantly into domains such as innovation economics, strategic management and technology marketing. The renowned KOF Swiss Economic Institute also belongs to D-MTEC. Today we have 23 Chairs, putting us in a position to offer a top-class, well-rounded education and operate at the very pinnacle of research.

Is today's D-MTEC one of a kind?
Our focus on technology distinguishes us from business schools and economics faculties at universities. We are unique in Europe. Stanford University has a similar department, the Department of Management Science and Engineering.

D-MTEC offers courses open to all students of ETH Zurich. It also offers a master's programme and two programmes in further education; an MAS in Management, Technology and Economics and an Executive MBA SCM.

Who should study at D-MTEC?
The master's programme is for those students who have completed a bachelor's degree and find that they would like to pursue a career as an engineer or scientist at the interface of management and economics. The MAS, meanwhile, is meant for people already working as engineers who want to gain in-depth knowledge in management and economics. Anyone interested in pursuing these programmes must have at least a bachelor's degree in engineering or science. The Executive MBA programme offers advanced education in supply chain management.

About half of our students come from Switzerland and the other half from abroad. When they graduate, most take up management posts at technology companies, although they can also be found entering start-up enterprises and the public sector.

What are your thoughts on the future of D-MTEC?
Just now, D-MTEC has around 60 students enrolled in its master's programme and 60 in the MAS each year; we want to see a little more growth in these numbers. Concerning content, we are in the process of incorporating several Chairs from the Department of Environmental Systems Science which will result in a stronger focus on agricultural and environmental economics.

We are also discussing the prospect of establishing a new MAS in Public Management and Governance, which will concentrate on public decision-making processes in which technology is a relevant factor. There is a strong demand in public administration for leaders who have a solid grounding in technology, for example in the fields of energy or the environment.

Finally, we want to create an even higher profile for ourselves both inside and outside ETH in the fields of innovation management and entrepreneurship. This anniversary is a marvellous opportunity to do just that.

Department of Management, Technology and Economics:
→ www.mtec.ethz.ch

Careers

JENS ALDER

At Alpiq Holding AG's seventh AGM, Jens Alder was appointed the new Chair of the Board of Directors, succeeding the retiring Chair Hans E. Schweickardt. The former Swisscom CEO studied electrical engineering at ETH and has been a professional member of boards of directors since 2008.

CHANGE IN WATTWIL

The Saurer Group has appointed Martin Folini as its new CEO. He took up the post at the end of April, replacing Daniel Lippuner. Folini obtained his doctorate in engineering at ETH and has many years of experience in textiles. Alongside his new appointment, he will continue as CEO of Schlafhorst Zinser, the Group's largest business unit.

NEW MANAGEMENT

Komax Holding has restructured its management, with former CEO and ETH alumnus Beat Kälin as the new Chair of the Board of Directors and Matijas Meyer – another ETH graduate – as the technology company's new CEO.

Picture Credits: Alpiq

Spark Award

PROMISING T CELL RESEARCH

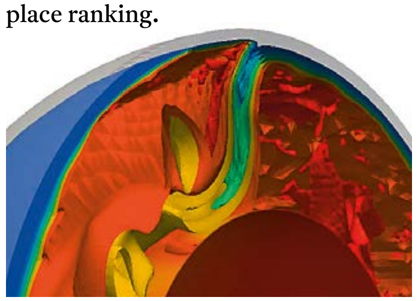
With 145 inventions under their belts – 82 of which were registered for a patent – ETH researchers were brimming with great ideas in 2014. Recognising their achievements was this year's Spark Award, which honoured the most promising invention. An award that ETH has given for a number of years now, this time the recipient was Professor Manfred Kopf's team, who had developed a method of identifying T cell characteristics. This technology has the potential to become part of the toolkit of personalised medicine.

The proud winners of this year's Spark Award

University Ranking

ETH: NUMBER ONE

Earth sciences at ETH have leapt to the top of the new subject ranking released by QS World University Rankings, coming in first in a worldwide comparison of performance in earth and marine sciences. Also holding their own among the high-flyers were environmental sciences, maintaining their previous year's third-place ranking.



The focus of ETH geologists: dynamics of the Earth's mantle

ETH Zurich Foundation

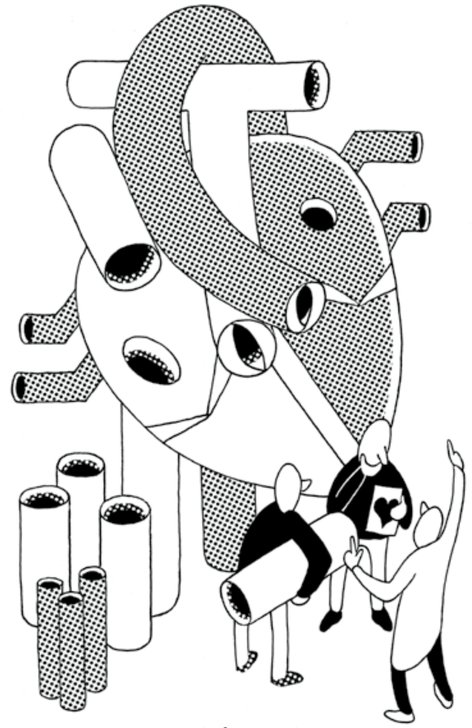
A STRONGER TEAM

In recent months, ETH Zurich has taken its collaborative partnerships to the next level in three key areas. One partner is the Huber + Suhner Foundation, which is supporting the ETH Zurich Foundation through its generous donation towards funding seed projects at the university. These projects provide rapid, practical avenues for bringing visionary ideas to life and subjecting them to preliminary review. The funds will be used to foster ideas within the ETH initiative entitled "Industrial production, processes and materials".

ETH Zurich was also the recipient of a generous donation from Walter Fischli, the doctor of biochemistry who spearheaded a variety of research projects at F. Hoffmann-La Roche over 15 years, and worked with colleagues to found the successful biopharmaceutical company Actelion Pharmaceuticals in 1997. As Senior Vice President, he was in charge of biological drug development. In the future, the newly established Dr. Walter and Edith Fischli Fund of the ETH Zurich Foundation will be used to provide support for doctoral and post-doctoral students working on the Fructose Metabolism project set up by Professor of Cell Biology Wilhelm Krek.

Finally, Nestlé is also helping ETH research through a partnership that supports the university's World Food System initiative. This will enable the World Food System Center to expand further and launch pioneering research projects. Nestlé is also contributing to the Partnership Council at the World Food System, a think tank for exchange, debate and information.

Picture credits: Oliver Bartenschlager; ETH Zurich



Detlef Günther

Medicine with heart

Enjoying a bit of sun in front of the ETH main building recently, I found myself watching the comings and goings at the University Hospital across the street. It didn't take long to see how much good modern medicine can do: a boy leaving the hospital with a bandage around his head, a woman limping through the doors on crutches, an elderly man brought to the hospital in a wheelchair, a young girl showing off her new cast with a proud smile.

What most patients probably don't know – but as an ETH "insider" I'm proud to report – is how much ETH is helping to advance diagnostic technology and treatment options for people affected by illness and accidents. ETH has joined forces with two other prominent institutions, the University of Zurich and University Hospital Zurich, to make the most of their impressive potential – and medicine is already benefiting from it. New networks, including the *Hochschulmedizin Zürich* platform (University Medicine Zurich) founded in 2011, have further strengthened the institutions' ties.

The University of Zurich and ETH Zurich have underscored their joint commitment to transdisciplinary and translational research by founding the Wyss Zurich centre. A medical design lab could play a vital role in developing radical new approaches to diseases like schizophrenia and AIDS.

Zurich Heart is just one of the visionary projects under the aegis of Hochschulmedizin Zürich, uniting doctors, engineers, clinicians and life scientists in pursuit of a single goal: developing an artificial heart capable of improving the lives of patients with severe cardiac disease. There are 17 professors and more than 60 researchers working on Zurich Heart today. This project is for me emblematic of how Zurich has burst onto the international scene as a major player in medical technology and health research.

Increasing dialogue between medicine, science and engineering is absolutely essential if we are to develop highly specialised diagnostic technologies and personalised treatment methods, or carry out minimally invasive procedures and complicated surgeries. We must make the necessary investments in educating and training the experts working at the boundary of these disciplines, and we must be willing to question current practice when it gets in the way of collaboration and progress.

Zurich has what it takes to improve heart pumps for cardiac patients, and maybe even to develop an entirely new artificial heart. But it's more than that too: Zurich has the potential to become the heart of health and medical research. The opportunity is there, and we are well on our way to seizing it.

Detlef Günther became ETH Zurich's vice president for research and corporate relations in 2015. He has been full professor of analytical chemistry since 2008.

Illustration: Thomas Fryscak; Picture credits: Giulia Marthaler

The wheelchair doesn't climb steps on its two wheels but with the help of the caterpillar tracks, which are lowered when needed and lift out of the way when not in use.

A master balancing act on the steps to success

Some merely dream of developing their own product, but for students on the mechanical and process engineering course, it's something they can do as part of their focus projects. The "Scalevo" group is developing a wheelchair that can climb steps. *Globe* joined them for some highs and lows.

TEXT Martina Märki **PHOTO** Annick Ramp

We're in a corridor on the institute premises. There's a scaffold, and a kind of motor with two big wheels hangs from it on ropes. Five young men peer into the machine's innards. All sorts of cables are spilling out, leading to a power source and to a table with two laptops. Further on, an open door reveals an office crammed full of desks and computers, where three young men stare intently at their screens. A remarkable silence hangs over the scene. "The software says there's an error," someone calls out – and a voice outside grumbles, "We knew that much already…" Then a third man reaches purposefully into the machine and pulls out a small green connector. Someone else passes him a soldering iron. It seems the group can communicate almost without words.

"I'm sorry, but nothing's working at the moment," we hear from Carlos, who is the project group's communications officer. "This connector is always giving us problems." Carlos and the other seven members of the project team are in the third year of their engineering studies at ETH. This year is a special one for these students, because they get to apply their knowledge to a practical problem in what is known as a focus project. The objective is to develop a product based either on an idea of their own or in partnership with industry. Carlos and his colleagues are working on an electric wheelchair that will balance on two wheels and climb steps with the aid of two additional caterpillar tracks. The project group is supported by two students from Zurich University of the Arts (ZHdK), who are responsible for the vehicle's design.

We meet the group as they approach a major milestone: the presentation of all focus projects at the end of May. That will be the first time the wheelchair is presented to the public. But the students also have their sights set on another goal. Their wheelchair is set to be put to the test in challenging conditions at Cybathlon 2016, a sporting competition for people with physical disabilities.

Day 1

Today, 19 March, is a special day. After months of research, calculations, planning, model building and negotiations with manufacturers and sponsors, the group is finally able to put together the heart of the wheelchair: the chassis, wheels, electronics, sensors and motor. All the necessary materials arrived over the course of recent weeks. The seat and exterior shell are still missing, and the caterpillar tracks for climbing steps have yet to be fitted. The battery hasn't arrived yet, either – and it will cause the group grief further down the line. But luckily, nobody has any inkling of that just yet. For now, everyone is overjoyed that the key parts all fit together – by no means a trivial matter. "The wheelchair is based on 175 technical drawings and involves 50 suppliers, 300 electronic components, and more than 2,000 nuts, bolts and screws," Roman tells us. He is responsible for the system engineering and project documentation. Now it's time for the project group to perform their first balance tests with the actual prototype. Until now, they've had to use Lego and wooden models to test all the functions.

At last, the soldering repair to the connector is completed. This is where things get interesting for Ian. It's ›

Repair work: Carlos, Miro, Roman und Ian (f. l. t. r.) before the first balance test.

COMMAND CENTRE
Peering into the wheelchair's brain: this green circuit board is where all the information comes together. It evaluates sensor data, receives commands from the user, and works out what to do to maintain balance and climb stairs before finally passing these actions along to the system.

Ian puts the wheelchair's balancing capabilities through systematic tests.

his job to optimise the software that lets the wheelchair keep its balance. The students switch the wheelchair on and carefully lower it to the ground on its ropes. It sits there balanced steadily on its two wheels. Ian gives it a little shove – and the judder that follows is comparatively big. That's not too good; at the end of the day, wheelchair users need to feel secure. Now Ian will have to configure the system so that its reactions are gentler. "This is just the first version of the controller," he says, turning to his computer to work with his colleagues in silent concentration. It will take a lot more testing and many more attempts before everything works smoothly.

Naomi from the design team arrives, bringing some parts from the university's own 3D printer. These will make up the housing for the display unit that allows users to control the wheelchair. Carlos and Naomi work as a well-oiled team to fit the parts together – and it all falls into place.

Then Carlos looks at the time: It's past 4 p.m. and too late to call sponsors and workshops, which is what he had planned to do. Instead, he discusses details of how to build the wheelchair's shell with Naomi. It turns out that it's still not quite clear how the large covers should be produced: should they use 3D printing or go for a fibreglass approach? It's also a question of cost; Carlos is still waiting for quotes.

Day 2
Two weeks later, the wheelchair has gained a large caterpillar track on either side. Carlos tells us that in the meantime everything has gone pretty well. He's particularly pleased to have found a manufacturer for the large coverings. It turns out that using fiberglass would have been far too expensive. Luckily, the designer from the ZHdK has just returned from an internship in Milan, where he found a company that could make the shell much more economically using 3D printing. Happy coincidences are also a natural part of a project like this!

Now things get exciting: it's time for the step test. For safety, the wheelchair is still attached to its mobile scaffold with ropes, so it doesn't wander off on its own somewhere. A wooden podium with steps built especially for the test stands one metre away. Gentlemen, start your engines! The wheelchair balances on its two main wheels and rolls backwards up to the steps. There, it lowers two small support wheels and its two caterpillar tracks until the main wheels lift off the ground. As the caterpillar teeth grip the first step, the support wheels retract. The wheelchair wobbles slightly. "Now keep going," Carlos directs. Amazingly, the wheelchair makes a slow ascent, step by step, with no more wobbles. Everyone holds their breath as the wheelchair reaches the top step. This is another tricky moment: when the wheelchair reaches the highest point, it shouldn't just thud down into a horizontal position. Instead, it stops, then extends its support wheels before slowly continuing. Once it's far enough up, the caterpillar tracks and support wheels lift up and the wheelchair lands gently on its two big main wheels. They've done it! It's big grins all round and congratulatory slaps on the back. Ian does another quick check of the balance stability, only to discover that one of the big wheels is blocked. Is it a mechanical problem? Everyone bends over to examine the wheel axle – but it looks fine. It seems there are still a few

issues with the software to sort out, the group concludes. But they all agree: that's how these things always go – so no need to worry.

Day 3
Monday morning, 20 April: Today there's going to be a conference with the experts, professors and assistants from the department overseeing the focus projects. Ian and Milan have prepared a PowerPoint presentation, and they give their report with impressive self-assuredness.

Then it gets serious. The experts gather around the wheelchair, which is still hanging naked from its safety scaffold, without its seat or covering. A short demonstration of its balancing runs less than ideally, so there's still room for improvement. But the group has another pressing problem, and they ask the experts for advice: it's about the battery that's supposed to power the wheelchair. What the group originally ordered was a battery that would provide 2 x 24 volts, but the one they were supplied has an output of 48 volts.

"The problem is that our main motors need 48 volts but the linear motors only need 24 volts," Carlos explains. "Might we be able to modify the battery ourselves?" Roman asks. The experts warn that this would be dangerous. "Stick with the battery you've got, but use converters; I think that would be better," suggests Roland Siegwart, a professor at the Institute of Robotics and Intelligent Systems. The students aren't happy. They foresee a major system alteration coming their way. What if that changes the weight distribution and leads to new control problems? They'll just have to see what kind of solution emerges over the coming weeks. Rollout is in five weeks' time. Siegwart gives the group these parting words: "You'll manage it as long as you focus on what's really important!"

Epilogue
At the beginning of May, Carlos gives us a call: "We're well on our way." The group did in the end manage to modify the battery themselves, and a crew from Swiss Radio and Television filmed the almost completed wheelchair taking its first manned test drive.

Then comes the big day: 27 May, the rollout for all the focus projects. Presented to a large audience, the wheelchair shows what it can do. The whole Scalevo team agrees that they have learned a great deal – "it was worth it!" ○

Links to the project:
→ www.scalevo.ch and www.facebook.com/scalevo

Information on the Cybathlon:
→ www.cybathlon.ethz.ch

Raffael, who uses a wheelchair himself, gives the group advice on how to make their designs disability-friendly.

Benjamin is the first one to tackle the steps. Naomi, Ian, Dario, Carlos and their advisor Raffael (f. l. t. r.) watch the wheelchair keenly as it takes its first passenger for a ride.

CONNECTED

1 ETH alumni

TUNNEL VISION

Alumni of the London School of Economics (LSE), the Massachusetts Institute of Technology (MIT) and ETH Zurich were given the chance to look round the Gotthard Base Tunnel – the longest railway tunnel in the world. With two separate single-track tunnels running in opposite directions for over 57 kilometres, the excavation stage required 11 years of work and accumulated around 25 million tonnes of material – five times the volume of the Egyptian Great Pyramid of Giza.

For the alumni, it was an opportunity to not only experience an impressive tour through a century of engineering, but also engage with former students of other universities and make new contacts.

2 Lokaltermin

DIGITAL FABRICATION

On 6 March 2015, ETH Zurich President Lino Guzzella hosted a *Lokaltermin* entitled "Digital fabrication in architecture – are robots set to build our future?" A demonstration of a construction robot provided by the Chair of Architecture and Digital Fabrication proved a real crowd-puller. Meanwhile, a discussion moderated by Roman Klingler, on the left in the photo, saw a panel consisting of (from left) Patrick Suter (Erne AG Board Member), Balz Halter (Chairman of the Halter AG Board of Directors), Remo Lütolf (CEO of ABB Schweiz AG) and ETH Professor Jonas Buchli examine possible applications for digital fabrication. The *Lokaltermin* was organised by ETH Zurich and the ETH Zurich Foundation.

1 *ETH alumni*

2 *Lokaltermin*

3 *Richard R. Ernst Lecture*

4 *Meet the Talent*

5 *Engineering for Development*

3 Richard R. Ernst Lecture

NOBEL PRIZE WINNER AND SECRETARY OF ENERGY

Nobel Prize winner Steven Chu (left) was the speaker at the Richard R. Ernst Lecture, where he addressed the topic of "Energy, Climate Change and Sustainability". Based at Stanford, the physicist received the Nobel Prize in 1997 and, as Secretary of Energy in President Barack Obama's government between 2009 and 2013, played a key role in developing the energy policies that the US is now pursuing. He was honoured with the Richard R. Ernst Medal by ETH President Lino Guzzella (right).

4 Meet the Talent

FRESH MINDS, NEW IDEAS

Meet the Talent 2015 provided patrons of the Excellence Scholarship and Opportunity Programme with the ideal opportunity to meet scholarship recipients face to face and find out more about their research projects. Scholarship holder and computer science student Daniel Graf (second from left) took full advantage of the experience, showing patrons exactly what his project will involve. The focus of his master's degree is on developing a system that bicycles can use to park efficiently with the aid of a robot.

5 Engineering for Development

SAMIH SAWIRIS COMES TO ETH

At the invitation of ETH Zurich, Rector Sarah Springman, entrepreneur Samih Sawiris and ETH Professor Dirk Hebel (from left) discussed opportunities that the Engineering for Development programme could tap into. Supported by the Sawiris Foundation and ETH Zurich, the programme fosters the development of methods that could directly impact and improve living conditions in developing countries.

Picture credits: ETH Alumni; Tom Kawara (2)

Picture credits: Heidi Hostettler (2); Patricia Heuberger-Meyer

Agenda

EVENTS

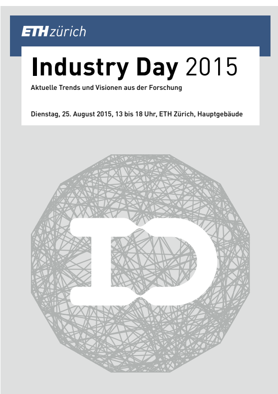
25 Aug. 2015

Industry Day

Visitors to Industry Day 2015 will learn about the latest trends and visions in research in a nutshell – and also have the opportunity to discuss them directly with the researchers themselves. Professors give brief presentations on their latest research in fields ranging from sensors and robotics to systems biology and personalised medicine. A special session will be dedicated to four particular highlights from ETH's own research. The event will conclude with a drinks reception, giving visitors and presenters the chance to expand their networks while discussing the needs and opportunities that science and industry have in common.

Register by 14 August at:
→ www.ethz.ch/industryday-en

Attendance is free. Presentations will be given in English and German.



A bird's eye view of the ETH main hall

Scientifica 2015

INSIGHT INTO LIGHT

5–6 Sept. 2015 On the occasion of the International Year of Light this year's Scientifica is dedicated to light and illumination. Without light there would be no imaging, no high-speed internet, no tattoo removal, no insight – and no life. This year's Scientifica will feature more than 50 exhibition stands with researchers discussing their projects, alongside a full programme of shows, talks, presentations, science slams and family-friendly activities. The event will take place in German.

The exhibition kicks off with a private view from 6 to 9 p.m. on Friday, 4 September in the main buildings of ETH Zurich and the University of Zurich. Current members of both universities, alumni and friends are cordially invited to this special preview.
→ www.scientifica.ch

Alumni Travel

WOULD YOU LIKE TO JOIN US IN BOSTON?

3–9 Aug. 2015 The New England Chapter of ETH Alumni is pleased to invite fellow alumni on an exclusive five-day trip to Boston, including tours of the city and a visit to MIT in Cambridge. Accommodation will be at the luxury Battery Wharf Hotel directly on the waterfront. This all-inclusive offer includes economy flights on Swiss, hotel stay, meals and drinks, transfers, entrance fees, tours and tips for CHF 5,980. Stays can be extended on request.

Registration at: *travel@alumni.ethz.ch*
→ www.ethz.ch/reise-boston

Picture credits: ETH Industry Relations; Frank Brüderli

26 June 2015 / 6–10 p.m.

Let's celebrate!

The MAS ETH MTEC/NDS BWI is celebrating its 35th anniversary – an excellent opportunity to bring together its alumni. Professors Hugo Tschirky, Roman Boutellier and Michael Ambühl will also give talks to mark the occasion.
ETH Zentrum, Auditorium Maximum
→ www.ethz.ch/35years-mas-mtec

8 Sept. 2015 / 5 p.m.

Paul Bernays Lectures 2015

Professor Serge Haroche (Collège de France, Paris), 2012 winner of the Nobel Prize in Physics, will give a talk entitled: "Celebrating the International Year of Light: How the laser has revolutionized physics".
ETH Zurich, Main Building
→ www.ethz.ch/bernays-2015-en

8 Sept. 2015 / 6.15–7.15 p.m.

World maps – a matter of perspective

The ETH-Bibliothek's extensive map collections comprise a wide range of contemporary and historical examples, including rare and valuable illustrated maps from the 18th and 19th centuries. Evening tour open to the public (in German).

ETH-Bibliothek
→ www.ethz.ch/eveningtour-maps

EXHIBITIONS

12 June–14 Nov. 2015

Einstein & Co. – Zurich and the Nobel Prize

Learn about the life and times of past Nobel Prize winners in Zurich, the impact of their discoveries, and the mark they made on the city. Visitors have an exciting opportunity to discover more about the laureates' multifaceted personal stories and the scientific and cultural backdrop to their work.
Private view: Thursday, 11 June 2015, 7 p.m.
Stadthaus Zürich
→ www.ethz.ch/nobelpreis-zuerich

25 Aug. 2015–28 Feb. 2016

Earth's treasures – How we use and value mineral resources

Mineral resources form the basis of our daily lives. What are the long-term consequences of our increasing use of non-renewable resources? What challenges will we be facing in the near future? This exhibition is about the formation, mining, processing and use of mineral resources and how we deal with products we no longer need. What can we do to ensure that resources are used and re-used for as long and as efficiently as possible?
focusTerra, ETH Zurich
→ www.ethz.ch/focusterra-resources

Book launch

SCIENCE NATION SWITZERLAND

From the origins of weather reporting and the Seismological Service to "race research" in Zurich and the use of science in colonialism and the Cold War: This wide-ranging collection features contributions from 15 historians examining the 200-year history of science in Switzerland. They consider how scientists have developed their insights, but also how they have stumbled into error – all the while establishing Switzerland as a major hub in the global scientific network.

Edited by ETH historians Patrick Kupper together with Bernhard Schär and published by Hier und Jetzt Press, *Die Naturforschenden* (*Scientists*; available in German and French) was initiated by the Swiss Academy of Sciences (SCNAT) to mark its 200th anniversary.

Picture credits: ETH-Bibliothek Image Archive (2); Hier und Jetzt Press

ABOUT
Suzanne Thoma

studied chemical engineering at ETH Zurich and also received her doctorate in this field. At Ciba Spezialitätenchemie AG, now BASF AG, she was employed for some ten years in leading roles both in Switzerland and abroad. As CEO of Rolic Technologies AG, she led a start-up firm specialising in high-tech materials and technology licensing, primarily supplying Asian electronics corporations. Until 2009, Thoma headed up the international automotive supply arm of the WICOR Group in Rapperswil, Switzerland. Since 2010, she has served as a member of BKW AG's Executive Board, and was appointed CEO in 2013.

PROFILE

"I don't have a starry-eyed view of the world"

Even as a child, Suzanne Thoma knew what it meant to carry on in the face of resistance. Her skill, endurance and ambition have marked out her rise to the top as CEO of BKW.

TEXT Samuel Schlaefli **PHOTOGRAPH** Daniel Winkler

Suzanne Thoma's ascent to the summit of BKW, Switzerland's third-largest energy company, is a story of both overcoming obstacles and an enduring sense of belief. Her upbringing in the 1970s took place in Canton Zug, in a part of central Switzerland that was holding fast to the societal conventions preventing women from straying far beyond a life of domesticity. The day on which her older sister's teacher phoned the girls' mother is etched onto her memory. Her sister had passed the examination to get into grammar school – but, as he put it, "you don't need qualifications to peel potatoes". Even back then, Thoma recognised the outrageousness of idle words like these. The confirmation in her eyes that women could make something of themselves came in 1979, when Margaret Thatcher was elected prime minister of the United Kingdom. It marked a watershed event for Thoma, plus a welcome insight into the future she could have: Thatcher was a European and, instead of coming from a royal dynasty, was a member of the middle classes – just like Thoma.

The search for "Bold New Horizons"

Thoma expressed an early interest in politics, economics and the business world. Then the 1980s dawned, a golden era for market liberalisation and greater entrepreneurial freedom: "Back then, I could sense that the most important changes in society stemmed from the economy." Given her insights, it is fair to ask why she chose not to follow up her Matura university entrance qualification with studies in economics at an institute like the University of St. Gallen – considered by many to be the key to a career in business. "I don't really think that's a big deal," says Thoma. "Just take a look at the management boards of Swiss companies. A huge number appoint ETH graduates." At that time, however, her reasons for pursuing engineering studies were different. A teacher at her grammar school had sparked Thoma's interest in chemistry – and her father, an ETH-educated physicist, was harbouring a desire for his daughter to go and study a "proper" subject. For him, this meant attending ETH. When she ultimately got hold of the university's prospectus, bearing the German title "Kühne Dimensionen" – "Bold New Horizons" – she knew she was where she belonged.

Thoma remembers the first two years of her chemical engineering degree as a time of tribulations: "Unfortunately, I was a bit late in realising that I wasn't at the top of the class any more, like I had been at school." She saw the light after the first semester, recognising that good results were only going to come if she genuinely dedicated herself to the course – despite the fact that, unlike her all-male cohorts, she didn't see herself as a chemistry geek. Thoma persisted in spite of patronising remarks from professors and a lack of solidarity in her class: "This period really shaped me. It was crucial in setting me on my career path. Every career presents difficult situations where it's worth sticking things out." This is a characteristic which she feels is sadly lacking in today's Generation Y – with one notable exception, as she emphasises: >

"Every career presents difficult situations."

> "I'm sometimes stunned at the decision I made back then."

At BKW, we readily appoint ETH graduates even if they have had to battle through their studies with only average marks." Thoma opted for a doctorate after her course of studies, despite a lack of academic ambition.

"I wanted to work in a major company – and in the world of chemistry at that time, you were nothing without 'Dr' in front of your name." Over three years, she conducted research into improving mixing systems in the context of scaling up production reactors. In addition to her practical work on containers that in some cases measured a cubic metre, she attended a two-year supplementary educational course in economics.

Even with a double workload, this period in Thoma's life gave her plenty of scope for socialising as she got to know fellow female students who had come from abroad to pursue a doctorate at ETH – and it gave her more time for discussions about economics and politics. In 1990, she took up her first job as a process engineer at Ciba Spezialitätenchemie AG (now BASF AG) in Basel. Before long, her boss packed her off to Taiwan for a two-year project in which she put a production plant for plastic additives into operation. It was a technical, organisational, regulatory and cultural obstacle course – and it suited Thoma down to the ground.

The strategy pays off

Thoma's return to Switzerland saw a tempting offer come through her door: a new internal position in investor relations. While this would have meant working closely with company executives, extensive travel and meeting interesting people, in the end she accepted the counter-offer from her group and headed back into the applications laboratory, where she went on to deal with issues raised by customers. Thoma sums up her thoughts: "Today, I'm sometimes stunned at the decision I made back then. But at that point, I realised it was important to know at least one field of business inside out. If you maintain a general view from the top, surveying everything below, over the long term you won't learn enough about how business works." Her strategy paid off. Four years later, she was promoted to head of her business unit, in charge of 250 staff members. This was the point at which her career took off, with a promotion first to a larger business unit, then to the staff of the then-CEO – followed by her decision to leave Ciba Spezialitätenchemie AG and become CEO of Rolic Technologies AG. Later, she took the helm in the automotive supply arm of the WICOR Group.

Advocate of the energy revolution

"Eventually, I wanted a bigger challenge and something more in tune with the major issues affecting society," recounts Thoma. In 2010 she joined BKW as a member of the Executive Board and Head of Networks Division. Her rise to CEO came three years later. Thoma spearheaded a radical transformation of BKW and redefined its corporate strategy, a move which included changes to the Executive Board and the second management tier, and led Swiss business magazine *Bilanz* to nickname her "The Sweeper". Since ascending to the role, Thoma has advocated a revolution in how we use energy. She also took the decision to remove Switzerland's Mühleberg nuclear power plant from the grid and dismantle it by 2019. "But don't get me wrong, I don't have a starry-eyed view of the world. As CEO, my job is to make BKW fit for the future and ensure its growth." A transition to new forms of energy, she believes, is an important factor in achieving this.

Thoma campaigns for more than just a restructuring of energy supply infrastructure nowadays, however: she also promotes an improvement in work-life balance. Although in the past she felt uncomfortable being viewed as the representative of successful women everywhere, she has since come to use this ambassadorial role very consciously. "Back then, I refused to come down on the side of either family or career." Today, she wants to show young, ambitious women that she has never regretted this decision. Thoma herself has two adult daughters, both of whom are following in their mother's footsteps by studying at ETH Zurich. And her feelings are clear: "I'm incredibly proud of them." ○

ABOUT THE COMPANY
BKW AG is an international energy and infrastructure company headquartered in Bern. It plans, constructs and operates energy production and supply infrastructures for businesses, households and the public sector. BKW's distribution network, the largest in Switzerland, supplies one million people with electricity. Today, the company and its subsidiaries employ just under 4,000 staff members.

5 QUESTIONS

Ueli Maurer wants to make facts as clear as possible. *“I can only understand simple things.”*

Ueli Maurer is a professor of computer science and leads the Information Security and Cryptography Research Group.
→ www.crypto.ethz.ch

1 *What was your first encounter with ETH Zurich like?*

I was at an event in St. Gallen for school-leavers who had done their Matura university entrance qualification, and Professor Hans Kern was giving a presentation on studying electrical engineering. I have to admit that I found it all a little provincial; it didn’t really show ETH to be a global player. It almost led me to study mathematics instead of electrical engineering.

2 *Which teacher made an impact on you?*

In my fourth year, I attended a lecture course by James Massey called Applied Digital Information Theory. This was a pivotal event in both my studies and my life: Massey completely set himself apart from other professors, and the fact that I became a doctoral student of his marked a significant step in my career. He took me right back to my love of mathematics. His lectures were fascinating and they always had a clearly stated aim. They also embraced simplicity – there were no unnecessary notations or transformations. You could see right through to their very heart. When I spoke to him about this style of teaching later on, he said something amazing – and I knew exactly where he was coming from: “I can only understand simple things – so I have to make things simple.” I try to live by this motto every day in my research. I aim for abstraction by letting go of anything that’s unimportant, and I try to strip things back to basics and make them as clear as possible.

3 *How useful are international large-scale projects?*

I really value the contacts I have across the world, but collaborative work in research projects isn’t a priority in my line of research. I think that international projects in theoretical fields often start because of funding-related reasons. This results in huge overheads, and the bottom line is that it gets in the way of the real aim: acquiring knowledge.

4 *Are today’s publishing methods damaging to science?*

In some ways, parts of science have become a paper production industry: all too often there is the feeling that racking up numbers of publications and citations is an end in itself, when in fact a long-term acquisition of knowledge and discovering new forms of technology are the real aims.

5 *What do you understand critical thinking to mean?*

I think critical thinking refers to the task of every person to openly care about developments in society, beyond the things that affect them directly. To my mind, this is a core task of academics. In discussions I try to take up issues that can perhaps best be described under the term “limits to growth” which made headlines when I was young. As an example, I get the impression that people see the proliferation of SUVs on our roads primarily as something positive spurring on the economy – but they don’t look at the bigger picture and see how absurd it really is.

– Recorded by Felix Würsten

Picture credits: Giulia Marthaler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