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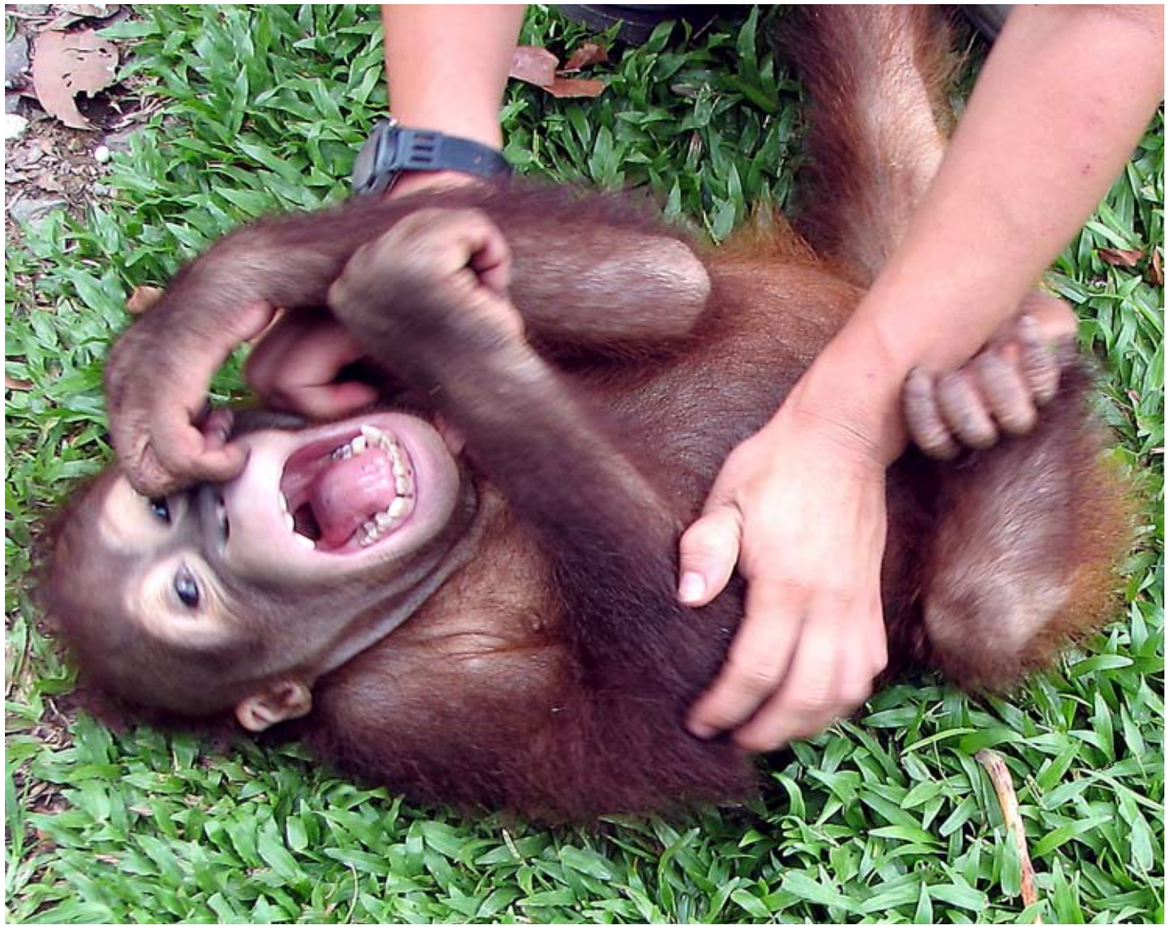

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Cover: TiHo Hannover/Institut für Zoologie

A sense of well-being is expressed acoustically – this baby orangutan likes being tickled. Even human laughter has a remarkable evolutionary past.

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Christine Windbichler

Selectivity and Transparency in Research Funding

Countdown to the online election of the DFG review boards: The "parliament of science" lets Germany's researchers raise their voices on their own behalf – for more quality and unconventional thinking in research and research funding.

As the DFG gears up for its upcoming online election of DFG review board members later this fall, the DFG has seen itself and its review system come under criticism. A small group of critics have voiced their scepticism over what they feel is the lack of transparency in the DFG's decision-making and funding decisions. Some would like to know the names of those seemingly anonymous reviewers who recommend to fund or not fund a project; others allege biases against certain disciplines.

Is there something to this criticism? No, but it does bring the focus back to two important principles of the DFG's work: selectivity and transparency.

The DFG *is* selective and competition for funding *is* fierce. But this selectivity is not based on a hidden agenda or secret criteria. Nor are decisions made by a select few. DFG funds are predominantly taxpayer's money meant to be spent according to scientific and academic criteria. How is this done? Representatives elected from and by the scientific community itself play the crucial role.

But what is the DFG exactly? The DFG is an association under private law: Its member organisations include, among others, higher education institutions, non-university research institutions, academies of sciences and humanities, and scientific associations; in short, the DFG is an association of science for science including the humanities.

Like all associations the DFG holds elections: The 95 member organisations elect the Senate and the Executive Committee. Additionally, the scientific community, again this fall, is called upon to elect the members of DFG review boards that are responsible for ensuring the overall quality of the DFG's review process. The review boards warrant high quality standards and criteria in the respective fields and selection of appropriate and qualified reviewers. Review boards make subject-driven award recommendations which the DFG Head Office then presents to the Joint Committee (consisting of the scientists and academics in the Senate as well as representatives of the federal and state governments that finance the DFG's funding activities). The names of these elected reviewers are published on our website.

And who gets to vote in these elections? Anyone who – at the time of the election – has completed a PhD (or equivalent) and works as a researcher at one of the DFG member institutions or an institution recognised by the Senate as a voting centre or is registered as an individual voter. But before votes can be cast, candidates must be nominated. Here too, the DFG looks for a broad base among and beyond its member organisations. Upon request of the Senate, scientific and academic associations may be granted nomination rights. From a large number of suggestions, the Senate compiles the official list of candidates. Scientists and academics with a doctorate who are active and independent investigators within the German academic research system are eligible for review board membership.

We trust that the scientific community in Germany will take advantage of this opportunity to make its voice heard. Detailed election information is available on the DFG's website at www.dfg.de/en/rb-election2011. The actual voting period will begin on 7 November 2011 and last for four weeks.


Illustration: HU Berlin

In such a bottom-up system, what are the chances for unconventional thinkers, for projects outside the mainstream? First off, researchers benefit from the fact that they can request grants for anything that seems worth investigating without being tied to calls for proposals or other guidelines. This science-driven approach is characteristic of the DFG. And sometimes this entails challenging prevailing doctrines, as the following example demonstrates.

When Harald zur Hausen began over 30 years ago to research the potential relation between viral infections and cancer, his theory was dismissed off hand by the scientific community. Zur Hausen's projects were supported by the DFG, among other funders. In 2008 he received the Nobel Prize in Medicine for his discovery of the role of the human papillomavirus in cervical cancer. In an interview he noted, "It's important to sometimes think outside the box. Don't let yourself be misguided by or get too comfortable with prevailing dogmas. You must not accept just everything, not even if it's considered standard science. But this also means that you most likely have to work even harder."

This is also the case for the DFG's Reinhart Koselleck Programme, whose objective is to enable established researchers to undertake highly innovative, high-risk projects. But here too, the DFG is selective. Applicants must have a demonstrated track record to succeed.

As science and research funding increase in complexity, the DFG is doing its part to increase transparency. The DFG traditionally publishes an annual report, which gives detailed information and statistics on its funding activities and use of funds. Projects that have been approved for funding are included in GEPRIS, the DFG's project database, which is available online; this year GEPRIS has been expanded to include not only project abstracts but also the results of DFG-funded research. The system will continue to be updated in the future.

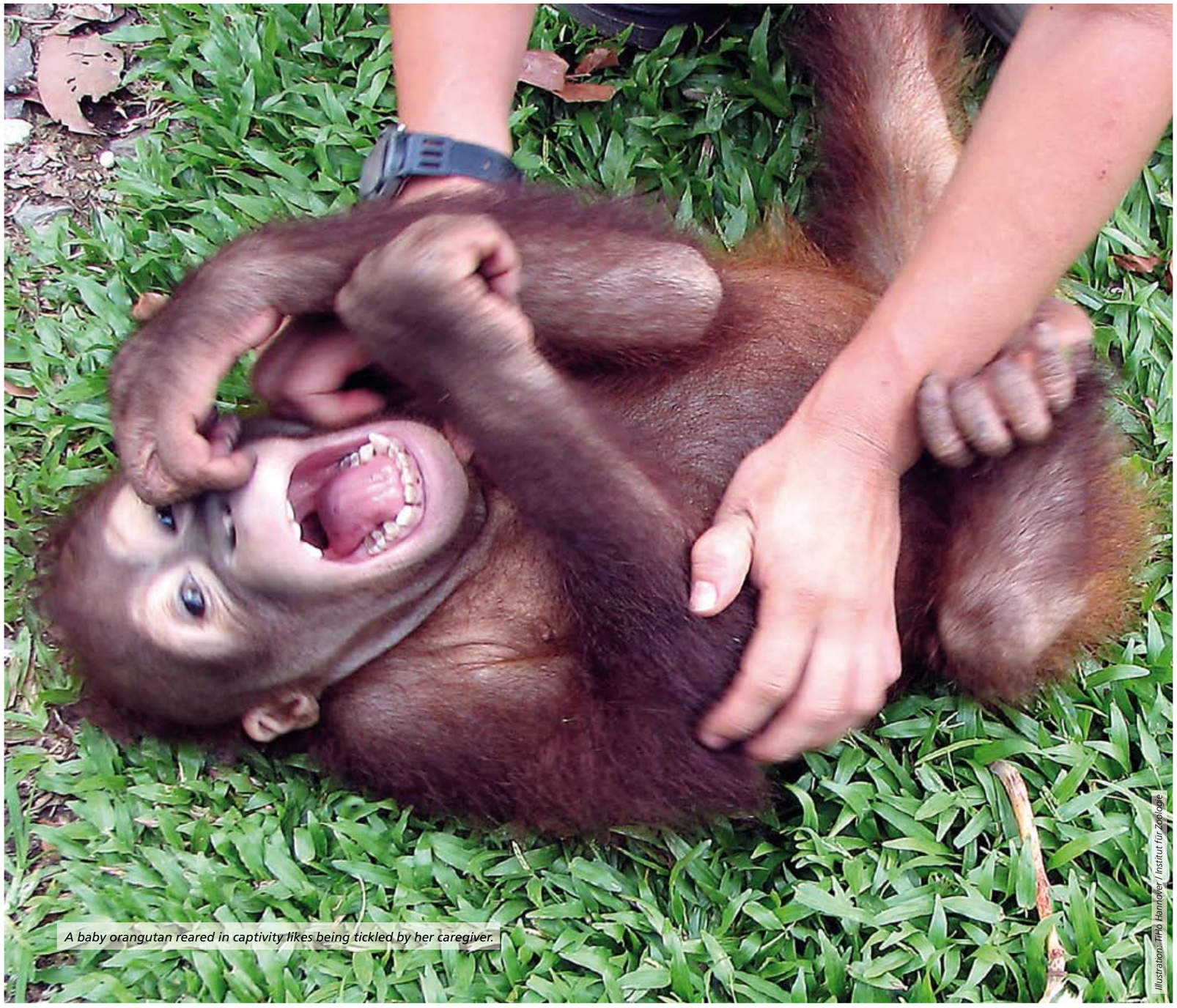
For the DFG, this increased transparency also involves the tried-and-true practice of publishing the names of those members elected to the various decision-making bodies by the scientific community on the DFG's website as well as in its annual report. The identities of review panel members in coordinated programmes, who often encounter the applicants on site, are also known. Although reviewers in the individual grants programme remain anonymous – a practice that reflects international standards of peer review – their assessments are shared in their gist with the applicants. And in all cases, both negative and positive, the elected review board members have the final say on funding recommendations.

In its effort to focus a reviewer's attention on the quality of a given project rather than the publication output of the applicant, the DFG has reduced the number of publications listed in a grant proposal. Reviewers should base their assessments on the proposals and read significant papers, not rely on bibliometric statistics.

These and many other activities have created a complex structure. Couldn't this all be a lot simpler? Sure, you could roll dice to decide on proposals. Personally, I would rather rely on elected scientists and scholars to make these decisions.

The 2011 review board election will take place from 7 November, 2 p.m., until 5 December, 2 p.m. To those eligible to vote: I hope you'll go online and choose wisely.

Prof. Dr. iur. Christine Windbichler, LL.M.
is Vice President of the DFG.



A baby orangutan reared in captivity likes being tickled by her caregiver.

Illustration: Prof. Hannover / Institut für Zoologie

Elke Zimmermann

The Voice of Emotions

Research on the role of emotions in acoustic communication and its evolution has been neglected for a long time. Ongoing comparative studies of nonhuman mammals and man are now providing new and surprising insights.

When we infect others with our laugh, soothe a grizzling baby with a lullaby or get goose bumps listening to classical music, we are barely aware of the complex processes upon which this behaviour is based. It is not facial expressions or body language that is affecting us, but acoustic vibrations. They are present in music and speech as "emotional prosody" and allow us to communicate not only verbally but also emotionally. Acoustically conveyed emotions, which require complicated generation and processing mechanisms, are of paramount importance and essential for communication across all human cultures.

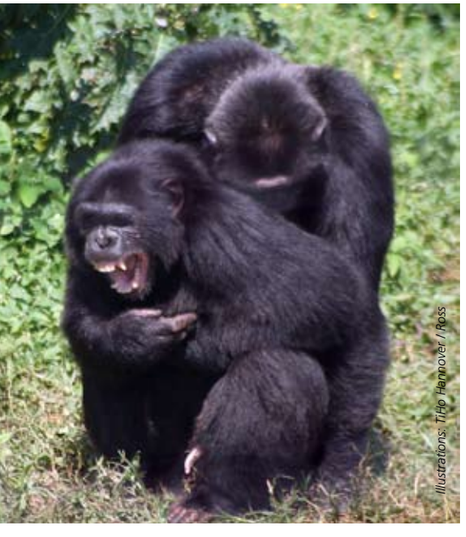
The DFG-funded Research Unit "Acoustic Communication of Emotions in Nonhuman Mammals and Man" aims to study the role of emotions in the evolution of acoustic communication. Production, perception and neuronal processing are studied in animal models and humans taking comparable approaches, with particular emphasis on speech and music.

For example, acoustic analyses of laughter, which expresses joy, taunting or schadenfreude, indicate that the different emotions are conveyed acoustically in specific prosodic cues. Psychoacoustic tests have shown that humans can recognise the corresponding emotion based on the emotion-specific acoustic cues. Interestingly, comparable acoustic cues convey specific emotions even across different languages and cultures.

Acoustic universals were also revealed in cross-cultural studies with music. When members of a native African population (Mafa) listen to European music that makes Europeans either happy, sad or fearful, the Mafas interpret this music similarly to Europeans even though they had not had any previous experience of European music. Europeans naïve to Mafa music behave similarly when they listen to Mafa music.

Acoustic components, which may be associated with strong emotional experiences, can affect sensitive people who may react with an accelerated heartbeat and even goose bumps. Analyses of brain activity using modern imaging methods have shown that listening to acoustically conveyed emotions activates

Common language: facial expressions of humans and apes – tickling voices are similar in play.



Illustrations: Tilo Hannover / Ross

a complex network of regions in the human brain that are linked to auditory and emotional processing as well as decision-making processes. Intermeshing of these processes and their functions has only been partially understood to date.

These examples illustrate that the ability of humans to communicate emotions acoustically is extremely complex and has very different facets: we must express our feelings acoustically, perceiving not only our own but also those of others, to interpret them solely on the basis of their expression, to control them and finally learn to imitate them consciously – and all this depending on the social context and individual experience. How did humans develop this highly complex ability to express and recognise acoustically conveyed emotions during the course of evolution? Did it evolve in our direct ancestors or does it have a pre-human history? Furthermore, how can emotions be investigated in non-linguistic animals so that we can improve our understanding of how acoustic communication of emotions evolved?

In his work "The Expression of Emotions in Man and Animals" (1872), the British naturalist Charles Darwin made the first comparisons between humans and animals. From the similarities he found, he concluded that our emotional behaviour is derived from previous phylogenetic stages in the animal kingdom. Empirical tests of this phylogenetic continuity hypothesis require comparable definitions and measurements of emotions in humans and animals. At the same time, standardised criteria are needed to describe their acoustic morphology.

In contrast to humans, animals cannot be questioned about their feelings when they make or hear vocalisations. This also applies to human babies. It is thus necessary to evaluate socially relevant situations indirectly using behavioural measurements that take context and individual personal history into account. Such a comparative approach aims to disclose the biological roots of emotional behaviour and to reveal characteristics that are unique to humans.

When we are excited or insecure, we automatically speak faster, in a more compact manner and with a higher pitch. The dynamics in the acoustic characteristics of voice as a function of the level of excitement have been measured by psychologists using acoustical methods. Interestingly, some of the acoustic components in the human voice correspond to those in the voice of six other mammalian orders.

As acoustic measurements on animals' voices by ethologists have shown, animal vocalisations in defined situations vary depending on the level of arousal. For example, if a female tree shrew (from the genus Tupaia), unwilling to mate, is being courted by a mate that is trying to mate, she gives defensive calls of which the acoustic features change in a predictable manner, depending on the distance or behaviour of the male. Playback experiments have confirmed that tree shrews can differentiate between different levels of arousal based solely on acoustic morphology. This arousal-dependent differentiation in voice is also reflected in social calls indicating disturbances. This ability is not exclusive to tree shrews; it also applies to very different species, including whales, elephants, pigs, ground

Foto: HMTM Hannover

Measurements of brain activity (EEG) give insights into the perception of acoustically conveyed feelings, for example, when listening to music, language or animal voices.

squirrels and bats as well as primates such as mouse lemurs, squirrel monkeys, macaques and chimpanzees.

Phylogenetic constraints have probably contributed to acoustic universals for communicating dangerous situations among mammals. The basic construction plan of the peripheral vocal system is similar in all mammalian groups, including humans. Short-term stress caused by predators or conspecifics activates the sympathetic nervous system in all species and thus influences both breathing and the associated process of vocalising – with consequences for tempo and pitch.

If the perceived stress level is expressed acoustically, living in communities with long-term social bonds and repeated social interactions will favour the evolution of acoustic communication since individuals in these communities may benefit from perceiving alarm calls conveying different types of predators and levels of urgency, without seeing them, or from avoiding physical conflicts with conspecifics by recognising different levels of threat acoustically. In communities in which the members learn to recognise social partners from their voice, defensive calls may also develop into calls for help. In the case of macaques and chimpanzees, visually isolated bonding partners may be alerted acoustically and specifically by the voice of familiar or related individuals and race to the rescue. Humans are unique in having the ability to control emotion and its intensity in voice consciously.

Laughter is an important emotional display in nonverbal communication across human cultures. Even babies are able to laugh, as are infants born blind and deaf. It is therefore assumed that laughing is an innate human ability to convey specific feelings. The question arises as to whether great apes are also able to laugh – and if the answer is yes, may the human voice of laughter be traced from phylogenetic precursors?

Illustration: TiHo Hannover / Scheumann

Mouse lemurs are the smallest primates in the world – and excellent models for studying the evolutionary history of acoustic communication.

Observation of orangutans, gorillas, bonobos and chimpanzees at play show that their young offspring like to play and tickle each other, just like human children. They sometimes emit staccato vocalisations during tickling. These play situations can also be simulated experimentally, for example when human parents tickle their babies and human carers tickle hand-raised young apes. The behaviour and staccato vocalisations in tickling situations of human babies and babies of all four ape species were recorded and analysed using comparable methods of acoustic analysis. The results were studied with respect to graded similarities in the acoustic characteristics of voice. Cross-species similarities and group- and species-specific divergencies in voice were used to establish a cladogram of tickling vocalisations. The topology of this cladogram indicates that human laughter has a pre-human origin and can be derived from gradual changes in the acoustic structure of the tickling vocalisations during hominoid evolution. The determined acoustic topology accurately reflects the phylogenetic relationships between humans and apes, known from phylogenetic trees based on comparative molecular genetic analysis.

Human laughter thus has phylogenetic roots reaching back ten to 16 million years – right back to the last common ancestor of apes and humans. However, humans are probably the only primate species which can convey different social emotions acoustically and which is able to use laughter consciously as a social tool. The comparative approach of the DFG-funded Research Unit enables to disentangle phylogenetically old adaptations from newly evolved human characteristics, thus providing insights into the role of emotions in acoustic communication and their evolutionary history.

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Erika Kothe

Microbes and Minerals

Microorganisms have a major impact, even on geological processes. A better understanding may help us to reduce environmental pollution in soils and plants.

Microbes are found everywhere on Earth. This insight, first formulated by Antonie van Leeuwenhoek at the end of the 17th century, has led to the widespread assumption that microbial activity on rock is insignificant and can be disregarded. No-one expected to find microorganisms deep in the Earth. When geologists were contemplating the formation of minerals, weathering or transformation of mineral phases, they didn't consider the possible effects of microbes for a long time. It wasn't until the last few years of the 20th century that scientists began to understand that microbes have an essential and, depending on the particular microbial community, varying impact on the aqueous and solid phases of the Earth. It is thus important and enlightening to study microbial processes more closely and to understand the details.

Analysing the effects of microorganisms on minerals is a relatively young sub-discipline, which lies at the interface between geosciences and microbiology. It involves the study of microorganisms from all three biological domains of cellular organisms: bacteria, archaea and eukaryotes. Algae and fungi, as representatives of the eukaryo-

Illustration: GRK 1257 / U Jena

Lab culture with pine seedlings and fungi that is used to study symbiotic relationships.

tes, are mostly found in the uppermost zone of the ground. The DFG-funded Research Training Group "Alteration and Element Mobility at the Microbe-Mineral Interface" studies the differing abilities of microorganisms with the aim of elucidating fundamental biogeological processes.

The work focusses on environmental problems arising from mining activities, particularly those caused by weathering of pyrite, a mineral that is frequently associated with metallic deposits. It has been known for a long time that bacteria participate in pyrite oxidation and the formation of acidic mine waters. Thus, the question is: Is it possible to influence processes that have a damaging effect on the landscape and environment, and once they are understood in detail, perhaps even exploit them for remediation purposes?

Illustrations: GRK 1257 / U Jena

Left: Focussing on geochemical properties of the ground. Top: Laboratory tests to study how heavy metals affect the metabolism of microbes.

The waste rock heaped up during extraction of metal ores is gradually weathered, thus releasing co-crystallised metals, which are particularly soluble in the resulting acidic waters. To analyse these processes, a test site was set up that is being used to study natural processes, the effects of microorganisms and, in particular, for controlled experiments to test and develop possible remediation methods. The projects at the University of Jena combine laboratory and field experiments to study the uptake of heavy metals in plants by inoculating the ground with suitable bacteria and fungi. This has the advantage that the plant material can be harvested and incinerated, and the resulting ashes can be disposed of without having to excavate the ground with its associated long-lasting impact.

The "playground" for this work is located at the former uranium mining site near Ronneburg, 50 kilometres from Jena. The research team has set up a test field on the remediated Gessen leaching heap to study processes involved in the interplay between water, rock and microbes. There are three topics of particular interest: biomineralisation, bioconversion, which is the conversion of minerals by microbes, and the influence of microorganisms on the weathering of minerals.

New biominerals have been identified at the site. For example, tests on culture media showed that certain species of streptomyces bacteria were able to form nickel struvite, a mineral related to struvite but replacing magnesium ions in the crystal lattice by nickel ions. This mineral had previously only been produced synthetically and was unknown in nature. That it is indeed a biomineral is seen by the fact that it did not form in the presence of dead cells: only growing cells were able to induce formation of the mineral. Researchers are now trying to identify the genes responsible for biomineralisation. It is quite likely that this ability evolved as a resistance mechanism because the nickel in this mineral is not biologically available and is thus no longer hazardous for a living cell.

With respect to land utilisation by humans, this could mean that in spite of a high total content of metals, the land could be used if these metals – as in the original rock – are present as minerals that cannot be assimilated by plants nor enter the food chain. This generally applies to all stable minerals and not just to nickel struvite. Streptomycetes grown on culture media containing soil were to form different minerals. But not just streptomyces, other bacterial genera were also shown to be capable of biomineralisation, or in other words, able to form minerals.

To study bioconversion, weathering products of the iron-containing mineral pyrite are particularly suitable. Weathering of pyrite releases iron, which reacts with oxygen to form iron hydroxides. This rust causes the red discolouration often seen in bodies of water in mining regions. But other hydroxides, such as those of manganese or aluminum, are also frequently found in mining waters, including the investigated site in Ronneburg.

Isolated microorganisms have to be characterised molecularly.

Illustration: GRK 1257 / U Jena

Illustration: GRK 1257 / U Jena

Growth under stressful conditions: sunflowers find it difficult to grow on soil polluted with heavy metals.

These metal hydroxides can also incorporate other metals and thus act as a geochemical barrier. However, dissolution of such barriers would inevitably lead to the release of these heavy metals.

But do microorganisms also participate in this type of bioconversion? This was investigated using elution experiments in which, for example, the added microbes intensified leaching of manganese. Applied to the research site, this means that the input from such biogeochemical barriers formed in the ground would increase if bacteria and fungi that dissolve manganese hydroxides find better growing conditions than bacteria that assist in the formation of metal hydroxides.

A third research topic looks at the direct influence of microorganisms on weathering processes. This has been demonstrated for minerals such as biotite, but the surface of black shale and graphite can also be attacked by fungi. This was investigated by growing a white rot fungus on a culture medium together with small pieces of rock that allowed the fungal network of filamentous hyphae to grow on the rock fragments. After three months, microscopically small pits could be discerned underneath the hyphae. Compared to the rest of the rock surface, their depth was between a quarter and a third of the hypha diameter. Or in other words, the fungus had "dug" into the surface and dissolved the rock, thus gaining an advantage – it can adhere to the smooth surface. Tests with powdered rock indicated that the organic carbon present in the rock is metabolised to carbon dioxide.

Overall, these studies have confirmed the broad impact of microbes on minerals with respect to their formation, conversion and weathering. These capabilities are well beyond those previously ascribed to microorganisms. The results can be used to predict how plant metal uptake can be controlled by the soil microbe population of a former mining heap. These plant experiments give cause for hope because a satellite image of the test site indicates that the plants in areas that had been inoculated with bacteria and fungi show improved growth. And a greater harvestable biomass also means a greater withdrawal of heavy metals out of the ground – a promising perspective.

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Rafed El-Sayed

Inside the Shrine of the Lion Goddess

Athribis is the last major unexplored temple complex of Ancient Egypt. A long-term binational project aims to get closer to uncovering the secrets of this unique limestone temple.

The several-ton casing block lifts, millimetre by millimetre, as two Egyptian excavation workers pump blasts of air alternately into the four lifting cushions placed beneath it. The awkward teetering of the limestone block, which is seamed with cracks and estimated at nine tons, is watched with eagle eyes by the supervising archaeologists.

The steel-reinforced lifting pads, which were manufactured in Germany and are normally used by fire service crews on rescue missions, enable the workers to successfully lift the fallen casing block into a stable position. With the aid of the "darfîl", a specially-

A noteworthy scene: A canopic jar procession in the sanctuary of Ptolemy XII's temple.

Illustration: Archive Athribis project

constructed conveyor comprising massive wooden planks and concreted steel rollers, the workers easily transport the stone block to its temporary home outside the temple ruins. For more complicated artefacts, particularly those blocks, column drums and capitals featuring fragile coloured decoration, complex lifting mechanisms and transport vehicles must be designed and constructed on a case-by-case basis.

Around 400 stone blocks, most of them featuring coloured relief images or other three-dimensional sculptural elements, still remain inside the Athribis temple ruins. They lie scattered and toppled in the chambers and corridors of the once mighty structure, which is now partially filled with rubble. Today, an estimated one-third of the original construct remains. Like Egypt's other limestone temples, the shrine of Athribis, which was dedicated to a trio of local deities during the 1st century B.C., fell victim to the need for building lime which had been increasing since Late Antiquity. The huge blocks of hewn stone were pounded into rubble in situ before being burnt in nearby lime kilns to produce powdered lime.

The archaeological team, which has been excavating Athribis since 2003, has already identified and mapped several of these lime kilns. According to the data collected to date, the destruction of Athribis' limestone monuments must have begun during the High Middle Ages and continued into the early modern era. Among the witnesses to this last phase of Athribis' history are countless ceramic vessels from the Islamic period, as well as coin hoards and several ostraca (pottery sherds) with Arabic inscriptions. By the time the first European travellers came to the Achmîm-Sûhâg region (and sometimes to Athribis itself) in the 17th century, the ruins of the town and its temple were already buried under a thick layer of sherds and drifting sand.

The excavation site lies in Upper Egypt, around 400 kilometres south of Cairo, on the West bank of the Nile near what is now the governorate's capital, Sûhâg. The ruins of the Ptolemaic-Roman town complex, which are now covered with wind-blown sand, lie directly on the edge of the Libyan Desert's high plateau, the limestone formation of which rises to 264 metres above sea level. The inhabitants of the town had their tombs cut into the face of the rocky outcrop, which slopes gradually down towards the town. This largely unexcavated necropolis is the source of a considerable number of the coffins (and the mummy plaques originally attached to them) which are to be found in many of the world's museums labelled with "Achmîm", an imprecise description of their origins.

Left: Heavy work – a one-ton building block is removed with the help of the "darfîl" track. Below: The view from the west overlooking the extensive site and the temple area.

Sections of the ancient living quarters in the east and south of the town have already fallen victim to modern development and land reclamation, a fact which prevents the original dimensions of the town from being precisely calculated. Covering around 20 hectares, Athribis was one of the country's medium-sized towns. The Athribis excavation site is also particularly prized by archaeologists investigating Graeco-Roman Egypt because the remains of the other known settlements in the Achmîm-Panopolis district have been buried beneath modern buildings, rendering them inaccessible to researchers.

The sacred shrine of the goddess Repyt, who was recognised since the pre-dynastic period but never one of the country's major deities, was originally shielded from the outside world by a brick enclosure wall more than ten metres high and five metres thick. Cult activities in Egypt's temples took place in secret. On certain festivals, however, a festive procession carried the religious symbols of the gods out into the open and paraded them along a special procession route for believers to see. Athribis was home to one of these procession routes. Back in the 1990s, ninety metres of a paved pathway were discovered leading from a quayside outside the town to the temenos' main gate. The remaining 100 metres are still awaiting excavation.

The massive enclosure wall, which enclosed an area of three hectares, has now been largely destroyed, leaving the interior ruins of the temple precinct exposed. This area was deconsecrated at the beginning of the 5th century A.D. by Christian monks. In the 19th and 20th centuries in particular, considerable sections of the enclosure wall and domestic buildings, as well as later monastic installations, were literally hacked down

The lion-headed goddess Repyt. The sun and "Uraeus" above her head indicate that the goddess of Athribis is a solar deity.

Illustrations: Archive Athribis project

A multi-coloured capital fragment rests on a specially constructed turntable. This facilitates changes of direction during transportation.

by fertiliser-hungry farmers, known as Sabbâkhîn, and carried to their fields. There is, however, still more remaining of the monastery in Athribis, the origins of which date back to the first half of the 4th century, than there is of most comparable sites.

The monastery complex is probably the large convent which formed part of the local monastic federation from the end of the 4th century. Under the direction of Abbot Shenute, this federation was expanded to become the most significant institution of its type during the period from 385 to 465 A.D. The Athribis excavation site therefore, not only holds particular importance for the archaeology and history of the final phase of pagan Egypt but also has strong significance for early Christianity in Upper Egypt.

While the Napoleonic Expedition, which documented the archaeological remains of the ancient Egyptians and the peculiarities of their contemporaries in minute detail during the first undertaking of its kind between 1799 and 1802, took no notice of the site, the expedition to Egypt and Nubia sponsored by the Prussian King, Friedrich Wilhelm IV, and headed by the linguist and Egyptologist C. Richard Lepsius, visited the Athribis ruins in 1845. As, at the time of Lepsius' visit, the temple and ruins of the town were already mostly covered with rubble and sand, his notes illustrate just a few wind-exposed inscriptions and the façade of the rock-cut temple at the centre of the necropolis.

Actual archaeological excavation began in 1906, when the founder of Egyptian archaeology, W. M. Flinders Petrie, partially excavated the main temple of Athribis during a six-week campaign commissioned by the "British School of Archaeology in Egypt". A preliminary plan of the temple, as well as descriptions of the part of the wall relief and inscriptions excavated during that short time, were subsequently published.

Regrettably, this hasty excavation resulted in the irrevocable destruction of the majority of the archaeological context. There was also no documentation made of the archaeological finds and discoveries, information which would have been invaluable in reconstructing the temple area's functions during Late Antiquity.

Luckily, Petrie left large areas of the temple ruins undisturbed and, even after the excavation campaigns carried out by the Supreme Council of Antiquities from 1983 to 1996, which aimed to re-excavate the temple Petrie had reburied, large sections of the temple ruins remain untouched. One factor in the premature end of the Egyptian venture were the problems involved in removing the stone blocks. These weigh up to 30 tons each and rest atop the heaps of rubble filling the temple ruins.

In 2002, on the initiative of the author of this article, a cooperation agreement was signed between the University of Cologne (Christian Leitz) and the Supreme Council of Antiquities (Yahya El-Masry). The new project, initially funded by the Fritz Thyssen Foundation in 2003 and 2004 and then adopted into the DFG's funding programme when it relocated to Tübingen in 2005, aims primarily at the archaeological and philological exploration of one of the last unexcavated temple complexes of Graeco-Roman Egypt.

The long-term project goals include the reconstruction of the history of ancient Athribis and its cults, and the publication of the hieroglyphic inscriptions. The 1500-plus inscriptions surviving in the temple built during the reign of Ptolemy XII Neos Dionysos (80–58 and 55–51 B.C.) to the deities Min and Repyt form the most significant cohesive text corpus originating from the region of Achmîm-Panopolis, an area in which the Ancient Egyptian cults persisted until the 5th century A.D.

Inside the Temple of Ptolemy XII: The inscriptions on this exterior wall list the names of the goddess Repyt.

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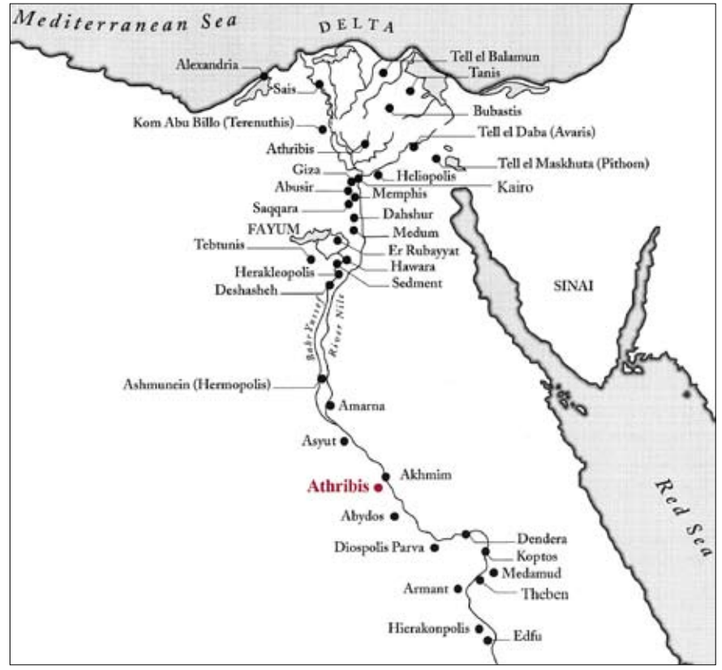

Kristine August

Passion Late Middle Ages

Between Cambridge and Heidelberg: Historian Jörg Peltzer has a European outlook – both in his research into princely elites and in his academic career

We join Jörg Peltzer in the Quellenraum [Primary Sources Room] of Heidelberg University's History Department: "This is the heart of the library. Working with contemporary sources is both the substance and the attraction of historical research." Peltzer, 36, is a historian at Heidelberg University's Institute of the History of Franconia and the Palatinate (FPI) whose current research topic is "European Princely Elites of the Late Middle Ages, A Comparison". Arriving in the department's old auditorium, one thing quickly becomes clear: delving into primary sources for research and teaching purposes is Peltzer's passion. Peltzer considers his student field trips another of his job's high points, describing them verbatim as "sunny days". "Direct interaction is very important in teaching. It's a tremendous motivator."

Peltzer's research group is particularly interested in the "formation and visualisation of rank and order" in the 13th and 14th centuries. The team is performing an interdisciplinary investigation into how electoral princes communicated and demonstrated their ranks. Two sub-projects, for example, are investigating how building massive fortresses literally reinforced a prince's status. The project combines historical and architectural perspectives, as well as taking into consideration issues pertaining to judicial, art and political history.

Peltzer researches, lives and thinks internationally. Having grown up close to France, he decided to spend a year studying in Angers under the ERASMUS programme. What began as a brief sojourn abroad would, in Peltzer's case, turn into eight years. He went on to pursue a Master's Degree in Birmingham and a DPhil in Oxford, and studied primary sources in Paris and London. Finally, he was offered his first job in Cambridge. The international nature of his career quickly explains why Peltzer publishes a great deal in foreign languages. In 2009/10,

Illustration: August

the Emmy Noether Programme took him back to the UK for a further year.

Gaining an external perspective and comparing different countries have influenced more than Peltzer's research. Although he doesn't consider England to be the researcher's paradise, his university experiences have had a profound effect on his attitude, and have particularly shaped his views on managerial tasks. "A group leader's job is to ensure that everyone knows where he or she stands. This is the basis for open, relevant and cooperative communication." Peltzer learned to appreciate this type of communication during his time in England. "It's important that everyone in the group gets along. Then everything else will fall into place." During his last year abroad, therefore, he met with his group regularly – almost every two weeks.

Clear perceptions and pragmatic decisions permeate Peltzer's CV and his daily work. In hindsight, however, some of them were coincidence. Indeed, Peltzer had almost studied business administration. At the last moment, however, he decided to pursue his deeper passion. "I can always do economics later." After completing his Master's Degree, Peltzer stayed in England – and with the Late Middle Ages, his first love. As history is his passion, Peltzer almost never has time to read for pleasure. Two walls in his office are lined by bookshelves, and the conference table is covered: His most recent reading material comes from England, where colleagues would hand him texts, telling him to "take them and do something with them". It is precisely this trust that the historian has learned to appreciate about the collegial working atmosphere in England. Although Peltzer still "had plenty to do" there, he returned to Germany in the autumn. For all his internationality, his life now centres on Heidelberg. The researcher – who is funded by an ERC Starting Grant – and father of three small children emphasises: "It was time. If I go abroad again, I'm taking my family with me."

Kristine August
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Ulrich Vogl and Martin Weitz

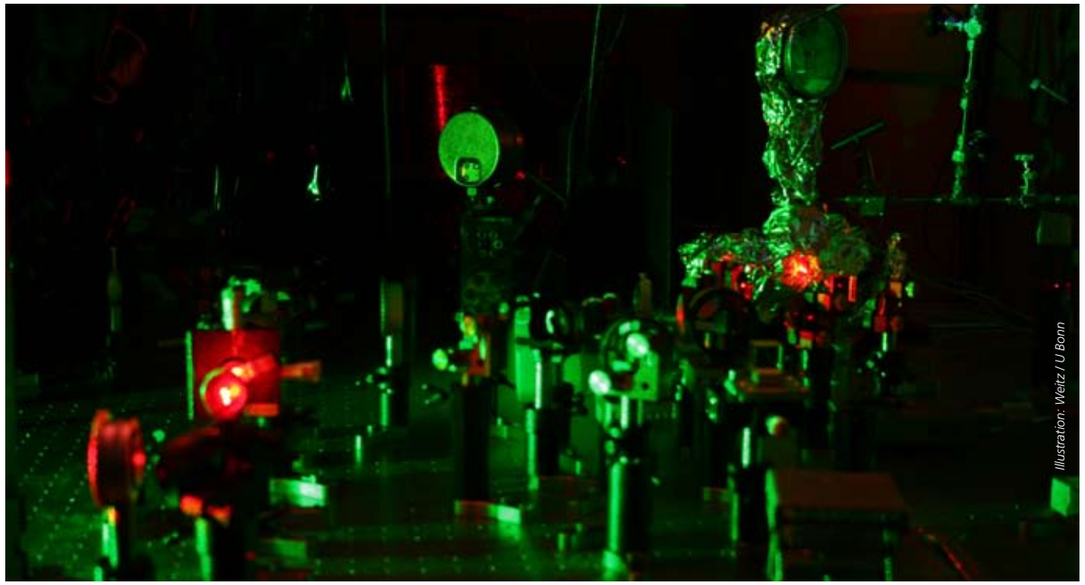


Illustration: Weitz / U Bonn

Cooled by Light

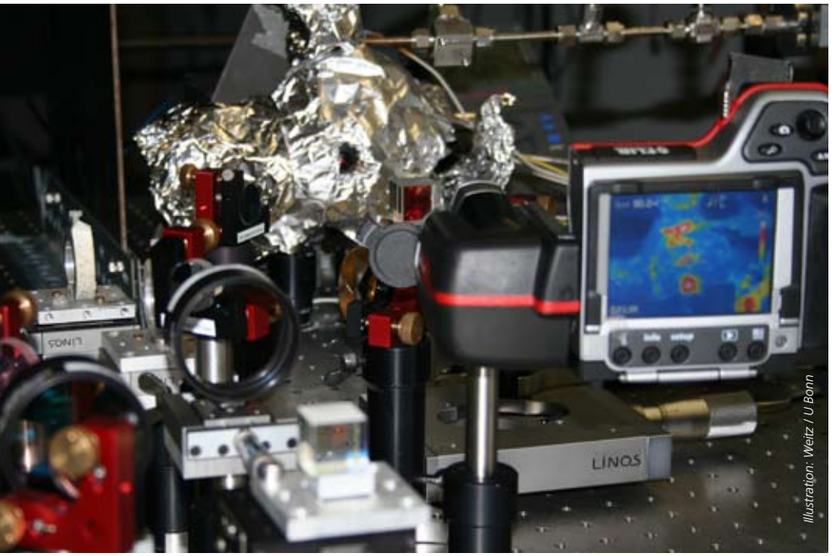
Using laser bombardment, physicists are developing a powerful method for lowering the temperature of atomic gases at very high pressures. For materials research, this opens new possibilities – and, in the long term, may even lead to the development of new freezers.

For decades, physicists have been fascinated by the idea of cooling materials with light. But light cooling would appear to contradict our everyday experience. Because normally, when material is illuminated with light, a large portion of the energy contained in the optical radiation is converted to thermal energy. This leads to heating, familiar from summertime sunbathing as well as laser welding.

Thus, the thought experiment posed by German physicist Peter Pringsheim in 1929 for light cooling was somewhat unusual. His initial idea was to use sodium vapour. Sodium atoms have two particularly strong optical transitions, the so-called sodium D lines, which are also responsible for the yellow colour of modern street lighting. Pringsheim suggested irradiating sodium vapour with light that is tuned to the lower energetic of the two transitions – the D1 line.

Normally, atomic gases illuminate energy-neutral at the incident wavelength. If, however, energy from the thermal movement of the gas were to be converted to excitation energy, which Pringsheim imagined to be possible due to the collisions between the atoms, the atoms should emit light at the more energetic of the two D lines, the D2 line. The result: the emitted photons take with them additional energy that originated in the atomic movement. Thus, more energy can escape from the sodium vapour than was supplied by the irradiating light field. This simply means that the gas is cooled.

During Pringsheim's time, it was not yet possible to realise light cooling of materials. With the discovery of the laser several decades later – a very spectrally pure and powerful light source – the idea of optical cooling entered the realm



The experimental setup for laser cooling (with infrared camera).

of the experimentally possible. The greatest influence on further research in this area was the suggestion of "Doppler cooling" of diluted atomic gases, a procedure suggested in 1975 by Theodor Hänsch and Arthur Schawlow and shortly thereafter experimentally realised by Russian and American researchers.

With gases, the temperature is a measure of the average speed of the atoms. In other words: the hotter a gas, the faster the atoms move. With Doppler cooling, atoms that are irradiated with a laser beam are pushed into resonance by means of the Doppler effect and braked by light pressure. Using several light beams, it was possible to cool very diluted atom clouds to temperatures just a few millionths of a degree above absolute zero. This led to the development of the very successful field of physics of ultracooled atomic gases, reaching what may be considered its highpoint in 1995 with Bose-Einstein condensation. To date, six Nobel prizes have been awarded in this area of research.

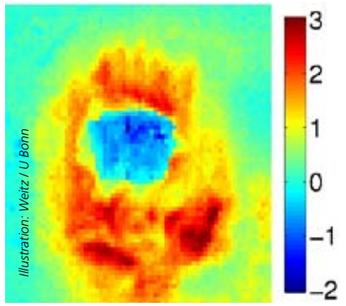
In the mid 1990s, solid materials, i.e., solids, were cooled by means of light using another approach: so-called anti-Stokes cooling. With this method, material is cooled if the energy of the photons emitted by the solid is, on average, higher than that of the incident photons. For the laser cooling of solids, atoms of rare earth metals with suitable optical transitions must be introduced into very pure glasses. The lowest temperatures achieved thus far are –130 degrees Celsius.

In our work, we are examining laser cooling of atomic gases at very high pressures, typically 200 times the standard ambient pressure. The gas density here is approximately ten billion times greater than the parameters used in the Doppler cooling experiments. As with the cooling of solids, this method involves the cooling of macroscopic materials.

In concrete terms, a mixture of rubidium gas and a high concentration of argon is used. Rubidium is an alkali metal and is, thus, chemically similar to the sodium discussed in Pringsheim's work. The addition of the noble gas leads to considerable broadening of the spectral lines of the rubidium atom: at gas pressures of 200 bar, pressure broadening of the spectral lines of the optically active rubidium atom is on the order of the thermal energy of the gas. Thus, the energy exchange between the light field during excitation of the rubidium atom and kinetic energy transferred during collisions between rubidium atoms and argon becomes efficient. The use of a nobel gas – alkali atom mixture for impact-induced laser cooling was proposed in 1978 by physicists Paul Berman and Stig Stenholm. Using gases at standard pressure, it was, however, never possible to observe any cooling.

For laser cooling of the high-pressure ensemble, we use a laser light with wavelength of 815 nanometres in our experiments in Bonn. This wavelength is several nanometres longer than the D lines of the rubidium atom (which lie at 780 and 795 nanometres). Thus, the energy of the incident photons is not actually sufficient for exciting rubidium atoms. But this changes if a rubidium atom collides with an argon atom. The rubidium atom is disturbed, its transition energies are shifted slightly and, at the time of collision, less energy than usual is needed to raise the electrons of the rubidium atom to an excited state. The rubidium-argon pair tensions a spring, as it were, when the atoms collide.

Following the collision, the electron orbits in the atom normalise. To remain in the high orbit, the electron needs a bit of energy. This is drawn from the kinetic energy of



the atom which, as a result, slows down. Both the rubidium and the argon atoms are slowed; the temperature of the gas drops. After a few nanoseconds, the excited state of the rubidium atom decays to the ground state. The atom is then available for further cycles of the laser cooling process. In order to verify cooling, a high rubidium density is necessary. At room temperature, rubidium is a soft metal; a sufficiently high rubidium vapour pressure is formed at temperatures of 350 degrees Celsius. It is the high rubidium vapour pressure that allows the gas to be cooled with the laser.

The cooling achieved by laser radiation could be experimentally observed for the first time using an infrared camera. For this purpose, the camera was pointed at one of the optical windows of the used high-pressure cell. Due to the thermal transport through the window material, we expected that the temperature decrease in the gas would lead to a temperature change of the cell window, albeit a considerably smaller one. In the experiment, the infrared camera was used to detect cooling of the cell window near the cooling laser beam (adjacent figure), allowing for a very direct, qualitative verification of the collision-induced laser cooling.

Later, the temperature change in the gas itself was experimentally examined. The cooling also changes the density of the gas. Density changes in gases are also responsible for phenomena such as the Fata Morgana or the "mirage effect" (reflections above heated road surfaces). In the experiment, the temperature profile produced by the first cooling laser beam was scanned with a second test laser beam. In doing so, a temperature change of 66 degrees Celsius could be measured in the centre of the cooling laser beam and the fundamental effectiveness of the process verified.

The cooling efficiency, i.e., the ratio of incident light power to cooling power, is approximately four percent, which is a factor of more than 10,000 above the cooling efficiency of the experiments for Doppler cooling of diluted gases. With an incident light power of three watts, this corresponds to a cooling power of approximately 100 milliwatts. The degree of the reduction in temperature achieved in the non-insulated gas sample is determined in these fundamental experiments by the thermal conduction to the outside. Recent measurements indicate that higher gas densities and stronger focussing of the cooling laser light can be used to cool the gas to considerably lower temperatures.

The new cooling method could help create new material states. With faster cooling, gases remain gaseous at temperatures at which they would normally be liquid or even solid. Similar effects occur with water, which can be lowered to –42 degrees Celsius without freezing. If cooling occurs very quickly, even lower temperatures are possible. "Supercooled" liquids and gases exhibit very interesting properties. The experiments could be advanced further if gases that are gaseous at room temperature, e.g., many molecular gases, could successfully be cooled using the collision-induced laser cooling method. This would allow one to forego the initial heating required for vapourising the rubidium atoms. The laser cooling method could be technically interesting for the development of innovative mini-refrigerators or even contribute to the cooling of infrared detectors or astronomical cameras.

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Brigitte Küppers

Like Attracts Like

Inspired by taking a close look at Mother Nature, polymer chemists began synthesising chains of molecules that all have the same length and structure and which can even self-replicate. With this work, they are developing fundamental principles for new and interesting materials.

Nature showed the way: genetic information of living beings is stored in chain-like DNA molecules that duplicate themselves during cell division when one DNA double strand produces exactly two new strands with an identical length and structure. About 1016 cell divisions take place during a human lifetime, and thus the DNA of a single fertilised egg can theoretically produce up to 10 000 000 000 000 000 identical copies. But the most remarkable fact is that the DNA molecule itself contains the necessary information for self-replication, for the helical arrangement and for further superstructures – including that of chromosomes – and this complex information is passed on with every replication.

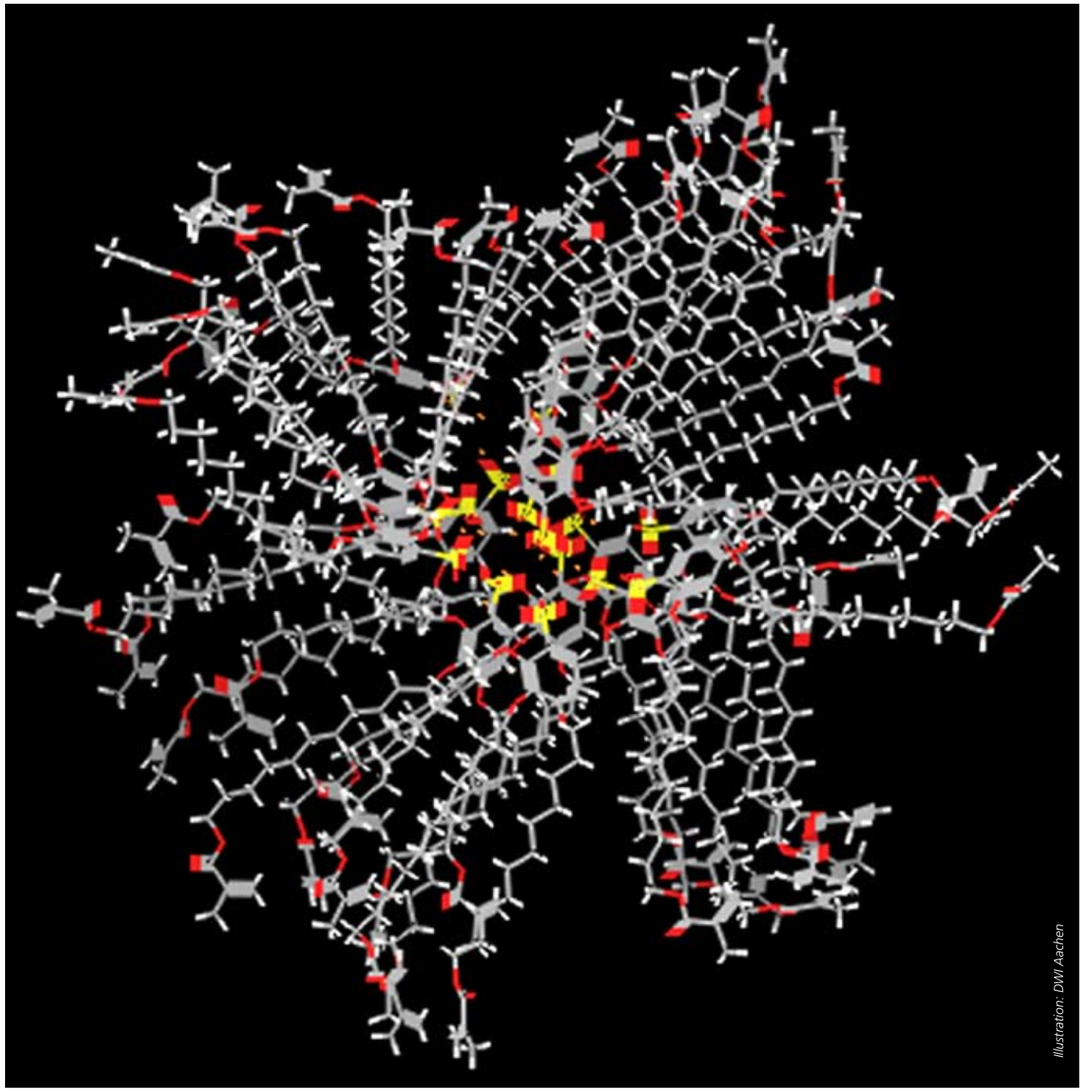
When humans want to produce parts with an identical shape, they use patterns or templates. A template is rather like a baking tin that always produces biscuits with the same shape. In the field of synthetic chemistry, there is no method or "baking tins" to synthesise polymer chains with an identical length and structure so far. Beverage bottles made of polyethylene terephthalate (PET) or Perspex sheets made of polycarbonate always consist of a mixture of polymer chains with different lengths. This is not a problem for mass-produced plastics. There are, however, other applications and products whose desired properties are associated with uniformity.

The Aachen polymer chemists Martin Möller and Xiaomin Zhu have developed a method with which polymer chains can replicate themselves. Similar to DNA, the polymer chain is simultaneously the template and the construction plan for the organisation of subunits into structures with a higher order. The trick: the superstructure governs the basic structure of the newly polymerised chains. Or in other words, the ability to self-organise is exploited during self-replication.

The chemical compounds used by Xiaomin Zhu are made up of two parts. One type of building block is wedge-shaped molecules with a sulphur-containing acidic group known as sulphonic acids. The water-attracting or hydrophilic acid group forms the tip of the wedge. The wider, outer part of the molecule is water-repelling or hydrophobic. The wedge-shaped sulphonic acid molecules spontaneously arrange themselves into rod-shaped, cylindrical structures.

The second building block is a polymer chain with basic side groups – a poly(vinyl pyridine). The chain acts like a backbone, and the basic side groups interact with the acidic functionality of the sulphonic acid molecules. Whereas the individual sulphonic acid molecules arrange themselves into cylinders, the sulphonic acids bound to the polymer backbone self-organise according to the degree of neutralisation. The complexes form lamellae or cylinders depending on how many basic groups of the polymer chain have been neutralised by the acidic groups.

A high degree of neutralisation of about 80 percent forces a particularly dense and space-saving packing into cylinders. If there are fewer sulphonic acids, they form layers. Replacing the poly(vinyl pyridine) backbone with other, less rigid polymer chains produces cylinders at lower degrees of neutralisation. The polymer chains inside the cylinders are not necessarily extended. The more flexible the chain, the more likely it is to form a helical structure. The key factor is that the contour length of the polymer backbone determines the length of the cylinder. Short contour lengths tend to produce a more spherical globular complex, whereas longer polymer chains



Like a piece of modern art: top view of a model of a supramolecular cylinder made of sulphonic acid molecules.

form cylinders. This means that it is possible to control the dimensions of the complexes.

The core/jacket structure of the cylinders mimics the structure and layout of the tobacco mosaic virus (TMV), which is one of the favourite "experimental animals" used by virus researchers. The TMV is a rod-like particle about 300 nm long and infects only plants, including tobacco. The RNA chain in the TMV is surrounded by protein molecules arranged highly symmetrically into a cylinder. In the synthetic system, the wedge-shaped sulphonic acid molecules represent the natural protein building blocks and the polymer backbone is the RNA. Beyond nature's building concept, the synthetic building blocks can

be varied, modified and combined in different ways.

The unusual feature of the self-organising polymers is not just that their structure follows nature's example and the possibility of dimensional control, they also have the ability to self-replicate. Unlimited numbers of identical copies can be made of both the outer cylinder and the central polymer chain. The cylinder acts as an external template for the polymer backbone. Dissolving the polymer chain inside the cylinder leaves a template into which the monomers can be incorporated so that they polymerise to form a new polymer chain with the identical length.

The polymer chain, on the other hand, is an internal template that can be used to produce many cylinders with the same length. If the interactions between the polymer backbone and the surrounding matrix are released and sulphonic acid molecules are added to the polymer chain, they form a new cylinder. This mutually interacting system is known as template-to-template polymerisation.

With the synthesis of polymers forming supramolecular structures of defined size and their self-replication, the Aachen researchers are carrying out internationally recognised basic research. They already have their sights on applications for their polymer systems. For example, the cylinders could be used as pores for selective transport systems. By selecting suitable sulphonic acid molecules, the interior of a cylinder functions as an ion channel. The pore diameter and thus the flow rate through the channel can thus be tailored. The channel is stabilised by cross-linking the sulphonic acid molecules. This polymerisation should take place in the outer region of the wedge-shaped molecules, as far as possible, and also be limited to the respective cylinder.

In a further step, the cylinders must be embedded in a matrix. As an everyday simile, this matrix can be likened to a cake batter with the cylinders as cherries. The cherries must be stabilised so that they do not fall apart during baking. Furthermore, the cherries should not clump together but remain evenly distributed in the batter and not sink to the bottom. Just like a cake batter that is spread on a baking sheet and then baked, chemists spread the matrix on a surface and polymerise it with light or heat to form a membrane.

To make the pores accessible, the rod-like cylinders must be oriented perpendicularly to the surface of the substrate. The orientation of the channels is controlled via surface tension and the surface structure of the substrate or by application of an electric or magnetic field. Future studies aim to develop switchable transport systems. This involves incorporating light-sensitive side groups in the sulphonic acid molecules whose three-dimensional structure undergoes light-induced changes that open and close the ion channels. Such "ion-selective membranes" can be beneficial for example, in fuel cells.

Illustrations: Winandy / DWI Aachen

Left: Working with an atomic force microscope. Top: Solutions with light-sensitive sulphonic acid molecules that change their three-dimensional structure on exposure to light.

The pores made of sulphonic acid complexes offer further possible applications. For example, the interior of the channel can accommodate an electrically conducting polymer. The oriented pores and polymer chains can be used to produce extremely uniform materials that are electrically conducting in only one direction.

The interior of the channels can also be used for "chiral" syntheses. The term "chirality" refers to the handedness of pairs of compounds as image and mirror image, like our right and left hands that are identical but do not match when laid on top of one another. Many biological objects, including the DNA double helix, are chiral and arrange themselves into helical superstructures. The cylinders composed of wedge-shaped sulphonic acid molecules can form helical polymer chains in their interior and are thus ideal candidates for copying the chirality of biological structures.

This involves a chiral arrangement of the sulphonic acid molecules that project into the interior of the cylinder. Using these cylinders as a template for the synthesis of the central polymer chains means that the alignment of the side groups on the chain backbone is also predefined. The aim is to develop a simple synthesis mechanism for polymers whose side groups are all pointing in one direction. Such polymers are interesting materials because they have a high tensile strength and a high melting point.

"Chirality", "selectivity" and "self-replication" are keywords for typical properties of natural systems. The templates of the chemists from Aachen were inspired by nature and enabled the synthesis of exact copies of polymer chains for the first time. This new synthesis technique opens up a route for applications that include selective transport systems, sensors or generation and storage of energy. Also their use as a membrane in fuel cells or lithium ion batteries is an important and wide field. Further applications are sure to come thick and fast.

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Michael Marré, Daniel Pietzka and A. Erman Tekkaya

Lithe and Lissom – From the Hands of Robots

Lighter frames make automobiles and aircraft more agile and environmentally friendly. Their design and manufacture require a complex combination of construction principles, materials and processes. Engineering scientists have created a production chain that combines automation with flexible manufacturing.

Illustration: Transregio 10

They are the supportive skeleton of automobiles, aircraft and motorcycles: frames that make a vehicle safe, strong and stable. In the event of an accident, they protect passengers, as they absorb a portion of the crash energy. And they withstand stress tests, such as hot summers, cold winters and potholes without problem.

In addition to these challenges with which they must contend on a daily basis, the frames must, above all, be lightweight and cost-effective to manufacture, whereby, the lighter, the better. Because a lower weight means lower energy consumption. This protects the environment and spares the wallet. Thus, frames can be considered to be hidden "jacks-of-all-trades" that do their important work in automobiles and aircraft behind covers of metal and plastic.

For engineers, it is a great challenge to design and manufacture such frames. In particular, when working to reduce the weight, i.e., in the lightweight construction of such frames, numerous and multidisciplinary questions arise that can only be addressed in a team. Lightweight construction is one of the most complex engineering disciplines, as it requires extensive specialist knowledge on design principles, materials and manufacturing processes. This, all with the goal of reducing weight and thereby saving energy.

But why does a reduction in weight always lead to lower energy consumption? In order for an automobile to drive up a mountain, for example, four forces need to be overcome: the rolling resistance of the tyres on the road, the grade force, the acceleration force and the air resistance. Rolling resistance is responsible for causing a rolling object – be it a ball or an automobile – to slow down and eventually come to a stop after having been given an initial push. In order for an automobile to be driven, the rolling resistance must constantly be overcome by the drive power. The greater the vehicle weight, the greater the rolling resistance.

Another force that must be overcome by a vehicle is the grade force. This is the force that makes skiing and sledging possible in the winter. A vehicle must overcome this force when driving up a mountain. Here too, the heavier the vehicle the greater the grade force. Every car journey naturally begins from a standstill. To increase the speed, the vehicle must be accelerated. The acceleration force is likewise dependent on weight. The fourth and final force is known as air resistance. Only this force is independent of vehicle weight.

To a certain degree, the motivation to reduce weight is driven by legislation. In the future, motor vehicle taxes will be coupled to CO_2 emissions. The more fuel a vehicle consumes, the more CO_2 it emits and, the greater the CO_2 emissions, the higher the motor vehicle tax. In 1995 the average CO_2 emission of all vehicle models of all automobile manufacturers was 185 grammes per driven kilometre.

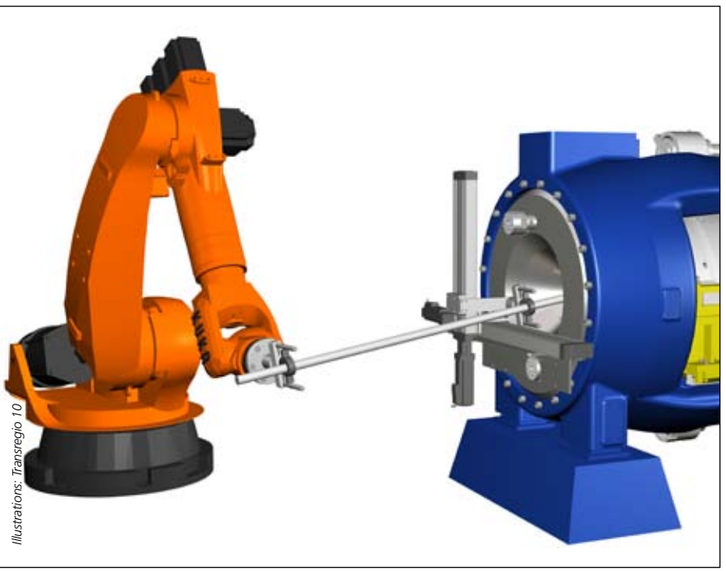
By the year 2012, automobile manufacturers hope to reduce fuel consumption by one third. Average emissions will then be just 120 grammes per driven kilometre. This goal can only be attained through lightweight construction.

Focus is, thus, primarily on the car body. This is not by chance, as approximately 40 percent of the vehicle weight is, at present, in the car body. But other parts of the vehicle, such as the steering column and its components, are affected by this "weight loss diet". Every kilogramme counts, a fact not lost on drivers when at the pump. Today, an average mid-size car weighs between 1500 and 2000 kilogrammes. A reduction in vehicle weight of just seven percent (equivalent to about 100 kilogrammes) can lower fuel consumption by nearly half a litre per 100 kilometres.

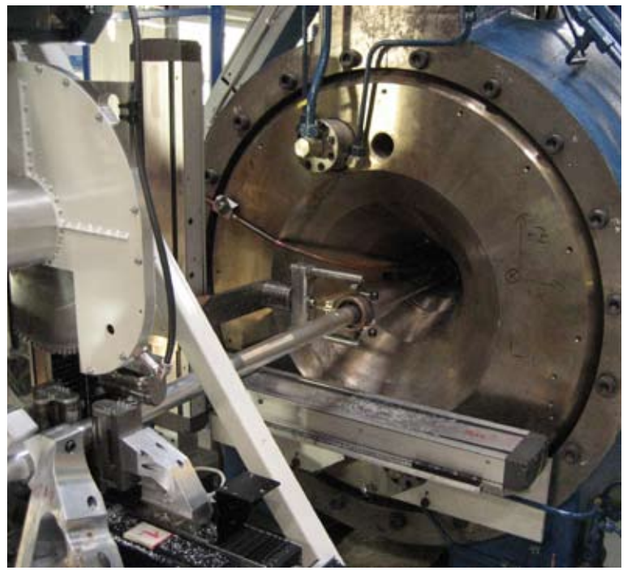
For the driver's wallet, a 100 kilogramme reduction in vehicle weight means an annual saving of approximately €300, at today's fuel prices. Because fossil fuels, such as gasoline and diesel, are becoming increasingly scarce, leading to corresponding increases in price, one can expect that the savings attained through lightweight construction will be considerably greater in the future. For the environment, this means a drop of 25 grammes of CO_2 per driven kilometre or the unimaginable amount of one tonne of CO_2 for every lighter-weight vehicle every year.

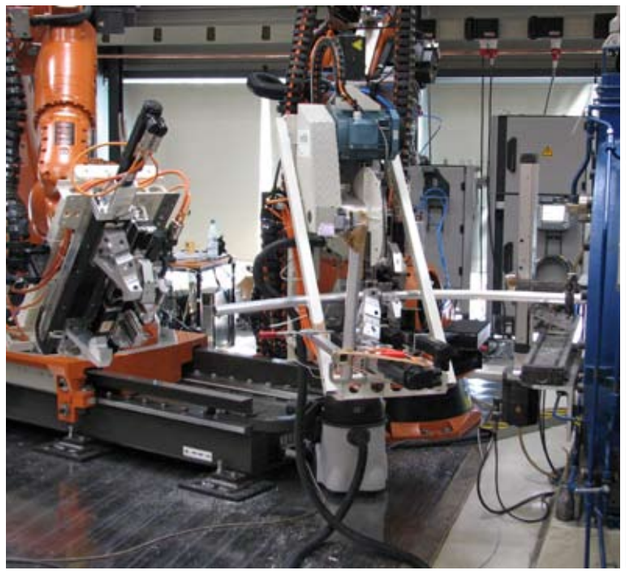
In their efforts to design lighter frames – and, thus, lighter vehicles – the engineering "slimming experts" need to know the wishes of the customers. In addition to a vehicle that has an economical purchase price and maintenance costs, the automobile buyer also wants a distinct car. This vehicle should be designed so that it meets the needs and wishes for individual mobility – be it for city traffic only, long commutes or for handling small or large transport tasks. The automo-

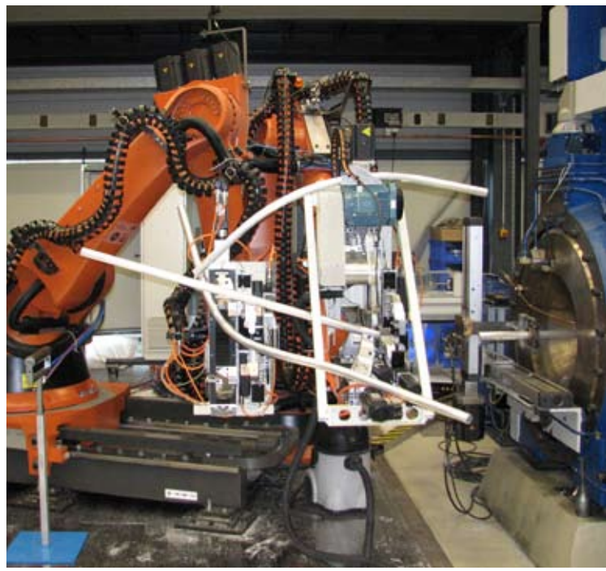
Sequence of steps in a productive process chain (left to right): First, planning takes place on a PC. Engineers calculate the coupled movements between robots (at left in image) and extrusion press (right). – The first robot deflects the straight profile and creates the desired curvatures, the second supports the profile and passes the created frame on for further processing.



Illustrations: Transregio 10







bile manufacturers responded to this issue long ago. Volkswagen, for example, has introduced a platform strategy. The various vehicles are constructed on a floor plate; various floor plates are available for a wide range of different requirements. Thus, maximum flexibility is required in the manufacturing process and must be developed further.

Lightweight construction and flexibility in manufacturing are viewed as two complex and challenging tasks. Engineers from Dortmund, Karlsruhe and Munich have now developed an assembly line for lightweight frames. What's clever: production can flexibly be changed from piece to piece on short notice. This was not previously possible when constructing lightweight frames. The assembly line starts with a process reminiscent of a Christmas bakery: when making shortbread biscuits, the dough is pushed out of a bag through a nozzle. Aluminium processing employs a similar principle. A block of aluminium is heated and, with the aid of a hydraulic press, is then pressed under great force through a nozzle. The aluminium profile that emerges is pressed in various directions by a robot. A ready-to-install profile with complex contour is thereby produced in a single step.

Machining of long, three-dimensionally curved profiles on a machining center. The center is built up of three major components: an industrial robot, a parallel kinematic machine tool and a flexible clamping device which is positioned in-between.

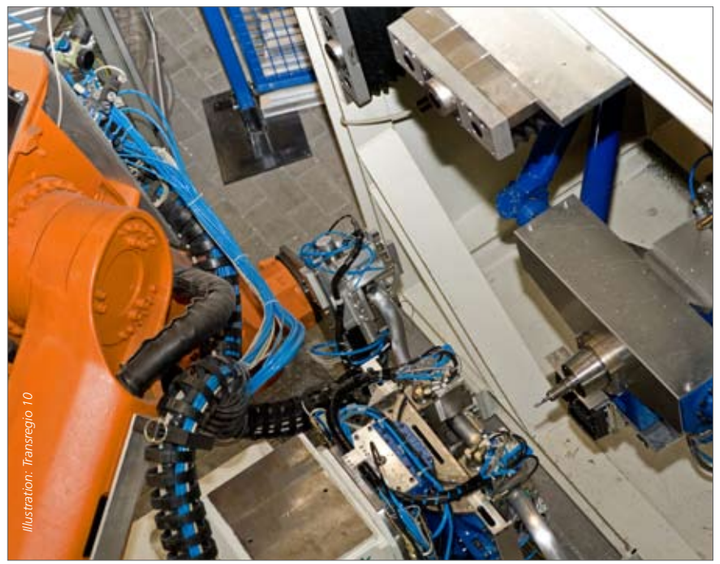


Illustration: Transregio 10

This innovative process is called curved profile extrusion. Using the profiles manufactured in this way, the frame can be assembled step by step. Because curved profile extrusion allows (nearly) any diameter and contour to be created, it was necessary to develop additional processes and tools for further processing. Robots, for example, are used to deflect the profile during extrusion, allowing it to be produced extremely accurately and precisely in just one step. The robots are integrated in the assembly line in such a way that they can communicate with one another with respect to position and orientation of the profiles and then make necessary adjustments to their movements. The robots cooperate with one another, thereby facilitating flexible production of the profiles with the extrusion presses and subsequent transfer in the assembly line.

But there is more: the robots transfer selected components to quality assurance inspections. Further down the assembly line, holes and pockets are milled into the profile. These are needed later for mounting panelling, lights, as well as the engine and transmission. The manufacture of these holes must be as flexible as the production of the profile itself. The engineers of Collaborative Research Centre/Transregio 10 "Integration of Forming, Cutting, and Joining for the Flexible Production of Lightweight Frame Structures" have developed a processing station that allows the manufacture of holes and pockets from five sides and does so without removing, realigning and re-securing the profile.

However, there is more to a lightweight frame than just profiles. To create a frame, these profiles must be securely and permanently connected to one another. Four new and innovative joining processes have been developed for this purpose: joining with internal high pressure, electromagnetic compression, bifocal-hybrid laser welding and friction stir welding for profiles. Due to the complex contour of the profiles, it is often not possible to connect them directly. In these cases, transitions must be created. When installing lightweight frames, joints and connecting elements milled for this purpose are used. These are produced using modern milling centres.

Illustrations: Transregio 10

A lightweight frame with the frame structure of the BMW C 1. The covered scooter was launched on the market in the year 2000.

Profile and joint are then joined together using water pressure. During this process, the profile is in a joint. The profile is widened using a water pressure of 1000 bar – 500-times greater than the pressure in a car tire – and thereby pressed into the joint. Another process shrinks the profile onto a connecting element. This shrinking is achieved through a strong magnetic field and takes place 4000-times faster than the blink of a human eye. Engineers call the process "contactless joining through electromagnetic compression".

With so-called bifocal hybrid laser welding, two laser beams are combined to securely and permanently connect the profiles. The laser beams used in this process are one million times stronger than a standard laser pointer. Friction stir welding is used, for example, to connect panelling to the profiles. With this process, a finger-like pin mixes the two materials in a manner similar to a household mixer. An individual frame is thereby created piece-by-piece. Once complete, the outer panelling is fitted to the frame.

In the future, it is hoped that cooperating robots will assemble the individual parts into frames. The imagination, at least, knows no limits to what might be possible with respect to future possibilities and applications.

Dr.-Ing. Dipl.-Wirt.-Ing. Michael Marré
was administrative director of CRC/Transregio 10: "Integration of Forming, Cutting, and Joining for the Flexible Production of Lightweight Frame Structures" before moving to industry.

Dipl.-Wirt.-Ing. Daniel Pietzka
is the new administrative director of CRC/Transregio 10.

Professor Dr.-Ing. A. Erman Tekkaya
is spokesperson of CRC/Transregio 10.

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www.leichtbau.de/tr10
www.youtube.com/user/SFBTransregio10

The Deutsche Forschungsgemeinschaft

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the areas of basic and applied research. Particular attention is paid to promoting young researchers. Researchers who work at a university or research institution in Germany are eligible to apply for DFG funding. Proposals will be peer reviewed. The final assessment will be carried out by review boards, the members of which are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme,* any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of twelve years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. *CRC/Transregios* allow various locations to cooperate on one topical focus. *Cultural Studies Research Centres* are designed to support the transition in the humanities to an integrated cultural studies paradigm. *Transfer Units* serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

DFG Research Centres are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

Research Training Groups are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focusses on a coherent, topically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In *International Research Training Groups,* a jointly structured doctoral programme is offered by German and foreign universities. Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme.* In so called *Reinhart Koselleck Projects,* the DFG supports especially innovative research undertakings by outstanding scientists and academics.

The *Excellence Initiative* aims to promote top-level research and improve the quality of German universities and research institutions in the long term. Funding is provided for graduate schools, clusters of excellence and institutional strategies.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals for scientific instrumentation. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

Another important role of the DFG is to provide policy advice to parliaments and public authorities on scientific issues. A large number of expert commissions and committees provide the scientific background for the passing of new legislation, primarily in the areas of environmental protection and health care.

The legal status of the DFG is that of an association under private law. Its member organisations include research universities, major non-university research institutions, such as the Max Planck Society, the Fraunhofer Society and the Leibniz Association, the Academies of Sciences and Humanities and a number of scientific associations. In order to meet its responsibilities, the DFG receives funding from the German federal government and the federal states, as well as an annual contribution from the Donors' Association for the Promotion of Sciences and Humanities in Germany.

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DFG recognised as family-friendly employer: Friederike Kölle from the DFG's Human Resources Division received the certificate for the Career and Family Audit from Josef Hecken, Secretary of State in the Federal Ministry of Family Affairs, Senior Citizens, Women and Youth at the end of May in Berlin. The DFG has been certified for the fourth time since 2001, putting it in the exclusive company of a small number of businesses and public institutions in Germany. According to DFG Secretary General Dorothee Dzwonnek, this honours the family-friendly climate and everyday compatibility of career and family – key elements of the culture of the DFG Head Office. "For us the renewed certification is acknowledgement that we are on the right track, and it is motivation for us to continue our targeted, family-conscious personnel policy in the interest of equal opportunity at the workplace. Beyond the DFG, it remains desirable that even more universities and research institutions consistently employ a family-friendly personnel culture."