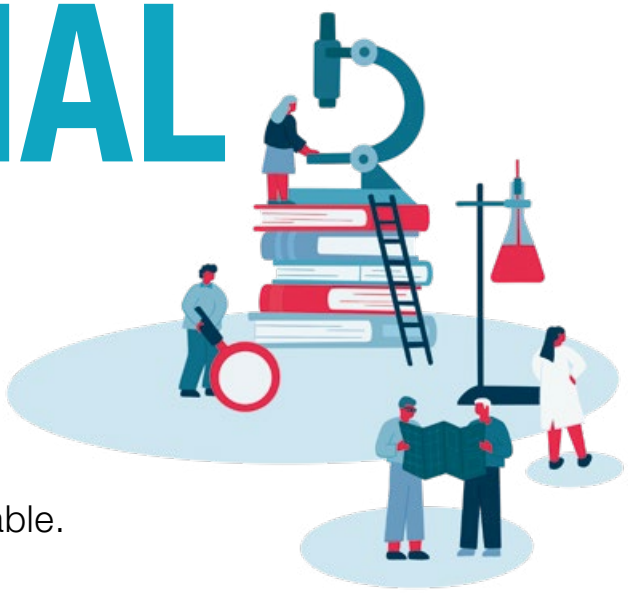
THE ETERNAL "WHY?"



Basic research is geared towards gaining knowledge. It's about understanding the world. At first glance, its economic benefit is not recognisable. But only at first glance.

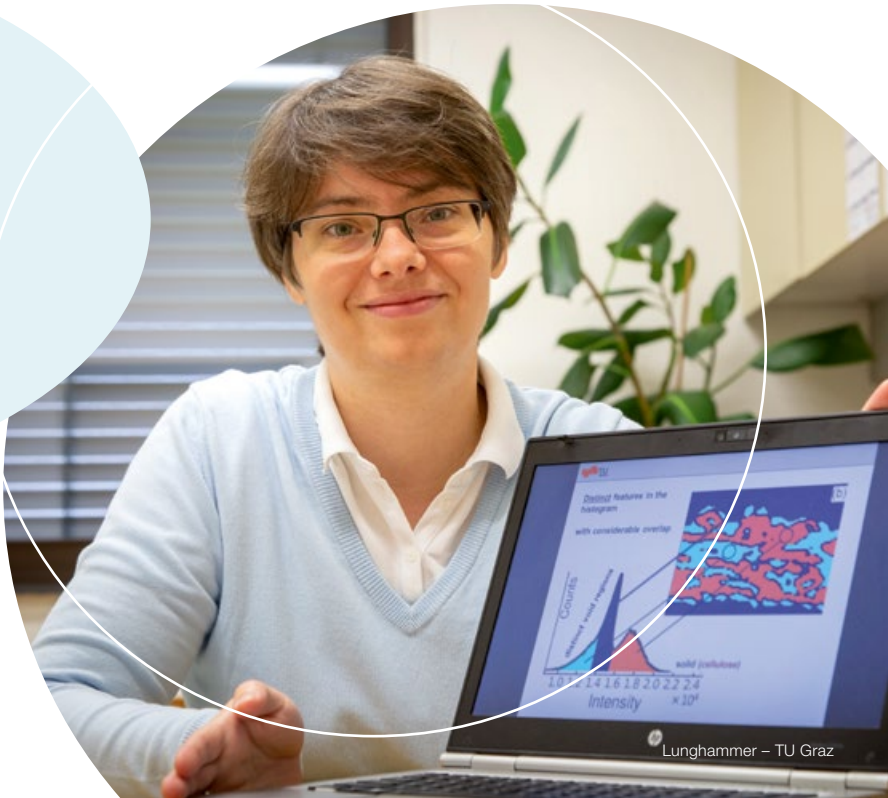
In basic research, "why" is the most important question. Why does our world work the way it does? Why does this material conduct electricity and the other not? How can I connect points without creating intersections? Basic research deals with the foundations of all things; it explains, discovers and reveals. For this reason it is also the basis of all applications and inventions. You have to understand the basics before you can build on them. If, for example, research had not been conducted on electricity, our society as it is today would not exist. There would be no computers, no lights, no electrical machines.

What unites most of those who carry out basic research is their curiosity. "Some things are just interesting," is often said. TU Graz research spoke to some of the researchers at TU Graz and put together a mosaic of basic research.

KARIN ZOJER

"For me, basic research means the freedom to find, ask and pursue questions that arise from the current state of knowledge, without the possible answers having to provide an application perspective. This means that new questions can always be addressed. Even when smart ideas fail, the challenge remains, because they lead to the next question – namely, why?"

Solid-state physicist Karin Zojer is primarily concerned with transport processes in solids. She investigates how particles or electrical charges can flow through certain materials or how these materials prevent flow. The special case that Karin Zojer has in mind is disordered materials. With ordered materials – it is sufficient to look at a sample in order to be able to make statements about the entire material. New concepts had to be developed for disordered materials. In her CD lab for mass transport through paper the researcher has been working on the material paper with the MONDI company for the past six years, investigating its structure and how paper interacts with liquids and gases. "Paper is an incredibly interesting material. It consists of a mixture of fibres and air, the ratio of which influences its transport properties," explains the researcher. The aim of the laboratory is to be able to predict the transport processes themselves and their efficiency depending on the respective paper and material. "We can now actually predict how certain gases diffuse through paper," says a delighted Zojer. This will subsequently become particularly relevant for the production of food packaging: "I want the cinnamon flavour of my cinnamon bun to stay in the pastry and not be transferred to the packaging material."



Lunghammer – TU Graz

Lunghammer - TU Graz

The paper properties are predicted using mathematical methods that take into account the cavities in the paper, their connections, the resulting paths between the top and bottom of the paper and its fibre surface. All these factors influence how a molecule moves through the material.

For Zojer, the questions in basic research never end. “The answer to one question always gives rise to new questions. Inspiration never stops. That’s also the reason why we as researchers love what we do.”

Interview with Karin Zojer.*

*Interview in German

CD LABS AT TU GRAZ

With Christian Doppler labs, the Christian Doppler Forschungsgesellschaft (CDG) promotes application-orientated basic research that is carried out jointly with a company from business or industry. The laboratories run for a maximum of seven years and are subject to strict scientific quality controls. They are jointly funded by the CDG and the participating company.

There are currently 14 CD labs active at TU Graz.

CD labs at TU Graz

ANNETTE MÜTZE

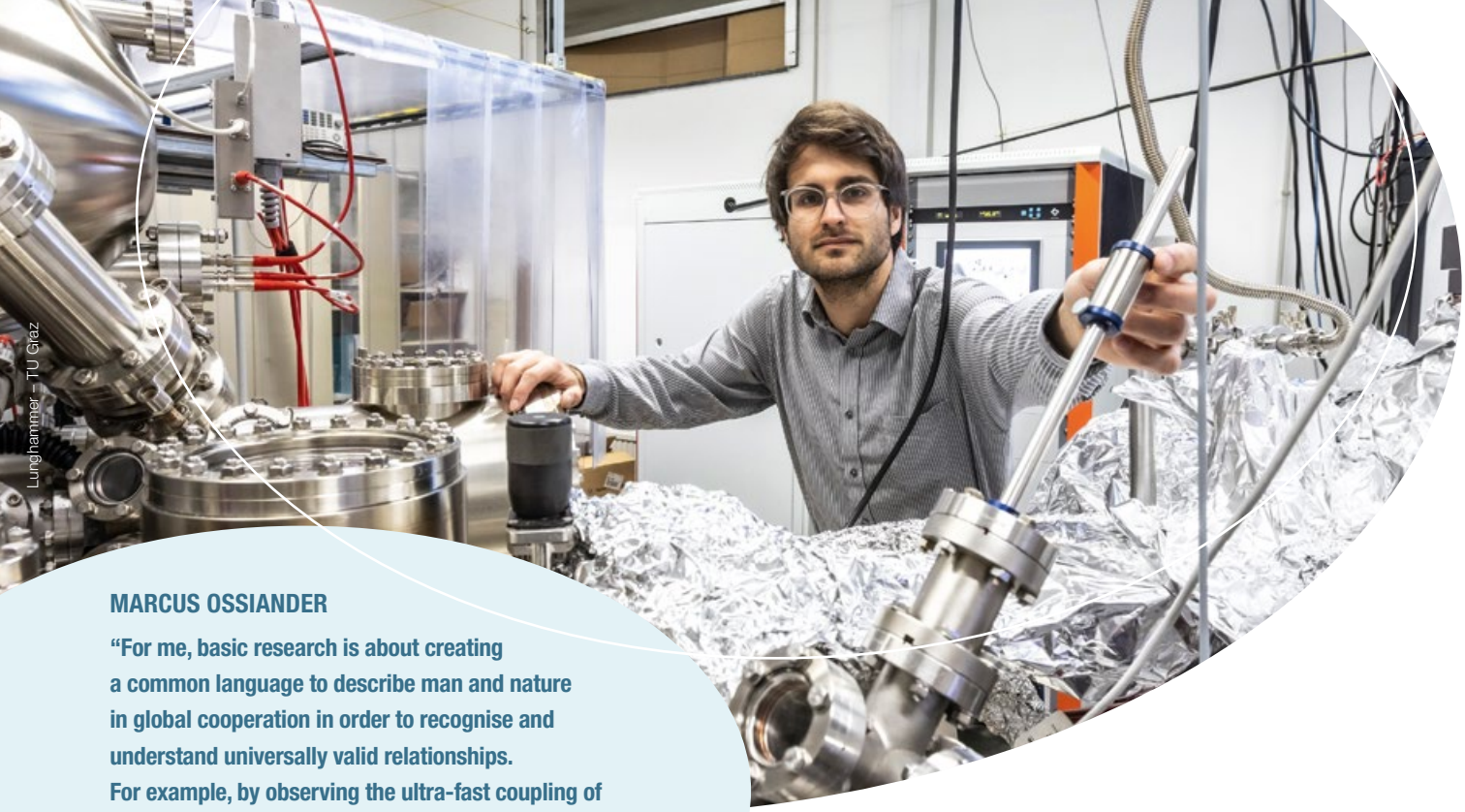
“For me as an electrical engineer, basic research is when I use an electric machine as a playground for new developments in materials science, mathematics or other areas. When I start playing with the different parameters and suddenly very interesting things happen without me immediatly having to wonder how industry could implement it.”

Annette Mütze started the CD lab for pump and fan applications utilising brushless drives in 2016 (seven years plus a one-year phase-out). The aim of the laboratory was to develop methods for designing small auxiliary motors whose efficiency, speed and torque density were significantly higher than those previously realised. “There were already many methods for larger drives; we specialised in small motors, of which there are very many,” explains Mütze. “However, we focused on basic research and did not build a large, all-encompassing simulation programme.” Instead, the researchers did research on individual elements of a possible modular simulation concept. “For example, we looked at PCB (printed circuit board) motors, developed a completely new control technology for single-phase micromotors and invented a new motor topology with extremely low noise levels. This was not foreseeable when the lab was established.”

What the researcher loves about the CD lab concept is the ability to conduct research without having to think about commercial realisation – and that several young researchers can work on different research topics but in the same subject area. This fosters the exchange of ideas and interdisciplinary collaboration that is otherwise often not possible in industrial projects. >

Interview with Annette Mütze.*

*Interview in German



Lunghammer – TU Graz

Interview with Marcus Ossiander.*

*Interview in German

MARCUS OSSIANDER

"For me, basic research is about creating a common language to describe man and nature in global cooperation in order to recognise and understand universally valid relationships. For example, by observing the ultra-fast coupling of light and electrons in semiconductors, we are trying to predict how fast processors and efficient solar cells can be produced."

Together with the arts and applied sciences, basic research creates the basis for developing as a human race and solving emerging problems technologically instead of counteracting them with renunciation and punishment, says Marcus Ossiander. This is precisely why he has dedicated his work to basic research and is doing research on the shortest units of time, which we can no longer even imagine. In 2023, the physicist moved to TU Graz with a START Prize from the Austrian Science Fund and an ERC Starting Grant from the European Research Council. His field of research is nano-optics. With these two highly endowed research prizes, he is working on a new type of optics that can measure ultra-short chemical reactions. And ultra-short means ultra-short. Its unit of time is the attosecond, i.e. a billionth of a billionth of a second or, expressed in figures, 0.000 000 000 000 000 001 seconds. "We can use it to investigate what happens in the first attoseconds when light hits a solar cell, for example, or how catalysis and other chemical reactions can be improved, or calculate how fast digital communication can be in the best case scenario."

CLUSTER OF EXCELLENCE

The Cluster of Excellence "Bilateral AI" is led by JKU Linz – a team of six scientists from TU Graz is involved headed by Robert Legenstein, head of the Institute of Theoretical Computer Science. Together, they want to create a new level of AI that goes beyond all previous systems. It is intended that it learns from raw data, combines learning with verified facts and draws its own logical conclusions. It would thus be equipped with comprehensive cognitive abilities and could also be creative itself in the narrowest sense and create something new.

The researchers at TU Graz are primarily contributing their knowledge from the fields of symbolic and sub-symbolic AI. The funding volume of the individual clusters is made up of a 60 per cent share from the Austrian Science Fund FWF and a 40 per cent share from the participating research institutions' own funds. The FWF is providing a total of 37.7 million euros for the first five years.

ROBERT PEHARZ

"Basic research is important to ensure farsightedness in society and research and to open up unknown territory in our store of knowledge."

Basic research is so close to Robert Peharz's heart because many important areas of application would not even exist if researchers had not laid the foundations for them hundreds or thousands of years ago. "I like doing basic research because it takes me into unknown territory and at the same time gives me a deep insight into our world."

He himself deals with the connections between probability and artificial intelligence. Above all, it is about being able to draw valid conclusions despite the uncertainty that characterises our world. "The rules for drawing conclusions are very rigid. But our world is not – it is uncertain, random. You rarely have all the information. But even in this world, artificial intelligence has to draw consistent conclusions," he explains. And this must also apply when different systems with different machanisms of valid conclusion are working on the same problem. This requires probability.

Robert Peharz is also involved in the Cluster of Excellence which is headed by JKU Linz (Johannes Kepler University Linz) and in which TU Graz participates.

Lunghammer – TU Graz

Interview with Anna Galler.*

*Interview in German

ANNA GALLER

"For me, basic research means pursuing scientific questions and ideas out of curiosity, and which may not be directly applicable in practice, but can contribute to technological development in the long term."

As a theoretical physicist and materials scientist, basic research is Anna Galler's day-to-day business. She is involved in creating theories, designing mathematical methods to describe observed phenomena and developing simulation methods to test new materials. In her recently launched Austrian Science Fund project, she is investigating 2D materials – in particular 1T tantalum diselenide. Experiments suggest that this material is a quantum spin liquid, meaning that its electron spins continue to move even at the lowest temperatures and are not aligned in parallel. This may have implications for the development of high-temperature superconductors and is of fundamental interest in solid-state physics. "I now want to develop a robust theory and also look at the interaction of the material with light," explains the researcher. "If you beam a very powerful laser at a solid light and matter together form a strongly coupled system – the light changes the material. I want to find out whether we can use light to control and influence the properties of the material."

OSWIN AICHHOLZER

"All research needs a solid foundation – which is basic research."

For Oswin Aichholzer, basic research is the basis of all knowledge and progress: "I want to find out how the world works down to the smallest detail, but also in the big picture," he explains. "My research is guided by pure interest and aims to track down generally valid connections and laws." The theoretical computer scientist is on the trail of basic mathematical rules which he can model and teach the computer. This involves geometric algorithms, such as how a certain number of points, for which there are a certain number of possible arrangements, can be connected to each other in such a way that every point is connected to every other point via straight lines and there are as few intersections of the lines as possible. This seemingly simple problem involves a great deal of computational effort for a computer – especially when new points are added. "And above all, when new types of lines – such as curves – are permitted, it becomes extremely complex." At first glance, there are few possible applications for these and similar research findings. But based on Aichholzer's work, other researchers have been able to develop new methods to fold stents used to dilate blood vessels, for example, or to model water runoff in a particular landscape after rainfall.

"Building on the knowledge gained over several decades, our research gives rise to new technologies, specific applications and innovations. Basic research is timeless and largely free from passing fads. The knowledge gained remains valid in the long term – there is something very reassuring about this, especially in today's fast-moving world." ■

Robert Peharz on artificial intelligence.*

*Interview in German

TU Graz promotes interdisciplinary basic research with the new TU Graz lead project. You can find out what this lead project is all about on the following pages. And you will get to know Martin Kracher, a researcher working on the lead project.