Originally from Iran, physicist Hanieh Fattahi was attracted to Germany because it offered many more research opportunities and greater freedoms in everyday life. Of course, once she arrived, she had to come to terms with the cultural differences. Nevertheless, she has since established her own research group at the Max Planck Institute for the Science of Light in Erlangen, Germany, where extremely short laser pulses are used to study biological microscopy. And with her talent for motivating people, Hanieh Fattahi is also active in climate protection.

TEXT: KLAUS JACOB

After completing her master's degree thirteen years ago, Hanieh Fattahi left Iran to come to Germany. To give us an impression of what everyday life was like for her as a student in Iran, she reaches for a scarf. It's not a hijab, but it does the job. With a practiced hand, she wraps the fabric around her head. The face was allowed to remain uncovered, but no hair was allowed to show. This was always checked by the guardians of public morals posted at the entrance to the university. Another restriction that impeded her studies is even more incomprehensible to Germans: Fattahi was not permitted to ride a bicycle in Iran; she could only look on with envy as her male fellow students pedaled past. When she did arrive on a bicycle one time at the university, the guards chased after her in their car and forced her to dismount.

Fattahi does not recount these incidents reproachfully, but rather full of self-confidence and humor as interesting anecdotes. And in Germany, she has built her career in a profession where women are still scarce even in this country: physics. And she pursues her work with great enthusiasm – which she considers an essential personal trait. It is also important to her to be able to explain her field so that anyone can understand it. This is hardly the norm in the German scientific community. For the last two years, Hanieh Fattahi has been working as a Research Group Leader at the Max Planck Institute for the Science of Light in Erlangen, where she wields femtosecond lasers, and also lectures at the Friedrich-Alexander University of Erlangen-Nuremberg.

One of Fattahi's high school teachers played a crucial role in kindling her passion for physics. Not only could her physics instructor explain the subject matter clearly and with enthusiasm, she was also a role model as a human being. Fashion played no small part here. While the students were required to wear a uniform that was so dark blue, it was nearly black, this teacher always wore colorful clothing. Clothing is more important in Iran than in Germany, as it can also represent a veiled criticism of the system.

The fact that Hanieh Fattahi went on to university after finishing high school is in some ways thanks to her parents, who encouraged her and were able to finance her education. Her two siblings also went to university – her older brother studied, economics and management, and her younger sister majored in genetics. Both still live in Iran. However, with physics, Fattahi chose a field in which it is nearly impossible to build a career in Iran; many can't even find a job after graduation. That may be the reason why this discipline is not very highly regarded by men in Iran, who – unlike in Germany – are by no means in the majority among college students. Furthermore, the country simply has no funds with which to purchase modern research equipment. The situation is not improved by the sanctions that the U.S. has imposed. The academic career of experimental physicists usually comes to an end after a master's degree, since doctoral research in this field is nearly impossible without expensive equipment. This was also what induced Hanieh Fattahi to move to Germany in 2008.

In her master's thesis, she investigated the effects of laser radiation on collagen bundles in the skin. Working with lasers was the focus of her interest even

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VISIT TO

HANIEH FATTAHI

PHOTO: AXEL GRIESCH

In sharp focus: Hanieh Fattahi and her team want to develop light microscopes that can photograph samples at high resolution without fluorescent markers and use them to observe processes in nerve cells.

then, and it has remained so to this day. The move to Germany was a real leap into the unknown, as Fattahi could not speak German when she first arrived. It was especially difficult for her to learn the language, as it has no similarities to her native language of Farsi. But still she managed, in part because English is the common language at the Max Planck Institute of Quantum Optics in Munich, where she conducted her research. Also, she was still able to converse in her native language with her husband, whom she had met at university in Iran and who came to Germany with her. Of course she also gradually learned German, if only to be able to run errands or shop for groceries. However, she still prefers to communicate in English.

Copping with the foreign culture also wasn't easy. Iran is characterized by a very complex form of etiquette known as "taarof". This basically means that no one is allowed to say directly what they really want. For example, guests must always say, "No," when asked if they would like a second helping of food – even if they are hungry. However, the host correctly interprets this doublespeak and takes the no for a yes. Fattahi explains how difficult it was for her to adapt in Germany with an anecdote: "We were visiting a friend's parents, and the mother asked if I would like more tea. I looked helplessly at my husband, because I simply didn't know how I should answer that."

She wrote her doctoral thesis in Munich on the subject of "Third-generation femtosecond laser technology." These lasers emit ultra-short pulses of light that last only 10^{-15} seconds, or one millionth of one billionth of a second. This dimension can be explained with the help of an analogy: if one second corresponded to the distance from the Earth to the Sun, a femtosecond would be roughly 0.15 millimeters long. This laser ultimately became Fattahi's ticket to an academic career. Once she had her doctorate, she was accepted into the Minerva Fast Track Program, an equal opportunity scholarship from the Max Planck Society that enables outstanding female scientists to live and work abroad and is intended to pave the way to forming one's own research group. Fattahi had initially wanted to go to continue her studies at Harvard University in the U.S. But that proved to be rather problematic. She was plagued by politics: "Donald Trump has had a big impact on my life," she says with amusement.

For it was at just that time that he came to power. Fattahi already had her visit to the U.S. planned and had worked out all the details with her advising professor at Harvard when Trump's "Muslim Ban," prohibited people from Muslim countries from entering the U.S. Due to its controversial nuclear program, Iran topped the list of sanctioned countries. Fattahi received an email from the States, informing her that her stay had been postponed. She had to wait a year and a half for a visa. Although she was permitted to briefly enter the U.S. for conferences, she could not remain for a period of months. And that decree was upheld, even though Fattahi has no connection with the Islamic religion, saying, "I don't believe in anyone." Nor did it help that she had since acquired German citizenship. In fact, Fattahi now feels herself to be part of the local society; she celebrates German holidays and cheers on German sports teams. However, she still has an Iranian passport and is therefore persona non grata in the U.S. So she went to England for a research residency at the University of Oxford instead. And when Fattahi was finally allowed to travel to the U.S., she stayed for only a few months: in 2020, she received the opportunity to establish her own working group at the Max Planck Institute for the Science of Light in Erlangen. That was a much more attractive offer. Her contract runs for five years and provides EUR 2 millions for research funding.

Fattahi is developing a camera with which she can record molecules in action. She is setting her sights primarily on biological processes.

But at first, it wasn't a smooth ride in Erlangen either: COVID-19 turned her new job into a series of hurdles. No sooner had she arrived than the lockdown brought the entire Institute to a standstill. "Nothing was working anymore, not even the telephone," she recalls. The mandatory shutdown was especially bitter for Fattahi, and not only because she was just get-

PHOTO: AXEL GRIESCH

Multicultural team: the members of Hanieh Fattahi's group come from various countries including China, South Korea, Iran and India. Their different cultural backgrounds enable each of them to approach research questions differently, which often leads to interesting discussions.

ting started. As an experimental physicist, her work relies on conducting laboratory work experiments. This is compounded by another problem: for safety reasons, two people must always be present when lasers are in use. But how is that supposed to work if only one person is allowed to be in the room at one time because of the pandemic? But there was no way Fattahi was going to sit and twiddle her thumbs. She quickly installed a camera so that a coworker could watch from outside the room and at least ensure that the necessary safety requirements were fulfilled. And she already had one employee, which was a stroke of luck: Fattahi had hired a student before she even started her own job. At a lecture at a U.S. university, she had asked if anyone would like to help her with her research in Erlangen, and Anchit Srivastava responded. So Fattahi already had a desk, a laser, and an employee. "It was difficult," she says, "but we conducted research." Fattah now has 11 employees – a colorful group of undergraduates, graduate students and postdocs from China, South Korea, Iran and India. The litmus test for Fattahi during the selection process for her team was a candidate's enthusiasm for the field. To demonstrate her relationship with her employees, Fattahi points to a toy laser lab made of Lego bricks that a former student gave her. Years ago, this German student insisted on doing his bachelor's thesis under Fattahi's tutelage, even though he was studying materials science. She finally agreed – on the condition that he learn the fundamentals of optics on his own. In fact, he successfully finished his bachelor's degree and even worked for her for a while. He is now in Bordeaux, studying for his master's degree in his new specialty. "He'll be back, that's for sure," Fattahi is convinced.

Anyone wanting to learn about her work as an experimental physicist has to don a pair of safety goggles and follow her into her laser lab. Its complex setup is slightly reminiscent of a model train set. But instead of trains, beams of light zip across the tabletop, and instead of signal towers, there are many small mir-

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rors and other optical instruments. It is not readily apparent what is being investigated here. Small wonder, because Fattahi works with structures that are invisible to the human eye. She is essentially developing a camera with which she can record molecules in action. Any photographer knows that it can be tricky to capture moving objects in a photo. The contours become blurred – unless you select a very short exposure time. But a molecule moves far, far faster than any bird in flight. This is where the femtosecond laser comes into play. Its flashes of light are short enough to take sharp images of moving molecules.

Using her special laser microscope, Hanieh Fattahi is currently focusing primarily on biological processes. The highly ambitious goal she has set for herself is nothing less than the visualization of human thought. It's about processes in the individual cells. The neurons, or nerve cells, are connected by countless synapses. These form a gigantic network in the brain, comprising roughly one hundred billion neurons and more than a trillion synapses. The signals are transmitted electrically – but only as far as the synapse. As of this point, nature switches to a chemical process: stimulated by the electrical impulse, chemical messengers known as neurotransmitters are released. These bridge the gap to the adjacent cell, where they once again generate an electrical signal. And Fattahi has trained her laser on these neurotransmitters. She wants to utilize her femtosecond laser to see how many of these molecules are required for a correct signal transfer and discover how this process works in detail. Understanding this would be a crucial breakthrough, especially for physicians, because flaws in this process can lead to diseases such as Parkinson's. Before placing human neurons under the microscope, Fattahi intends to work with animal cells. She is also starting out with a different type of synapse: a connection between a nerve cell and a muscle cell. She hopes to be able to launch her first experiment next summer.

In order to get an initial feel for the laser, Hanieh Fattahi is also currently working with biotechnologist Daniel Wehner from the Institute. His work is focused on zebrafish, a model organism favored by geneticists and developmental biologists. His team also studies nerve cells: they are investigating the incredible ability of these fish to regenerate an injured spinal cord. Spinal injuries heal again in zebrafish, when similar traumas, e.g. from accidents, leave many humans paralyzed for life. To better understand how the fish can do this and whether we could possibly learn from this how human spinal cord injuries could be healed, the researchers first use Fattahi's laser technique to precisely sever the fish's nerves – and then observe in detail how they grow back together. Sitting in on one of her working group's meetings, it becomes clear that Fattahi is still in the early stages of her project. The presentations do not cover results, but rather experimental configurations that are going to be set up. The COVID-19 pandemic is still having an impact on the meetings: people entering the Institute must wear a mask, and the employees sit far away from each

Handcrafting scientific gadgets: not least because of the restrictions imposed by the COVID-19 pandemic, Hanieh Fattahi continually had to take matters into her own hands in the lab. That is how she finally managed to generate the intense laser pulses with a duration of only five femtoseconds.

PHOTO: AXEL GRIESCH

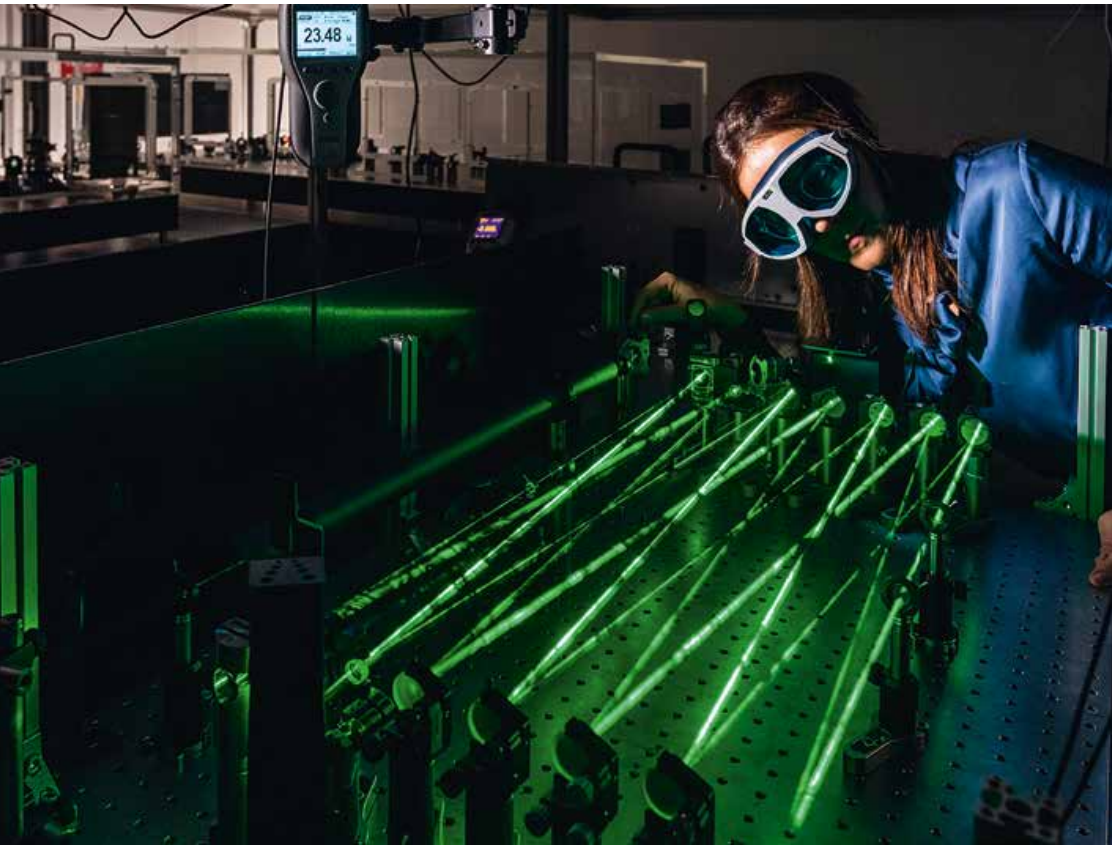

PHOTO: AXEL GRIESCH

A new instrument for climate research: Hanieh Fattahi's group developed an optical oscillator that generates intense femtosecond pulses of short-wave infrared light from green laser light. These light pulses can be used to measure greenhouse gases in the atmosphere.

other in the meeting hall. They literally lose touch with each other in the large space. Despite this, Fattahi's casual and companionable relationship with her employees is obvious. Several of them take turns stepping up to the lectern and explaining what experiments they are planning and what goals they seek to achieve. They also explain what equipment they need and how they intend to obtain it. Money also plays a role here, because Fattahi has to manage her budget. Discussions sometimes ensue about whether a component could be obtained more cheaply elsewhere. Fattahi grants her employees a great deal of freedom, but repeatedly redirects the discussion back to the experimental plans at hand.

Although the set-up phase for her group demands a lot of her time and attention, Fattahi isn't only keeping tabs on the femtosecond laser and synapses. She also wants to work actively to prevent climate change, "the most serious problem of this century," as she says. A year ago, she started the "Greenroom Book Club," to address this topic. She has the impression, she says, that the people around her are not informed enough to recognize how serious the situation is. So she sent out an email inviting everyone she knew, whether in academia or not, to participate in the book club. Since then, they have been meeting online every two weeks to discuss a book on the climate that everyone attending is supposed to have read beforehand. The club now has its own homepage and is attracting a lot of interest. But it wants to be more than just a debate club: Fattahi wants her initiative to have an influence on society. Everyone should be thinking about how they can contribute. This also applies to herself. For example, she and her team have developed an optical instrument that can be used to detect short-lived greenhouse gases such as methane, ozone and fluorocarbons. Fattahi wants to use it to help clarify the question of the sources of these gas emissions and how they are distributed within the atmosphere. Knowing this could help to more precisely determine the effects of these gases on the climate. But Hanieh Fattahi doesn't apply her talent as a laser physicist to climate protection alone. She also has a gift that has helped her build up her group even in the difficult times during the COVID-19 pandemic: the ability to motivate people to work towards a common goal.

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