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Press Release

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Fast MRI in medical diagnostics

Jens Frahm nominated for the European Inventor Award 2018

The European Patent Office has nominated physicist Jens Frahm of the Max Planck Institute (MPI) for Biophysical Chemistry in Göttingen as one of the three finalists in the category *research*. The prize is awarded in five categories and honors individual inventors and teams who have helped find technical answers to the most pressing challenges of our time. The winner will be elected in Paris, Saint-Germain-en-Laye (France) on June 7, 2018.

In nominating Jens Frahm, the European Patent Office is honoring his breakthrough developments in magnetic resonance imaging (MRI). In two steps, the scientist and his team succeeded in speeding up MRI by a factor of up to 10,000: FLASH MRI, which has become one of the most important clinical imaging methods worldwide, was developed in the mid-1980s. Then, in 2010, the researchers in Göttingen achieved a breakthrough to real-time MRI with the FLASH2 method. FLASH2 makes it possible for the first time to film processes inside the body in real time. It is currently being tested for clinical use at a number of hospitals in Germany and abroad.

Does a patient have brain tissue abnormalities? Have an accident victim's internal organs been damaged? Is there a herniated disc? Is a patient's heart function impaired? To answer such questions, radiologists turn to MRI – and FLASH technology. MRI rapidly delivers precise cross-sectional and even three-dimensional images of the body. The technique is particularly good at detecting pathological changes in virtually all organs of the body. Unlike X-ray methods, such as computed axial tomography (CAT scans), it is also completely safe for patients.

MRI exploits a special property of hydrogen nuclei, which are ubiquitous in the body: their angular momentum, also known as nuclear spin. Nuclear spin makes the atomic nuclei act like tiny magnets. When exposed to a magnetic field, they align themselves along the magnetic lines of force. An MRI scanner generates this type of magnetic field as well as short radio pulses in the VHF range, which temporarily nudge the nuclear spins out of their normal equilibrium state. As they return to their original orientation, they emit radio waves that are then detected by highly

sensitive coils. After many repetitions, the location-dependent signals generated can be used to compute an image that accurately captures details of organs and vessels.



Thanks to Jens Frahm and his team, MRI scans can be performed relatively quickly.
(Copyright: Frank Vinken / Max Planck Society)

100 million scans a year with FLASH

Frahm's technology revolutionized MRI around twelve years after its invention by Paul Lauterbur in 1973 by greatly speeding up the process. Until then, MRI had a serious drawback: For being used in clinical diagnostics, it was simply too slow, with a single cross-sectional image taking several minutes to capture. This was due to the large number of measurements with different spatial encodings needed and the necessary pauses between them. "Our idea in the 1980s was to use only part of the available MRI signal for each measurement. This physical trick allowed us to eliminate the pauses completely and to dramatically shorten the measuring times by a factor of at least a hundred," Frahm explains. Today, around 100 million MRI scans are performed every year – all taking advantage of Frahm's technology. FLASH is the Max Planck Society's most successful patent to date and it has helped MRI to achieve a breakthrough in medical diagnostics.

Live video of the beating heart

In 2010, Frahm and his team finally solved the problem of needing a large number of individual measurements. To put it simply, FLASH2 is FLASH with video speed. It uses a new mathematical algorithm for reconstructing images from only very few measurements with different spatial encodings. The technique again significantly increases the speed of MRI scans and can capture up to 100 images per second.

FLASH2 brings MRI to life as it renders processes within the body visible – a landmark advance for medical diagnostics. For the first time, it is possible to directly observe joint movements, speech and swallowing processes as well as the beating heart in real time. It further allows to draw

conclusions, for example, about why a patient experiences knee pain, has heartburn, stutters, or has chest pain. The new technique could also potentially be used as an aid in minimally invasive surgery and other interventions that, until now, have been performed under X-ray control. Real-time MRI is currently being tested for routine use on patients at the University Medical Center Göttingen and at several other universities in Germany, the UK, and the United States.

About the European Inventor Award

The European Inventor Award, a prestigious prize for innovation in Europe, will be presented for the 13th time in 2018. It has been awarded annually by the European Patent Office since 2006. To qualify for the prize, submitted proposals must meet specific criteria, such as proof that the European Patent Office has granted at least one patent for the invention.

A high-calibre international jury from the worlds of industry, politics, science, and research then reviews the extent to which the nominated inventors have contributed to technical and social progress, prosperity, and the creation of jobs in Europe.

About Jens Frahm

Jens Frahm studied physics at the University of Göttingen and carried out research for his PhD in physical chemistry at the MPI for Biophysical Chemistry. He then worked as a scientific assistant at the same institute, where he headed the independent *Biomedical NMR* research group from 1982 to 1992. Frahm has been director at the *Biomedizinische NMR Forschungs GmbH*, a non-profit organization set up within the institute, since 1993. He habilitated at the University of Göttingen in 1994 and became adjunct professor at the university's chemistry department in 1997. Jens Frahm is listed as the inventor of four European patents.

Jens Frahm has received many prizes for his research work, including the European MRI Award of the *Deutsche Röntgengesellschaft* (1989), the Gold Medal Award of the International Society for Magnetic Resonance in Medicine (1991), the Karl Heinz Beckurts Award (1993), the Research Award of the Sobek Foundation (2005), the *Stifterverband* Award (2013), and the Jacob Henle Medal (2016). Jens Frahm was elected into the Hall of Fame of German Science in 2016. (cr)

Real-time MRT movies

(Copyright: Jens Frahm / Max Planck Institute for Biophysical Chemistry)

Watch speaking live

<https://youtu.be/6dAEE7FYQfc>

This real-time MRI film shows the movements in the mouth and throat when speaking live: The spatial-temporal coordination of lips, tongue, soft palate, and larynx, which is necessary to form vowels, consonants, and coarticulations, becomes visible.

Sung live

<https://youtu.be/519LLxaqi8E>

The real-time MRI video makes the movements in the mouth and throat visible when singing.

How our heart beats

<https://youtu.be/UP1wvguTg3A>

The real-time MRI movie shows the natural movements of the chest: Breathing and heartbeat are clearly visible. In contrast to clinical practice with conventional magnetic resonance imaging, the patient does not have to hold his breath thanks to the fast image rate, nor does the recording have to be controlled by the ECG signal.

Further publications on the topic

Live-View of the focus of diseases: Doctors and patients can thank magnetic resonance imaging – and not least Jens Frahm – for the fact that many diseases can now be diagnosed far more effectively than 30 years ago. The research carried out by Frahm and his team at the Max Planck Institute for Biophysical Chemistry in Göttingen has greatly simplified the process of capturing images of the body's interior. Now, the team from Göttingen wants to bring those images to life. (*MaxPlanckResearch*, 2/2017)

https://www.mpg.de/11357102/W003_Material_technology_054-061.pdf

Further information

Website of the *Biomedical NMR*
Max Planck Institute for Biophysical Chemistry
<http://www.biomednmr.mpg.de>

Website of the European Inventor Prize 2018 of the European Patent Office
<https://www.epo.org/news-issues.html>

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