Breakthrough in magnetic resonance imaging of the heart

Cardiovascular diseases (CVDs) are the number-one cause of death globally. To date, several areas of significant unmet needs remain unaddressed. The "MetaboliQs" project combines diamond-based quantum sensor technology and medical imaging to advance personalized diagnostics.

Magnetic resonance imaging (MRI) methods have been used widely in past decades as a safe, non-invasive, and non-radioactive method of diagnosing CVDs. However, even the most expensive MRI scanners (with the strongest magnets) cannot detect and visualize molecular and metabolic activity in the heart with sufficient sensitivity. To this end, emerging hyperpolarization-based MRI techniques play a pivotal role, as they allow the sensitivity of MRI to be increased by up to five orders of magnitude.

Unfortunately, the hyperpolarization process takes a very long time (90-180 minutes per procedure), is extremely costly and cumbersome (>$2 million initial cost, room-sized equipment), and requires temperatures colder than -270 °C. The MetaboliQs project, in which also the Fraunhofer Institute for Applied Solid State Physics IAF is involved, therefore aims to enable a new method for MRI by leveraging new advances in quantum physics.

Higher-precision diagnostics and personalized treatment using advances in quantum physics

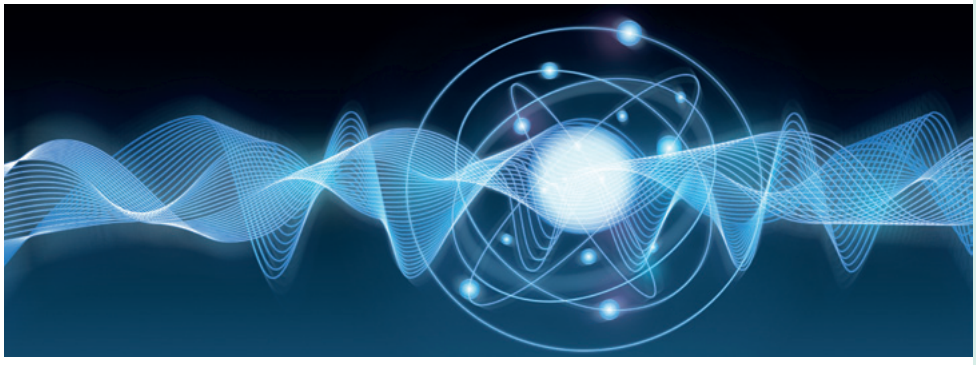
The method, termed hyperpolarized MRI, will allow imaging and visualization of key metabolic substrates in the heart and other organs (e.g., kidney, liver) via hyperpolarization of nuclear spins of substrates that are natural to the body and non-toxic. In this way, a number of important metabolic reactions can be tracked non-invasively. This technology will enable a previously unachievable and highly sensitive quantification of metabolic activity, paving the way for precision diagnostics and better patient-centered treatment of cardiovascular diseases. For example, it will become possible to distinguish patients who will most likely benefit from invasive or pharmacological treatments from those who would be more suited to other medical treatment approaches. It may also become easier to accurately diagnose patients at the disease's early stages.

The MetaboliQs project will leverage the transformative features of diamond nitrogen vacancies (NV), such as high quantum coherence and quantum control, to offer a breakthrough in hyperpolarized MRI. A low-cost and high-throughput diamond polarizer is to be developed for use with any commercial MRI scanner and shows results within minutes instead of hours.

This unique utilization of quantum coherence is made possible by new technology to atomically grow diamond material (quantum-grade diamond), including 12C isotopic purification, precise control of nitrogen defect concentration, and nanofabrication of the diamond surface.

The MetaboliQs project is part of the overall Quantum Flagship initiative, funded by the European Union.

The MetaboliQs project combines diamond-based quantum sensor technology with medical imaging. © Fraunhofer IAF



New technologies for the atomic growth of diamond material will improve MRI. © Fraunhofer IAF

About MetaboliQs

The members of the multidisciplinary consortium MetaboliQs are:

- Fraunhofer IAF in Freiburg, a leading research institute for quantum technology with diamond
- NVision Imaging Technologies GmbH, Germany, a quantum technology company supported by Silicon Valley
- Element Six Limited, UK, a world leader in the research and production of synthetic diamond
- Hebrew University of Jerusalem (HUJI), Israel, a leading research institute for diamond quantum technologies
- Bruker BioSpin GmbH – market leader in preclinical MRI and NMR spectroscopy
- ETH Zürich in Switzerland
- Technical University of Munich, Germany.

Contact:
Dr. Anne-Julie Maurer
Phone +49 761 5159-282
anne-julie.maurer@iaf.fraunhofer.de

Dr. Christoph Nebel
Phone +49 761 5159-291
christoph.nebel@iaf.fraunhofer.de

Fraunhofer Institute for Applied Solid State Physics IAF
Tullastrasse 72
79108 Freiburg
Germany
www.iaf.fraunhofer.de