PRESS RELEASE

Start of New European Innovation Council Pathfinder Project 4D-NMR:

Advancing Nuclear Magnetic Resonance Technology from Ensemble Measurements to Sub-molecular Imaging

International research team aims to re-invent Magnetic Resonance Microscopy to revolutionise science and industry

Linz, Austria, 19 May 2023 - Nanotechnology is rapidly emerging as a key area to address various global challenges in fields such as health, energy, environment, and information technologies. However, researchers are still investigating most nanomaterials with bulk techniques that average over large samples rather than looking at single nanostructures with true nanoscale sensors. Nuclear Magnetic Resonance (NMR) is a game-changer for biochemical synthesis and medical imaging, but it is inherently limited to a substantial number of molecules. In response to this challenge, the new project 4D-NMR aims to revolutionise nuclear magnetic resonance (NMR) technology by enhancing its sensitivity and resolution to image individual molecules at the nanoscale level. The 4D-NMR team will tackle this by using the atomic resolution capabilities of Scanning Probe Microscopy (SPM) alongside resonant, high-frequency electromagnetic excitation and readout techniques. The latter will also include significant advances in GHz and Rf technology The project brings together five partners from Austria, Israel, Italy, Spain, and the United Kingdom. Over the next three years, the project will receive a total funding of more than 3 million EUR from the European Union's European Innovation Council (EIC) Pathfinder Programme, which supports the exploration of bold ideas for radically new technologies.

4D-NMR's goals are to develop a single-molecule Magnetic Resonance Microscopy (MRM) technology that will enable the identification of the 3D-chemical structures of complex molecules in 3 dimensions. The development of this technology aims to revolutionise NMR spectroscopy, transforming it into an imaging technique with sub-molecular spatial resolution. By applying synchronised magnetic pulse excitation, 4D-NMR will add ad the fourth dimension the dynamics of the sample under study. This could have significant implications for fields such as life science, materials science, and chemical applications, where processes involving small amounts of chemical or biological molecules need to be detected. Additionally, the fact that this technology will be able to operate in vacuum but also in in-situ in liquid, makes it particularly relevant to these fields. This represents a significant advantage over commercial NMRs.

"The aim is to establish a system that can operate at the single spin level in complex spin systems. With the ability to resolve individual spins, researchers will be able to gain a deeper understanding of molecular interactions and processes at the atomic level, which will have a significant impact on a range of industries, including pharmaceuticals, materials science, and biotechnology," says project coordinator Dr Georg Gramse from the Institute of Biophysics at Johannes Kepler University Linz.

Combining different techniques to advance commercially-available NMR and SPM solutions

4D-NMR will adapt and tweak the Electron Spin Resonance - Scanning Tunnelling Microscopy (ESR-STM) technique, which allows for the detection of single spins in molecules and that was to a strong extend developed by Yishay Manassen from Ben Gurion University, one of the scientific key partners in the project. The NMR spectrum is coupled with the ESR signal and will be extracted point by point throughout the microscopy images. Manassen says: “Challenge is to create a large enough signal-to-noise ratio (SNR) that allows acquiring a spectrum of a single molecule in a short enough time to be combined with imaging.”

Apart from tackling this hurdle and aiming to advance the technique, the 4D-NMR team will make use of a recently developed, extremely sensitive heterodyne GHz absorption spectroscopy technique. GHz absorption spectroscopy is a technique used to study the interaction of matter with high-frequency electromagnetic radiation in the gigahertz range. In this technique, a sample is irradiated with a GHz electromagnetic wave, and the absorption or reflection of this radiation is measured.

“The frequency of the electromagnetic wave is tuned until it matches the resonance frequency of the probe-sample system. This provides us with information on the chemical or physical properties of the sample, such as its electronic structure, or magnetic properties,” adds Georg Gramse.

By detecting single-spin NMR and exploring nuclear-electron interactions in molecular nano-objects like, carbon nanoribbons, and atomically thin magnetic materials, 4D-NMR has the potential to provide new fundamental scientific insights and impact the markets of both NMR and SPM.

The 4D-NMR team’s ultimate goal is to develop a versatile upgrade for commercially-available SPMs or NMRs, based on simple and inexpensive electronic components, that can operate in various environments and with different types of molecules and materials.

***

KEY FACTS

Full name: 4D-NMR: Single Molecule Nuclear Magnetic Resonance Microscopy for Complex Spin Systems

Start date: 1 April 2023

Duration: 36 months

Budget: 3 Mil EUR

Coordinator: Johannes Kepler University Linz

Website: www.4D-NMRproject.eu

Social media: LinkedIN and Twitter

PRESS RELEASE

PROJECT PARTNERS

AUSTRIA

- Johannes Kepler University Linz

ISRAEL

- Ben-Gurion University of The Negev

ITALY

- Gruppo Tecniche Avanzate – G.T.A di Giuseppe Boscolo – Societa in Accomandita Semplice

SPAIN

- University of Valencia

UNITED KINGDOM

- University of Oxford

CONTACT

Project Coordinator

Johannes Kepler University Linz

Georg Gramse

Mail: georg.gramse@jku.at

Project Management

EURICE GmbH

Djevaire Memedi

Mail: d.memedi@eurice.eu

Funded by
the European Union