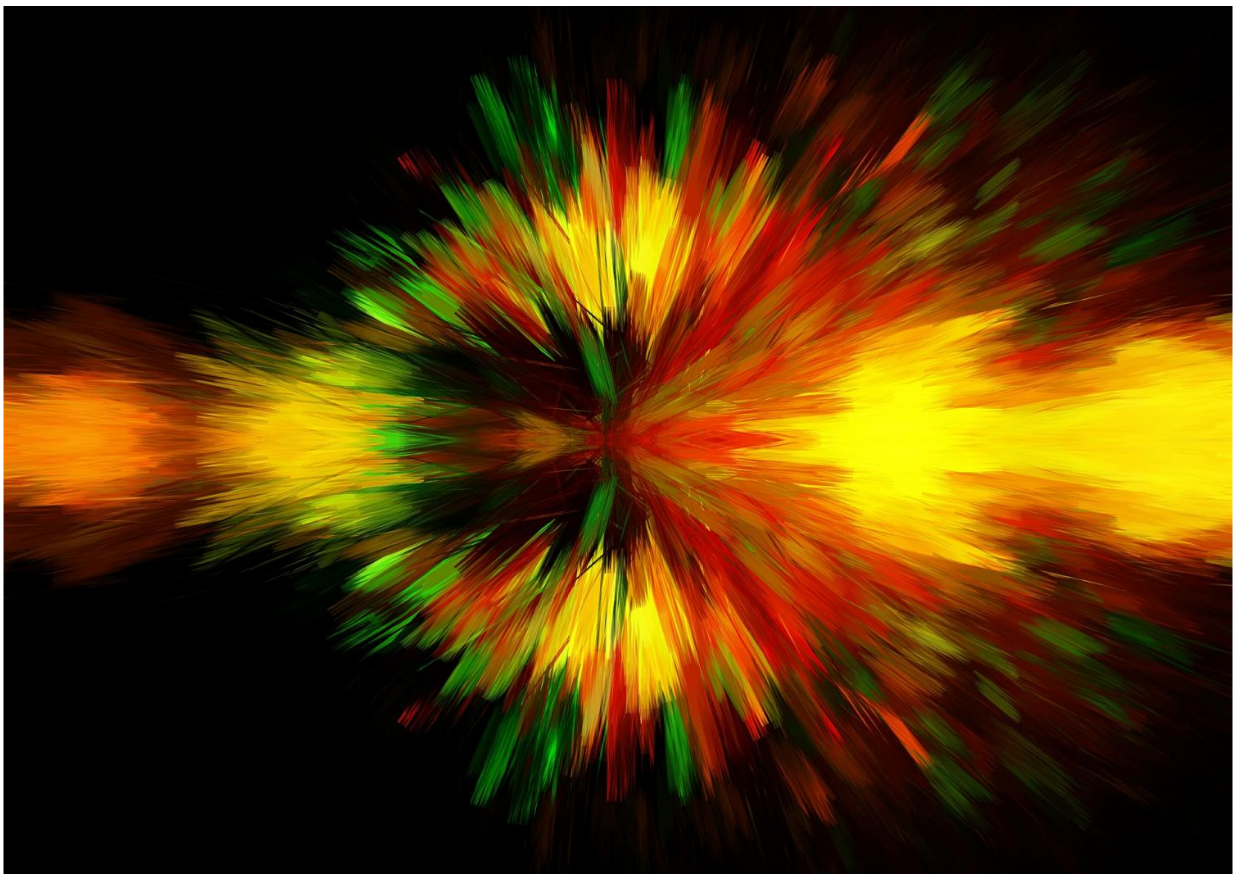
Quantum sensors providing magnetic resonance with unprecedented sensitivity

January 21 2019



Credit: CC0 Public Domain

A study by the Quantum Technologies for Information Science (QUTIS) group of the UPV/EHU's Department of Physical Chemistry, has produced a series of protocols for quantum sensors that could allow images to be obtained by means of the nuclear magnetic resonance of single biomolecules using a minimal amount of radiation. The results have been published in *Physical Review Letters*.

Nuclear magnetic resonance (NMR) has a variety of applications, such as medical imaging, neuroscience and detection of drugs and explosives. With the help of quantum sensors, NMR has been adapted to work in the nanoscale regime, where it has the potential to impact disciplines such as life sciences, biology and medicine, and to provide measurements of incomparable precision and sensitivity.

"We expect that the combination of quantum sensors and dynamical decoupling techniques allows NMR imaging of single biomolecules," write authors Dr. Jorge Casanova and Ikerbasque Professor Enrique Solano. This quantum-enhanced NMR "will be able to resolve chemical shifts in tiny picoliter samples, producing biosensors with unparalleled sensitivity and providing new insights into the structure, dynamics, and function of biomolecules and biological processes."

A fundamental tool to improve the sensitivity of NMR setups is to apply large magnetic fields "that polarize our samples, enhance the signal and increase coherence," they write. This strategy is used, for instance, in MRI, in which the human body is subjected to large magnetic fields generated by superconducting coils. However, they note, there are problems when interfacing these samples with quantum sensors, "because our samples may oscillate much faster than our sensor can follow."

In the work published in *Physical Review Letters*, the authors developed a protocol to allow a quantum sensor to measure the nuclear and electronic spins in arbitrary samples, even when they happen in large magnetic fields. These methods use a low-power microwave radiation to bridge the energy difference between their sensor and the sample.

"The protocol is robust and requires less energy than previous techniques. This not only extends the operation regime of the sensor to stronger magnetic fields, but also prevents the heating of biological samples that would result when using conventional protocols and microwave powers. As a consequence, this work opens a new research line and paves the way for the safe use of nanoscale NMR in the study of biological samples and large biomolecules," write the authors.

More information: J. Casanova et al. Modulated Continuous Wave Control for Energy-Efficient Electron-Nuclear Spin Coupling, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.122.010407

Provided by University of the Basque Country