Nanoscale quantum magnetic and electric-field sensing of neurons using nitrogen-vacancy centers in diamond

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Abstract

Brain research and quantum technology are at the focus of 21st century science. Although theoretical and experimental studies have provided some insights regarding the mechanisms with which the brain acquires, represents and stores information, a comprehensive theory of the brain and the underlying neural information processing is still missing. Experimental techniques to study brain processes at different levels of description, notably the sub-neuron, single neuron and neural network level, are therefore of fundamental importance for brain research. Recently, a new promising technique in solid-state physics has emerged for measuring electric and magnetic fields at the nanometer scale with unprecedented spatiotemporal resolution (sub-micron and sub-ms range). The nitrogen-vacancy defect (or NV center) in the crystal structure of the diamond is a unique ultra-sensitive quantum device that can sense external magnetic and electrical fields via its spin states, which can be read-out optically using electron spin resonances. I will present the efforts undertaken in the "NeuronQ" project that aims towards the development of an ultrasensitive, NV center based, quantum sensor under ambient conditions for real-time recording of neural activity on the sub-neuron, single neuron and network level.