Diamond on the Brain: Quantum diamond magnetometers for imaging neuronal connectivity

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Diagnosis of central nervous system diseases such as Alzheimer’s disease, Parkinson’s disease, and epilepsy is largely based on clinical symptoms and cognitive testing, which show a high rate of misdiagnosis. To minimize misdiagnosis and to develop next-generation drugs for them, microscopic mapping of functional activities in neuronal networks is highly demanding. Quantum diamond magnetometers could be one of the candidates for imaging neuronal networks. A nitrogen-vacancy(NV) center in a diamond is an atomic defect in which magnetic sensitivity is in the range of several microteslas with the nanometer spatial resolution at room temperature. The magnetic field sensitivity even reaches below 1 pT/Hz0.5 by adopting NV ensembles at the cost of the spatial resolution. Detections of bio-magnetic fields arising from neurons, mammalian muscles, and hearts using NV ensembles have been demonstrated, but their spatial resolutions are limited at the millimeter scale. In this talk, we show our endeavors to improve the magnetic field sensitivity in micrometer and millimeter scales using quantum diamond magnetometers. These could be a step forward in mapping functional activity in neuronal networks in microscopic spatial resolution and positioning brain activity in millimeter-scale resolution.