Quantum sensing of biological processes using single electron spins in diamond

The bio-compatible nature of diamond, and photo-stable emission from colour centres within, allows nanodiamonds to be tracked and located in 3D with nm precision over long periods of time [1]. As such, the majority of biological investigations have focused on using the negatively charged Nitrogen-Vacancy (NV) defect centre for single particle tracking applications [1-4]. But as our understanding and control over the quantum properties of this system has evolved in recent years, the electron spin of the NV centre has emerged as an ideal quantum platform for probing electromagnetic properties of room-temperature biological processes. Our previous work has demonstrated quantum control over the NV system in the complex confines of a living cell, showing that NV centres can be used to report orientation changes as well as local magnetic field fluctuations [5]. In this talk, I will present our recent work on using single NV centres in nanodiamonds to detect near individual Gd$^{3+}$ atomic spin labels in artificial cell membranes and discuss how this detection scheme may be used to non-invasively detect signalling events of ion-channels [6]. I will also describe our efforts to track and tag individual fluorescent nanodiamonds in vivo by micro-injecting nanodiamonds into the model embryonic system Drosophila melanogaster.