Observation of tunnel rates of phosphorus dopants using silicon SETs

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— Charge centres, such as donors in semiconductors, have significant potential for quantum information processing. In silicon, which can be produced nuclear-spin free, phosphorus donors are a prime candidate for implementation of a qubit, due to their long spin coherence times. In this presentation we will discuss a hybrid structure, consisting of implanted phosphorus donors controlled by a gate potential in close vicinity to a gate-induced, MOS-based silicon single electron transistor (Si-SET). We study the dual functionality of the nearby Si-SET as a sensitive charge detector as well as a gate-induced electron reservoir. Experimentally, we observe shifts in the position of the Coulomb peaks of the Si-SET corresponding to ~20% of an electron charge. We attribute these shifts to charge transfers between the Si-SET island reservoir and the nearby phosphorus donors. Pulsed voltage spectroscopy on one of these charge transitions allows us to investigate the capture and emission times of a donor resulting in a capture rate of 3000 s⁻¹ and an emission rate of 1000 s⁻¹ corroborating expectations from device modelling.