Silicon Colour Centres

The future global quantum internet will require high-performance matter-photon interfaces at scale. The highly demanding technological requirements indicate that the matter-photon interfaces currently under study all have potentially unworkable drawbacks, and there is a global race underway to identify the best possible new alternative. For overwhelming commercial and quantum reasons, silicon is the best possible host for such an interface. Silicon is not only the most developed integrated photonics and electronics platform by far, isotopically purified silicon-28 has also set records for quantum lifetimes at both cryogenic and room temperatures [1]. Despite this, the vast majority of research into photon-spin interfaces has notably focused on visible-wavelength colour centres in other materials. In this talk I will introduce a variety of silicon colour centres and discuss their properties in isotopically purified silicon-28. Some of these centres have zero-phonon optical transitions in the telecommunications bands [2], some have long-lived spins in their ground states [3], and some, including the newly rediscovered T centre, have both [4] and can be integrated into silicon photonics chips at scale [5].

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[3] K. Morse, R. Abraham, A. DeAbreu, et al. Science Advances 3:e1700930 (2017).
[4] L. Bergeron, C. Chartrand, A.T.K. Kurkjian, et al. PRXQuantum 1:020301 (2020).
[5] D. Higginbottom, A.T.K. Kurkjian, C. Chartrand et al. Nature 607:266 (2022).