Highly enriched ^{28}Si – the perfect semiconductor

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Enriched ^{28}Si is the material of choice for silicon-based quantum computing schemes involving electron or nuclear spins [1–5], since the removal of the ^{29}Si nuclear spin results in very long coherence times [4, 6–8]. Several methods for achieving quantum logic with spin states of the shallow neutral donor ^{31}P in ^{28}Si have been proposed [1–3] and the manipulation of electron and nuclear spin coherences have been demonstrated [4], but unsolved challenges include the measurement of single spins and the initialization, or polarization, of these spins. Fortuitously, the isotopic enrichment of ^{28}Si has another dramatic effect: the linewidths of many optical transitions are drastically reduced [9–13], including those involving ^{31}P. These narrow transitions have been proposed both for measurement of single spins [12–14] and for preferentially populating specific spin states [12, 13].

I will describe recent advances in our understanding of the optical properties of this remarkable material, which can be thought of as the most perfect semiconductor, in that almost all inhomogeneous broadening processes have been eliminated. In particular, I will focus on new results that may provide unexpected approaches to problems with silicon-based quantum computing.

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