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Thermodynamic implications of ^{29}Si spin impurities on scalability of silicon-based quantum computing[1] PAVEL LOUGOVSKI, NICHOLAS A. PETERS, Quantum Information Science Group, Oak Ridge National Lab — It is anticipated that ^{31}P donors in silicon have the potential for realizing scalable quantum processors in analogue to classical computer chips[2]. In classical computing, removing excess heat is a challenge that sets practical limits on performance. Here we consider what fundamental thermodynamic limits exist for the P-donor quantum computer in isotopically enriched ^{28}Si. Specifically, we consider the effect of ^{31}P nuclear spin rotation on the nuclear spin dynamics of the remaining ^{29}Si impurity atoms within a single-qubit gate volume. Our simulations show that a π rotation of ^{31}P nuclear spin induces ^{29}Si nuclear spin flipping resulting in an average energy decrease of the ^{29}Si nuclear spin bath. For a gate volume of 5 nm^3 and ^{29}Si concentration of 800 PPM at $250\mu K$, the average energy decrease per single qubit rotation is $4.74\times10^{-12}eV$. This suggests that the scalability of ^{31}P-donor quantum computer will not be limited by energy dissipation from single qubit control pulses into the ^{29}Si nuclear spin bath. Moreover, randomized single qubit rotation promises to be useful for cooling the ^{29}Si nuclear spin bath.

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[2]B. E. Kane, *Nature* **393**, 133 (1998).

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