Erratum: Coherent Multispin Exchange Coupling in a Quantum-Dot Spin Chain [Phys. Rev. X 10, 031006 (2020)]

Haifeng Qiao, Yadav P. Kandel, Kuangyin Deng, Saeed Fallahi, Geoffrey C. Gardner, Michael J. Manfra, Edwin Barnes, and John M. Nichol

(Received 29 April 2021; published 11 June 2021)

DOI: 10.1103/PhysRevX.11.029904

Equation (3) in our paper should be

$$J_{HL}(V_0,a)=\frac{2S^2}{1-S^4}\left\{\frac{\hbar^2a^2}{ml_0^4}-\frac{2V_0l_xl_y}{\sqrt{(l_x^2+l_0^2)(l_y^2+l_0^2)}}\right.$$
$$\times\left[1+\exp\left(\frac{-(2a)^2}{l_x^2+l_0^2}\right)-2\exp\left(\frac{-a^2}{l_x^2+l_0^2}\right)\right]$$
$$\left.-\sqrt{\frac{\pi}{2}}\frac{e^2}{4\pi\epsilon\epsilon_0 l_0}\left[1-SI_0\left(\frac{a^2}{l_0^2}\right)\right]\right\}. \tag{3}$$

In the published version, the "1" inside the square brackets was missing. The code we used to fit our data correctly included this term. However, the code mistakenly omitted the minus sign in the last exponential in Eq. (3). We have refit our calibration data using the correct function. Included here is the corrected version of Fig. 3 in the main text. The agreement between the data and fits is approximately the same with the corrected function. Using the correct function, the fitted values are $V_0 = 7.4$ meV, $\alpha_1 = -0.47\ \mu\text{mV}^{-1}$, $\alpha_2 = 0.29\ \mu\text{mV}^{-1}$, and $\alpha_3 = 0.01\ \mu\text{mV}^{-1}$. These new fitted values remain close to the simulated values and do not affect the argument that wave-function position shifts are responsible for the observed exchange couplings.

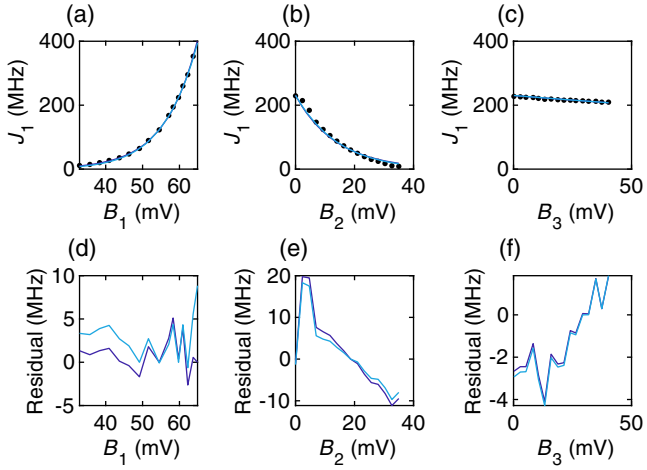

FIG. 3. J_1 vs B_j. (a) J_1 vs B_1. (b) J_1 vs B_2, for $B_1 = 60$ mV. (c) J_1 vs B_3, for $B_1 = 60$ mV. The black data points in each panel are obtained from the fast Fourier transform of a dataset similar to Fig. 1(b) in the main text. In (a)–(c), the dark blue line is the fit to the exponential model, and the light blue line is the fit to the HL model. The dark and light blue lines are nearly overlapping. Panels (d)–(f) show the difference between the fits and the data for the two models.

On refitting the entire calibration data set (Fig. 4 from Supplemental Material), values of V_0^i range from 6.8 to 7.4 meV, and values of α_{ii} range from -0.41 to -0.48 μmV^{-1}. In refitting the data, we adjusted the equilibrium lengths associated with quantum dot pairs. Previously, the equilibrium lengths were fixed at 100 nm for all pairs. After refitting, the equilibrium length for dots 1–2 is 100 nm; for dots 2–3, the equilibrium length is 94 nm; and for dots 3–4, the equilibrium length is 86.5 nm. Changes on the order of 5 nm from these values do not affect the fits of the calibration data. Using an equilibrium length $a = 90$ nm, $l_0 = 32$ nm, and taking a typical value of $\alpha_{ii} = -0.45$ μmV^{-1}, we expect $\delta_{ii} \approx 158$ V^{-1}, which agrees reasonably well with our fitted values from the electrostatic simulations discussed in the main text. As before, a modified set of parameters is needed to reproduce the voltages required for the three-spin exchange experiment. As discussed in the main text, the magnitude of the confinement strength V_0 must be slightly increased to generate voltages that match what was used experimentally. Figures 4 and 5, as shown here, are corrected versions of Supplemental Material, Figs. 4 and 5, and illustrate the effect of the modified parameters.

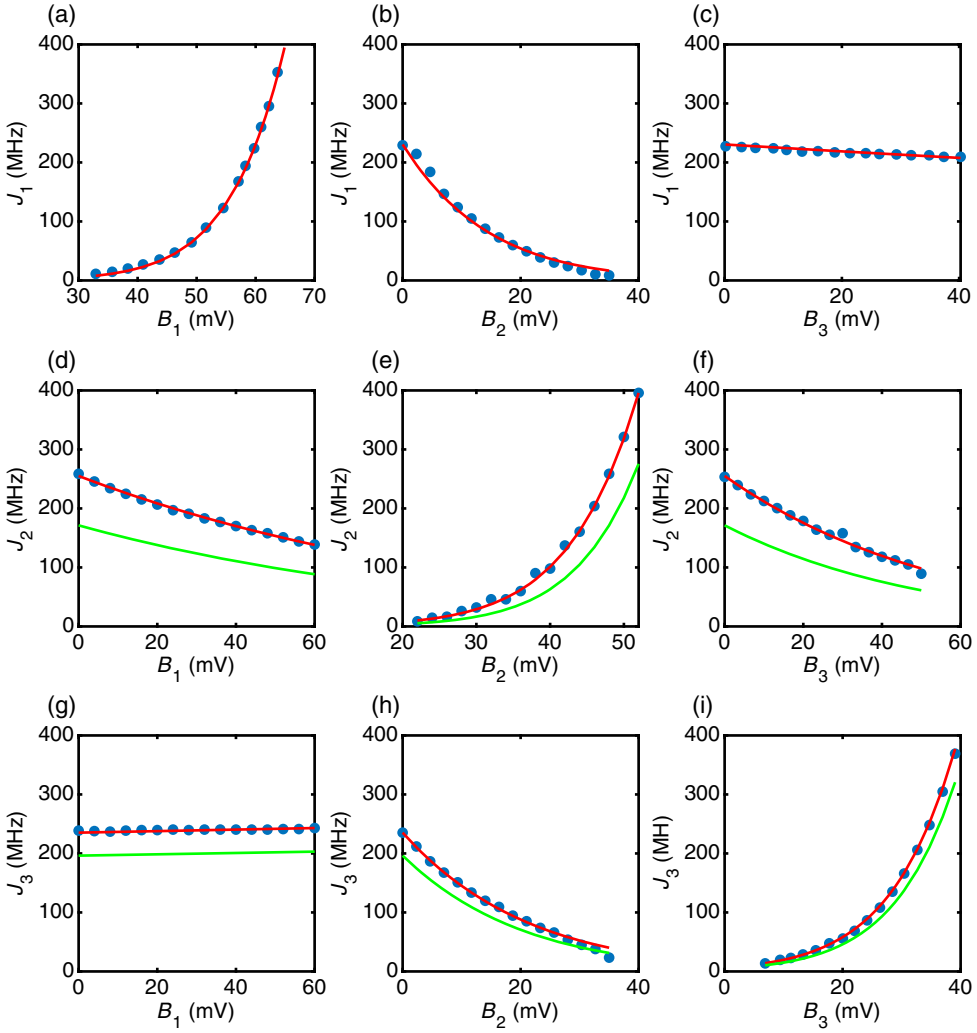

FIG. 4. Full calibration data, initial, and modified fits for the correct HL model. Blue data points are experimentally measured two-qubit exchange oscillation frequencies, red lines are correct HL model fits, and green lines are predicted frequencies using the model with modified parameters. To generate the modified parameters, we adjusted the HL parameters to generate voltages to match the voltages used in the three-spin exchange-oscillation experiment. We only adjust parameters for J_2 and J_3.

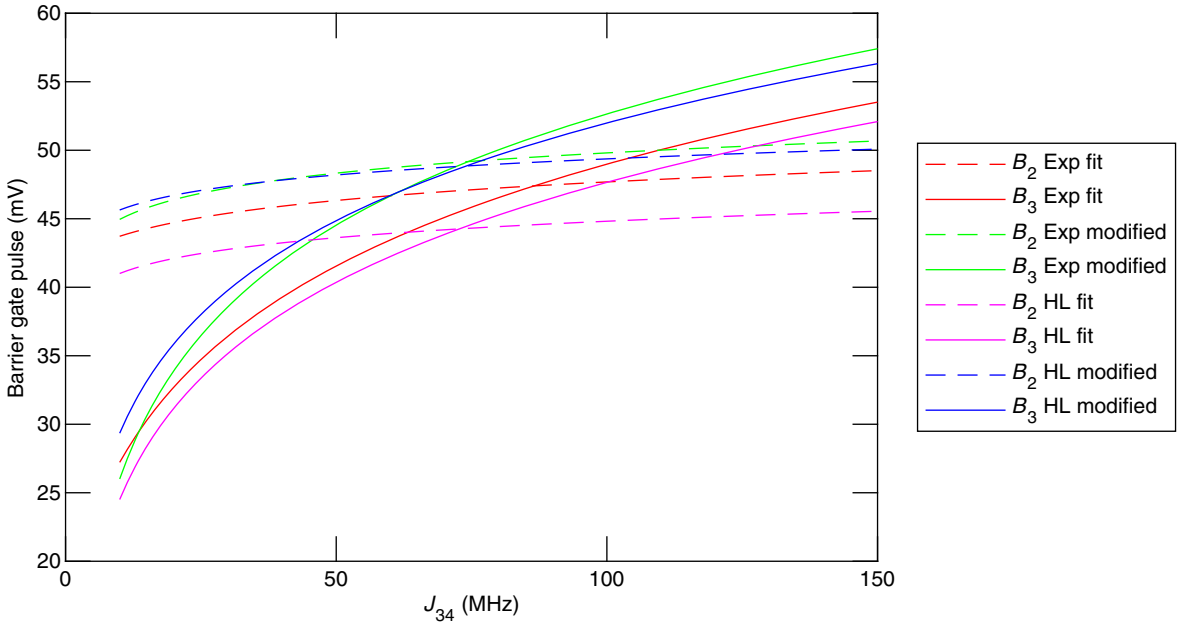

FIG. 5. Comparison of gate voltages predicted by initial and modified fits for both the exponential and corrected HL models. The red solid and dashed lines are the gate voltages for B_2 and B_3 generated by the exponential model for the three-spin exchange-oscillation data presented in the main text. The gate voltages were calculated using the parameters we obtain after fitting the calibration data. However, as discussed in the main text, these gate voltages generate exchange couplings that are too small. Therefore, we modify the model parameters as discussed in the main text, and the actual gate voltages we used are shown in the green solid and dashed lines. The magenta and blue lines show the gate voltages predicted by the initial and modified parameter sets for the correct HL model for the same experiment. The modified parameters for both the correct HL model (blue lines) and the exponential model (green lines) generate rather similar gate voltages.

These changes do not affect the claims of the text. The exponential model was used to acquire the coherent three- and four-spin exchange data.