Coherent and optimal control of adiabatic motion of ions in a trap

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Small anharmonici , crea ed along he a ial direc ion of he rap, allo s con rolling he mo ional s a e s of ion s adiaba icall sing elec ric fields. In hi s paper se eral impor an a spec s of hi s con rol scheme are e plored heore icall . The p l se s for ario s s a e ran sforma ion s, incl ding ni er sal q an m ga e s, are deri ed sing he op imal con rol heor . The e hibi simple

$$\hat{H} = \hat{H}_0 + E(t) z q . \quad (2)$$

The last term in Eq. (2) can be viewed as the electrostatic energy in the linear potential with the slope $E(t)$ that changes in time. The dependence $E(t)$ defines what we will call *the control pulse*. In the simplest control scenario one can consider, for example, the field amplitude, the pulse duration, and the frequency as control parameters and try to tune them to achieve the desired control, but we go beyond that and search for an optimal pulse shape by allowing $E(t)$ to the range from 5.54 to 27.7 kHz (i.e., between 0.2% and 1% of the frequency value) keeping the values of ω_z and T fixed. For each value of Δ_z we carried out the pulse optimization for the gate NOT and calculated its fidelity $F = \frac{1}{2}\sum|\langle\psi_i|T|\varphi_f\rangle|^2$, where the sum is over the two transitions optimized simultaneously, NOT$|0\rangle \rightarrow |1\rangle$ and NOT$|1\rangle \rightarrow |0\rangle$ [13–15].

la ion

(Δ_z ≈ 1% of [illegible] ʻho ld permi one o ca [illegible] q er acc ra e ʼ a e- o-ʼ a [illegible] n ʻforma ionʼ ʻing ʻhor (T ≈ 10 μʼ) ʻimple-ʻhaped p l [illegible] mpli de of he elec ri [illegible] ac field req ired for ch p lʻeʼ [illegible] he order of E_{ma} ≈ 2[illegible] mV/cm. In general, he al eʼ o[illegible] and E_{ma} are al [illegible] q pled and he p lʻe op imi a ion [illegible] in orde [illegible] chie e high fideli of he ʼ a e- o-ʼ a e [illegible] hiʼ con rol ʻcheme can be ʻed for ʼ a e ini [illegible] ʻimple cooling, and e en for appl ing he q an m logicʼ ga eʼ. Iʼ prac ical reali a-ion ʻeemʼ o be in he reach of oda ʼʼ echnolog . No e ha he ga e p lʻeʼ op imi ed ʻing he coheren con rol heor repreʻen ni ar ranʻforma ionʼ, i.e., he preʻer e phaʻe informa ion and ac on an arbi rar perpoʻi ion ʼ a e (14,16), hich makeʼ hiʼ ʻcheme i able for q an m com-p a ion.

When ʻe eral ionʼ are rapped, a m l iq bi ʼ ʼ em can be crea ed b encoding differen q bi ʼ in o differen mo ional modeʼ of he Wigner cr ʼ al (e.g., ʼ mme ric and an iʼ m-me ric ibra ion modeʼ). Again, he elec ric field can be ʻed o con rol and co ple hoʻe modeʼ. No e ha he ʻingle ion addreʼʻing iʼ no req ired for hiʼ con rol ʻcheme. The Co -lomb in erac ionʼ be een differen ionʼ in rod ce addi ional anharmonici ieʼ in o he ʻpec ra of he mo ional ʼ a eʼ, hich facili a eʼ he con rol. Recen ork on ibra ional q bi ʼ (13 17) indica eʼ ha he o-q bi ga eʼ are poʼʻible. Op-imi a ion of ch con rol p lʻeʼ iʼ echnicall feaʻible, al-ho gh he p lʻe ʻhapeʼ ma be ʻome ha more complica ed d e o he preʻence of ʻe eral modeʼ i h differen freq en-cieʼ and he