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DEFINITION OF CONTROL SIGNALS FOR PERFORMING CERTAIN GATES BY KERR CELLS IN A NONLINEAR RESONATOR

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Considered the effects of external optical signals on the entangled states of the Fock of Kerr qubits in a nonlinear resonator. The necessary time dependence of the Hamiltonian for the realization of negation, Hadamard and controlled negation operators for the algebra of quantum logic have been found.

***Keywords*:** helix–coil transition, biphasic denaturation, multiple binding.

Introduction. Currently, the main problems of quantum computers are associated with an increase of coherence time in a state of quantum system and with an increase of temperature of functioning computer. For this matter most suitable computers are the optical ones, since for them at a room temperature the condition $h\omega \geq kT$ is satisfied and substantial dissipation occurs only on the mirrors of the resonator (see [1–3]). However the performance of binary operations of quantum logic often requires simultaneous two-channel control [4–6]. In [7] it is demonstrated that phase shifting can serve as a means of control in the Gaussian impulses sequence. To this end it is necessary to determine the temporal dependence of controlling signals, which is the goal of the present research.

Theory. Consider the quantum Kerr effect represented by the Hamiltonian

$$H = \hbar\Delta a^{+}a + \hbar\chi(a^{+})^2a^2 + \hbar f(t)\left(\Omega a^{+} + \Omega^{*}a\right), \tag{1}$$

where a^{+}, a are the creation and annihilation operators; $\Delta = \omega_0 - \omega$ is the detuning of the resonance from the normal mode of oscillating system ω_0; Ω is proportional to the amplitude of the external field of the coupling constant; χ is coefficient of nonlinearity; τ is the distance between two consecutive impulses; φ is the phase shift between them; $f(t)$ is the sequence of impulses of the external field that takes into account the phase shift $e^{i\varphi}$, so that

$$f(t) = \sum e^{-\frac{(t-t_0-n\tau)^2}{T}} e^{i(n-1)\varphi}. \tag{2}$$

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The Hamiltonian (1) differs from the corresponding Hamiltonian [1] by the factors of impulses of $e^{i\varphi}$ phase shift in the $f(t)$ control signal sequence. Consider the temporary members $f^{\pm}_{N_k}$ and f_{H_k} of Hamiltonian (1) for solving unary operation of negation

$$N = \begin{pmatrix} 0, & 1 \\ 1, & 0 \end{pmatrix} \text{and Hadamard } H = \frac{1}{\sqrt{2}} \begin{pmatrix} 1, & 1 \\ 1, & -1 \end{pmatrix}.$$

Numerical analysis by method [1] leads to following result (here γ is the coefficient of dissipation)

$$f^{\pm}_{N_k} = (0.75 + 55\gamma k)n + (3.75\gamma + 11k)(1-n), \quad k = 1,\ 2,\ 3\ \ldots, \tag{3}$$

$$f_{H_k} = 5.57 + 11\gamma k, \quad k = 0,\ 1,\ 2,\ 3\ \ldots \tag{4}$$

The same way we find the signal $f_C(t)$ to perform controlled negation

$$C_N = \begin{pmatrix} E, & 0 \\ 0, & N \end{pmatrix}, \qquad E = \begin{pmatrix} 1, & 0 \\ 0, & 1 \end{pmatrix}. \tag{5}$$

To this end, consider the Hamiltonian entangled states [2, 3], for instance

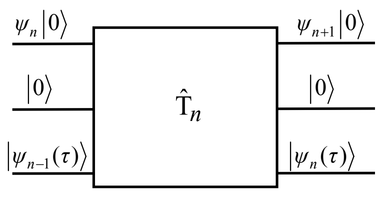
$$\begin{aligned} H_e = -\frac{g^2}{\delta_a}\left(a^+a|g\rangle\langle g| - aa^+|e\rangle\langle e|\right) - \frac{\mu^2}{\delta_b}\left(b^+b|e\rangle\langle e| - bb^+|f\rangle\langle f|\right) + \\ + x\left(aa^+bb^+|f\rangle\langle f| - a^+ab^+b|g\rangle\langle g|\right), \end{aligned} \tag{6}$$

where $a^+a(b^+b)$ are the creation and annihilation operators of resonator $a,(b)$. Resonator a is far-off resonant with $|g\rangle \leftrightarrow |e\rangle$ transition of coupler with coupling strength g and detuning δ_1, while resonator b is far-off resonant with $|e\rangle \leftrightarrow |f\rangle$ transition of coupler with coupling strength μ and detuning δ_2. Here $\delta_a = \omega_{eg} - \omega_a < 0$ is a negative detuning, but $\delta_b = \omega_{fe} - \omega_b > 0$ is a positive detuning. On the basis of Eq. (6), for $f_C(t)$ we derive

$$f_C(t) = \frac{\pi}{|x + 2\pi k/t|}. \tag{7}$$

Relation of Eqs. (3), (4) and (7) fully ensure the performance of quantum algorithms based on Kerr qubits taking into account the dissipation effects as well.

Conclusion. The results obtained permit to perform the operations of quantum logic, as well as to devise the cycle number shifting operator necessary for the "quantum feedback":



$$\hat{T}_n \begin{pmatrix} |\psi_n(0)\rangle \\ |0\rangle \\ |\psi_{n-1}(\tau) \end{pmatrix} \longrightarrow \begin{pmatrix} ||\psi_{n-1}(0)\rangle \\ |0\rangle \\ |\psi_n(\tau) \end{pmatrix}.$$

The operator $\hat{T}_n$ permits the repetition of the recursive cycle with the change of the initial state, but it does not permit the procedure convergence, so the calculation process with the probabilistic results stops after numerous attempts.

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