ISSN 1062-8738, Bulletin of the Russian Academy of Sciences: Physics, 2017, Vol. 81, No. 5, pp. 566–569. © Allerton Press, Inc., 2017.
Original Russian Text © N.S. Perminov, R.S. Kirillov, R.R. Latypov, S.A. Moiseev, O.N. Sherstyukov, 2017, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2017, Vol. 81, No. 5, pp. 611–615.

Optimum Quantum Memory Conditions for a Spatial Frequency Resonator Grating

N. S. Perminov[a, b], R. S. Kirillov[c], R. R. Latypov[c], S. A. Moiseev[a, b, *], and O. N. Sherstyukov[c]

[a] *Kazan Quantum Center, Kazan National Research Technical University, Kazan, 420111 Russia*
[b] *Zavoisky Physical-Technical Institute, Russian Academy of Sciences, Kazan, 420029 Russia*
[c] *Kazan (Volga Region) Federal University, Kazan, 420000 Russia*
**e-mail: s.a.moiseev@kazanqc.org*

Abstract—The dynamics of the interaction between microcavities connected to a common waveguide in a multiresonator quantum memory circuit is investigated. Optimum conditions are identified for the use of quantum memory and a dynamic picture of the exchange of energy between different microcavities is obtained.

DOI: 10.3103/S106287381705015X

INTRODUCTION

Let us discuss the dynamics of the interaction between quantum subsystems in a quantum memory circuit that is integrated into a waveguide system and is capable of retaining a wideband microwave signal over much longer times than the duration of the microwave field pulses. The initial idea is based on approaching a quantum memory as a photon echo [1] of the type found in atomic systems with a periodic spectral structure of the inhomogeneous resonant transition broadening [2] known as an AFC protocol.

In the considered multiresonator scheme (the MR scheme shown in Fig. 1), instead of an atomic system we use a system of several microresonators connected to a common waveguide and arranged at regular intervals in the waveguide, producing a periodic discrete structure of narrow resonant lines as well. An experimental prototype of such a resonator system for the microwave frequency range is shown in Fig. 2. The setup includes a section of the microwave waveguide that has a wide transparency band for the microwave signal field. It is capable of transmitting any information that has to be retained in the microresonator system for periods of time much longer than the duration of an incoming pulse.

To retain the information of the signal field, we connected microresonators to the lateral walls of the microwave waveguide; these were cylindrical resonators made of a composite material and containing a dielectric with a high refractive index. Because of this, the diameter of the microresonators could be made smaller than the wavelength of microwave radiation in the waveguide. This allows us to position a sufficient number of the microresonators along the waveguide. The electromagnetic field of every microresonator interacts with the microwave field in the waveguide through a narrow slit in their common wall. Several microresonators can be arranged along the waveguide wall at distances close to the radiation wavelength, resulting in the virtually simultaneous absorption of a signal pulse by the entire system of microresonators. Our numerical calculations of the MR scheme and the initial experiments confirmed the possibility of stably positioning of several resonant lines of microresonators near one another, even when they are in close proximity inside the waveguide.

THEORETICAL MODEL

In theoretical simulations of the interaction between the resonators and the electromagnetic field

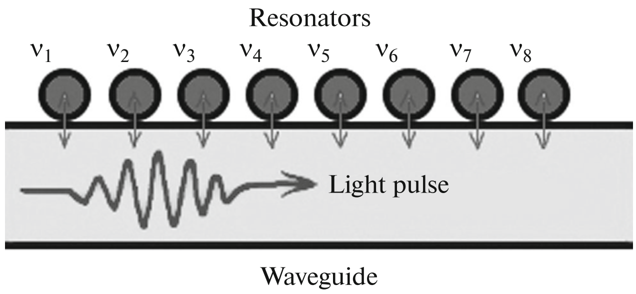

Fig. 1. MR scheme of quantum memory. The waveguide is coupled to a system of resonators through slits in the wall. The distance between neighboring resonators is equal to the wavelength, and the frequencies of the resonators form a periodic structure. The frequency and Q-factor of each resonator can be controlled independently.