# Toward the physical nature of the self-healing effect of light

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**Abstract**

When a narrow beam of light meets an opaque obstacle, then part of the beam is scattered, and the other part behind the obstacle can restore its initial shape. This interesting and counterintuitive self-healing effect has long been studied theoretically and experimentally. There is a detailed mathematical description, but no clear physical explanation. Such a simple and universal physical explanation is discussed here.

When a narrow beam of light meets an opaque obstacle, then part of the beam is scattered, and the other part behind the obstacle can restore its initial shape. This interesting and counterintuitive self-healing effect has long been studied theoretically and experimentally [1 - 5]. There is a detailed mathematical description, but no clear physical explanation. Frequently this effect is associated with "self-accelerating optical waves" [6 - 8], but the physical reason for this "acceleration" of light is not known. The authors [2] suggest that the self-healing effect is somehow related to the concept of ‘classical entanglement’. This is a correct assumption. However, the problem here is that no one understands the physical nature of entanglement [9]. Here we very briefly discuss this whole physical nature and some possibilities of its experimental study.

A number of direct and indirect experimental evidences of the non-equivalence of the forward and backward processes in quantum physics have been known for quite a long time [10 - 12]. The differential cross section of a quantum process reversed to its initial state can be many orders of magnitude larger than that of a direct process. This is the physical basis for many effects in nonlinear optics. It is highly likely that the self-healing effect is one of the numerous manifestations of this inequivalence between the forward and reversed to the initial state quantum processes.

A natural and necessary property of the non-equivalence of forward and reversed quantum processes is the presence of some memory of the quantum system about its initial state. Without such memory, it is impossible to distinguish between a forward quantum process and a reversed one. *This non-local memory of a quantum system about its initial state is the physical essence of entanglement* [11]. Such quantum memory looks like a physical equivalent of entropy. Such memory can be stored, accumulated, blurred, but it does not disappear. We don't know where it is stored. However, some of its nonlocal properties can be easily studied in experiments with a beam splitter.

We are talking about the Hong-Ou-Mandel (HOM) effect in the case when the synchronization of entangled photons occurs after the beam splitter [13, 14]. It looks like a violation of causality: the consequence (splitting of photons on the beam splitter) precedes the cause (synchronization of entangled photons in the Pockels cell). The photons, coming to the beam splitter, in some mysterious way “know” what will happen later and behave accordingly. This situation is completely analogous to that which exists in the classical two-slit interference. When a photon or electron passes through a slit, it somehow mysteriously "knows" about the existence of the second slit [15]. The mysterious “knowing” is a manifestation of nonlocality in quantum physics. More precisely, this is a manifestation of the non-local memory of a quantum system about its initial state [16].

In the case of slits, for various reasons, we cannot spread them far apart. However, in the case of the HOM effect, we can separate the beam splitter and Pockels cell at least several kilometers away. We can experimentally study in this way nonlocality of quantum memory. At some distance the HOM effect should disappear. In this case, we will get an idea of the degree of nonlocality of the memory of this quantum system.

Then we can try to determine how fast this “knowledge” spreads. If a high-speed Pockels cell is used, then in the version of the so-called “delayed choice” [17], the speed of information (memory) propagation in space from the Pockels cell to the beamsplitter can be measured. Could this speed be greater than the speed of light?

## Conclusion

It is high time for physicists to recognize the experimental fact of the non-equivalence of forward and reversed quantum processes and, associated with this, the non-local memory of a quantum system about its initial state. Some non-local properties of such memory can be studied in HOM experiments, when synchronization of entangled photons occurs after the beam splitter. These experiments are very simple [18]. There are many experimenters who have all the necessary equipment for such experiments. We hope that someone will at last carry out these important, interesting and simple experiments [19].

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