Comment on “Memories of amplitude and direction coexist and compete in non-Brownian Suspensions”

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Abstract

A recent article [Phys. Rev. Lett. 136, 258201 (2026)] continued the experimental study of an interesting physical phenomenon, where the viscosity of a suspension can be greater when moving forward than when moving backward. The authors attribute this phenomenon to the presence of a certain memory in the environment. The physical nature of both the phenomenon itself and the supposed memory is unknown. A possible explanation of the physical nature of this effect is proposed here and simple experiments to study some properties of such non-local memory are discussed.

For many years, the effects associated with the presence of a certain memory in a solid or liquid medium have been studied experimentally [1, 2]. One of the most characteristic phenomenon here is the dependence of the viscosity of the suspension on the direction of its movement forward or backward [3]. The physical nature of both the phenomenon itself and the supposed memory is unknown. Now we can offer a real version of such a physical explanation.

There is direct experimental evidence of the non-equivalence of the forward and reversed processes in quantum physics [4]. 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 quite possible that the discussed effect of suspension viscosity asymmetry is a manifestation of this inequivalence between the forward and reversed quantum processes.

The nonlocal memory of a quantum system about its initial state is a natural and necessary property of the nonequivalence of forward and reversed quantum processes. Without such memory, it is impossible to distinguish between a forward quantum process and a reversed one. 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 non-local properties can be easily studied experimentally using 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 [5, 6]. 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 [7]. 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 [8].

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 [9]. 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” [10], 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

The observed effect of viscosity asymmetry in the suspension appears to be one of the numerous manifestations of the fundamental property of quantum physics - the nonequivalence of forward and reversed processes in it. The experimental study of some properties of the non-local memory of the medium is simpler and more convenient to study in the HOM effect variant, when the synchronization of entangled photons occurs after the beam splitter. These experiments are very simple. 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 [11].

References

[1] N.C. Keim, J.D. Paulsen, Z. Zeravcic, S. Sastry, and S.R. Nagel, “Memory formation in matter”, Rev. Mod. Phys. **91**, 035002 (2019).

[2] J. D. Paulsen and N.C. Keim, “Mechanical memories in solids, from disorder to design”, e-print, arXiv:2405.08158.

[3] S. Padamata and N.C. Keim, “Memories of amplitude and direction coexist and compete in non-Brownian suspensions”, Phys. Rev. Lett. **136**, 258201 (2026).

[4] V.A. Kuz'menko, "Time reversal noninvariance in quantum physics", e-print, viXra:2004.0160.

[5] T.B. Pittman, Y.H. Shih, A.V. Sergienko, and M.H. Rubin, "Experimental tests of Bell's inequalities based on space-time and spin variables", Phis. Rev. A, **51**, 3495 (1995).

[6] T.B. Pittman, D.V. Strekalov, A. Migdall, M.H. Rubin, A.V. Sergienko, and Y.H. Shih, "Can Two-Photon Interference be Considered the Interference of Two Photons?", Phys. Rev. Lett., **77**, 1917 (1996).

[7] G. Greenstein and A.G. Zajonc, "The Quantum Challenge", Jones and Bartlett Publ., Boston (2006).

[8] V.A. Kuz'menko, "Toward the experimental study of indefinite causal order phenomenon", e-print, viXra:2507.0034.

[9] W. Tittel, J. Brendel, H. Zbinden, and N. Gisin, "Violation of Bell Inequalities by Photons More Than 10 km Apart", Phys. Rev. Lett., **81**, 3563 (1998).

[10] T. Hellmuth, H. Walther, A. Zajonc, and W. Schleich, "Delayed-choice experiments in quantum interference", Phys. Rev. A, **35**, 2532 (1987).

[11] V.A. Kuz'menko, Comment on "Experimental evidence that a photon can spend a negative amount of time in an atom cloud", e-print, viXra:2604.0108.