Academic Journal of Polymer Science
ISSN: 2641-8282

Juniper Publishers
key to the Researchers

Mini Review
Volume 3 Issue 2 - October 2019
DOI: 10.19080/AJOP.2019.03.555607

Academ J Polym Sci

Quantum Teleportation Under the Influence of Classical Mechanical Forces

Aatolii Isaev*

Russian Academy of Sciences, PN Lebedev Physical Institute (FIAN), Moscow, Russia

Submission: October 23, 2019**; Published:** October 31, 2019

***Corresponding author:** Aatolii Isaev, P. N. Lebedev Physical Institute, (FIAN) Russian Academy of Sciences, Leninskii pr. 53, Moscow, Russia

Abstract

The article presents the experimental results of the behavior of semiconductor quantum dots in a focused optical beam. These results prove quantum teleportation under the influence of weak classical mechanical forces. These forces cannot cause real flows in a fluid, but cause flows of quantum states, which are flows without a trajectory of motion in classical space.

Keywords: Quantum Teleportation; Quantum Entanglement; Quantum Superposition; Qubits

Introduction

Quantum teleportation is the concept of quantum physics, which is being studied in a large number of recent published works. The main research topics are quantum communication, quantum computing and quantum networks. The term teleportation means the process by which bodies and objects are transferred from one place to another without moving along any path. The "quantum teleportation" boom begins with article [1], in which an unknown quantum state is first measured and then reconstructed at a remote place. The implementation of this information protocol requires a classical communication channel [1], and quantum entanglement [2,3]. Quantum entanglement is a new resource of quantum physics, the same as, for example, energy [2]. Obviously, new resources allow opening new potentials and implementing fundamentally new processes of quantum physics. The authors [2] argue that this new resource "is very complex and difficult to detect." Another key property of quantum entanglement is that: "entanglement" implies the existence of global states of the composite system, which cannot be written as a product of the states of individual subsystems [4]. An example of quantum entanglement is the "Schrödinger cat" in the "quantum box" invented by the founding fathers of quantum mechanics. This example demonstrates the key physical property of quantum entanglement: complete uncertainty from the perspective of an observer from classical space. This is about - difficult to detect. Indeed, how can one detect a state if it is not completely defined? "Fragility" in relation to the interaction with the environment is another key physical property of entanglement, which also demonstrates the example of Schrödinger's "cat". The "Schrödinger cat" state becomes available to the observer from the classical space only after opening the quantum "box" or, in other words, after we have destroyed the state of quantum entanglement. Therefore, the consequence of "fragility" lies in the fundamental impossibility to manage the states of entanglement without destroying the entanglement itself. "Entanglement" implies the existence of global states of the composite system, which cannot be written as the product of the states of individual subsystems [4]. In fact, this statement is the recognition of the fundamental non-classical aspects of entanglement in 1935. Therefore, attempts to detect entanglement in laboratory reality were performed by numerous experimental tests of quantum formalism, for example, tests for breaking Bell's inequality [5,6]. All such experiments convincingly confirmed the feeling that quantum entanglement is a purely quantum process, and it is a necessary process for quantum teleportation. The purpose of this article was to present experimental results that substantiate the possibility of organizing the quantum entanglement of an array of quantum objects in a simple way. Thus, organized array of entangled states can detect the unique properties of quantum teleportation in terms of development, as a fundamental physics and practical applications.

Experiment and Discussion

The details and ideology of the experiment are described in [7]. Here we present these ideologues in a brief, concise form. The main premise of the work lies in the fact that quantum superposition is the source of an array of entangled states. Indeed, the quantum state $|\Psi\rangle$ of a quantum superposition contains 2N completely undefined states that obey an exponential, rather than a polynomial dependence. The time decoherence of a quantum state $|\Psi\rangle$ is determined by internal and external forces, and it is short. Therefore, this state ideally satisfies the key properties of quantum entanglement, which were discussed above. Quantum superposition is a self-assembly of two-level quantum objects, like most other quantum objects [8]. Semiconductor quantum dots (QDs) of CdSe/ZnS were used in this work (as in [7]) as quantum objects with two stable quantum states, which qubits are. The first stable quantum state $|0\rangle$ was a quantum dot in the ground quantum state. The second stable quantum state $|1\rangle$ was QD with a metastable exciton, the relaxation of which is the millisecond range of time [9]. This time exceeds the relaxation time of other quantum states of quantum dots by 6 orders of magnitude, which ensures the relative stability of this quantum state. Decoherence translates (unravels) all 2N entangled states into N stable $|0\rangle$ or $|1\rangle$ states of each qubit of the classical space that participated in the formation of quantum superposition. Therefore, the task of registering the result of quantum superposition coincides with the problem of registering stable quantum states $|0\rangle$ or $|1\rangle$ of the qubit in the classical space. The experiment was quite simple. The focused laser beam of a cw laser shined through a cell with a colloid of CdSe/ZnS semiconductor quantum dots (QDs) in toluene. This beam passed through the cuvette and formed on a remote screen a kind of intensity distribution or beam trace profile, which was recorded by a digital camera in the "video" mode with of 25 s-1 frequency. This article presents and discusses the experimental results of the transformation of the beam trace profile in the process of moving the table with the cuvette from one location along the Z axis to another position. The fact is that the table with the cuvette was located on the table, the surface of which was painted. The painted surface usually has micro-irregularities, the movement along which the base with the cuvette causes a micro-shake of the cuvette itself. The result of this micro-shaking was manifested as a "whistle" of the pattern of the beam trace profile. The analysis of this "whistle dance" is the goal and the subject of this work. The input beam parameters were beam convergence angle θ =5.45 10-3; w0=$\lambda/\pi\,\theta$ =28 μm; I0=2Pl/ π w2=2436 W/cm2; z0=πw02/λ= 5.2 mm. The thickness of the cuvette with colloid was 5 mm. The wavelength of a single-mode cw laser was 437 nm, power ~ 30 mW. (Figure 1) represents a typical view of the beam trace profile at the beginning of illumination (320 ms) and in the steady state (1600 ms). The beam trace profile has a typical pattern: a wide bright outer ring and inner rings with decreasing brightness and width between them towards the center of the pattern, which coincides with the axis of the input beam. This pattern is a result of transverse self-phase modulation in an optical medium with a Gaussian refractive index distribution, which has an inflection region [10]. The distribution of the refractive index in the colloid of QDs forms the distribution of the concentration of QDs with a metastable exciton. A metastable exciton is an electron—hole pair, in which an electron is captured by a surface trap with a long lifetime [9]. As a result of this capture, charge carriers are divided by the size of the QD, which is several nm. Such a large separation of charge carriers is the source of a very large light-induced dipole moment p of an individual QD with a metastable exciton. The dipole moment p is responsible for the amount of light-induced change in the refractive index [11]. Therefore, a large value of p makes it possible to record the distribution of the concentration of individual QDs with a metastable exciton and, with a sufficiently large accumulation, obtain a "giant" nonlinear-optical response [12].

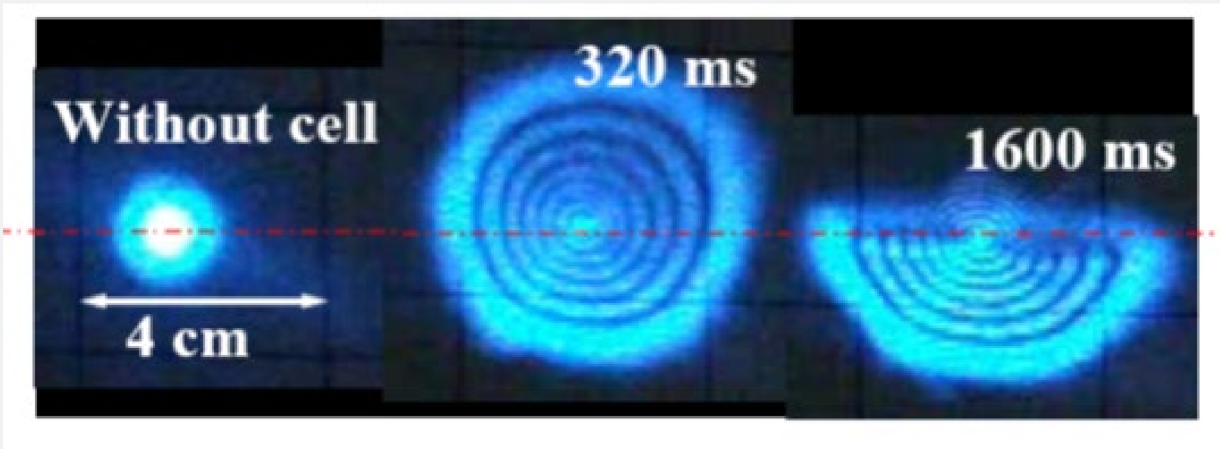

Figure 1: The trace profile of the input optical beam and the trace profiles of the output beam in the process of accumulation of long-lived QDs, z = -29z0.

(Figure 2) contains information about how the dimensions of the pattern of the beam trace profile change in the process of establishing a steady state and after the beginning of the movement of the cuvette with the colloid QDs. These data were obtained at the position of the cuvette along the axis Z = -15z0. Here Dhor, Rdw Rup is the horizontal diameter, the radius of the lower half and the radius of the upper half of the pattern of the beam trace profile. τ is the characteristic relaxation time of accumulation and decay of the horizontal and vertical size of the beam profile trace pattern that extrapolated exponential function. The beginning of the movement of the cuvette with colloid took place after 3 seconds of illumination. It is obvious that the establishment of a stationary state takes place

How to cite this article: Aatolii Isaev. Quantum Teleportation Under the Influence of Classical Mechanical Forces. Academ J Polym Sci. 2019; 3(2): 555607. DOI: 10.19080/AJOP.2019.03.555607

as a result of two processes. The first ~ 400 ms there is an increase in all sizes of the pattern of the beam trace profile. Then, we see a dramatic change in the size behavior of this pattern. An obvious reduction in all sizes of this pattern is observed. We should note that the increase and subsequent reduction in the size of the pattern is well extrapolated by exponential functions. Moreover, the pattern of the upper half of the beam trace profile is reduced to a much greater degree and significantly sooner. The analysis of these experimental results will be postponed for another article. Here, we consider the situation after the beginning of the movement of the cell with the colloid to another location along the Z axis. The beginning of this movement took place after 3 seconds of continuous illumination, and this movement caused a complete "whistleblower" or "orgy" of the dimensions of the beam trace profile pattern, which (Figures 2 and 3) demonstrate quite well. We must note that the pattern of the profile of a beam trace changes its structure in an abrupt manner. Details of the pattern of each frame in (Figure 3) do not coincide with the details of the pattern of the previous frame of the video. All patterns of each frame change their details "jump". Recall that the time between frames was 40 ms. Here we should especially note that all the processes that controlled the size of the pattern immediately before the beginning of the displacement had characteristic relaxation times of 200–300 ms, which significantly exceeded the actual time of a cardinal change of the pattern itself.

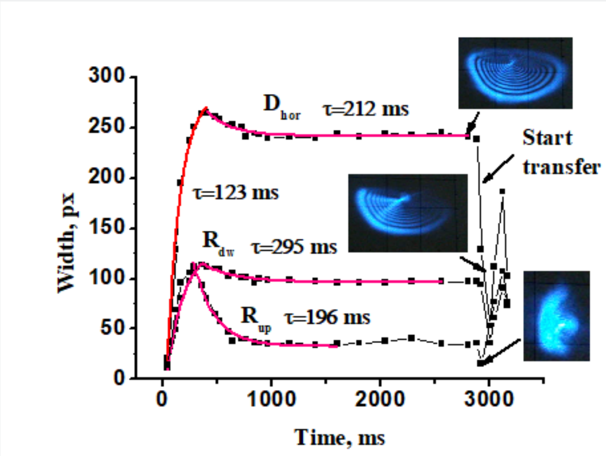

Figure 2: The establishment of a stationary beam trace profile pattern. The inserts show the direct transformation of the pattern after the beginning of the movement from the position along the axis Z = -15z0 towards the side closer to the waist of the focused beam.

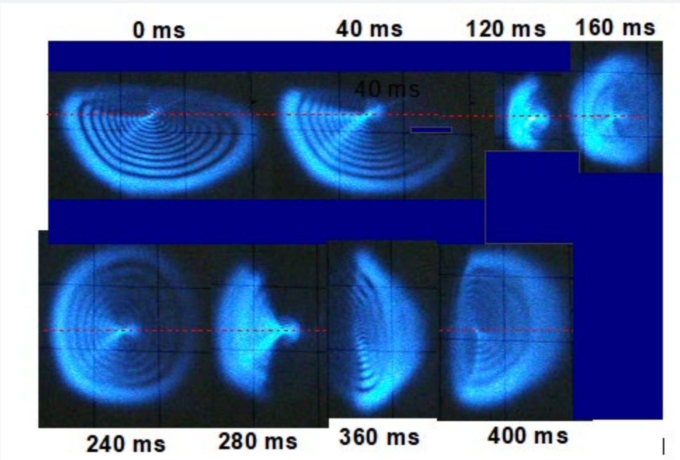

Figure 3: Transformation of the pattern of the beam trace profile during the movement of the colloid from the position z = -15z0.

Another key result is shown in (Figure 4) and it lies in the fact that the axis of the output optical beam coincides with the axis of the input optical beam for all "manipulations" with the cell with colloid: its movement along the Z axis (± 49z0); micro-shaking due to the unevenness of painting the surface of the table on which the table with the cuvette was moving. Here we note that the cuvette was oriented at a small angle to the axis of the input optical beam, and the axis of direct movement of the cuvette did not coincide with the axis of the input optical beam. (Figure 4) illustrates this situation. Here the profile of 0 ms is the profile of the input beam without a cell in the beam. We see that the axes coincide with each other for all the digital profiles of the beam trace pattern, both at the beginning of

How to cite this article: Aatolii Isaev. Quantum Teleportation Under the Influence of Classical Mechanical Forces. Academ J Polym Sci. 2019; 3(2): 555607. DOI: 10.19080/AJOP.2019.03.555607

the illumination (40-520 ms) and when the colloid is micro-shaken from one location to another location (3 seconds). The pattern of the beam trace profile changes its structure and dimensions "abruptly" in each frame of the video. (Figure 5) shows how the digital profile of the beam trace profile pattern changes its structure and size after the beginning of the displacement (0 ms) of the cuvette along the z axis and after 120 ms. Here we have to remind that the beginning of movement took place after 3 seconds of continuous illumination, when the pattern of the beam trace profile was in a steady state with a characteristic exponential relaxation time $\tau \sim$ 200-300 ms.

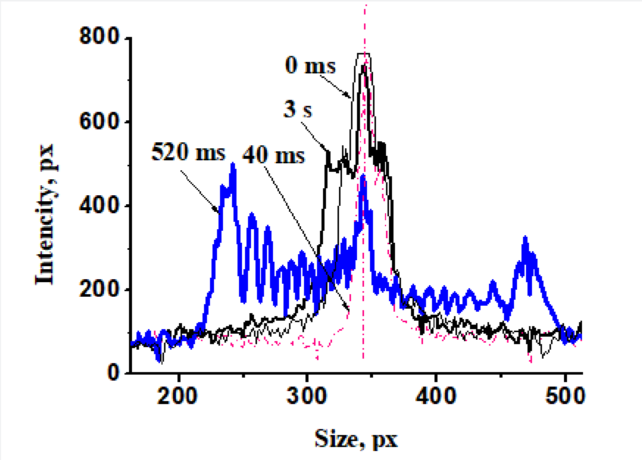

Figure 4: Digital profile of the beam trace pattern at different times after the start of illumination.

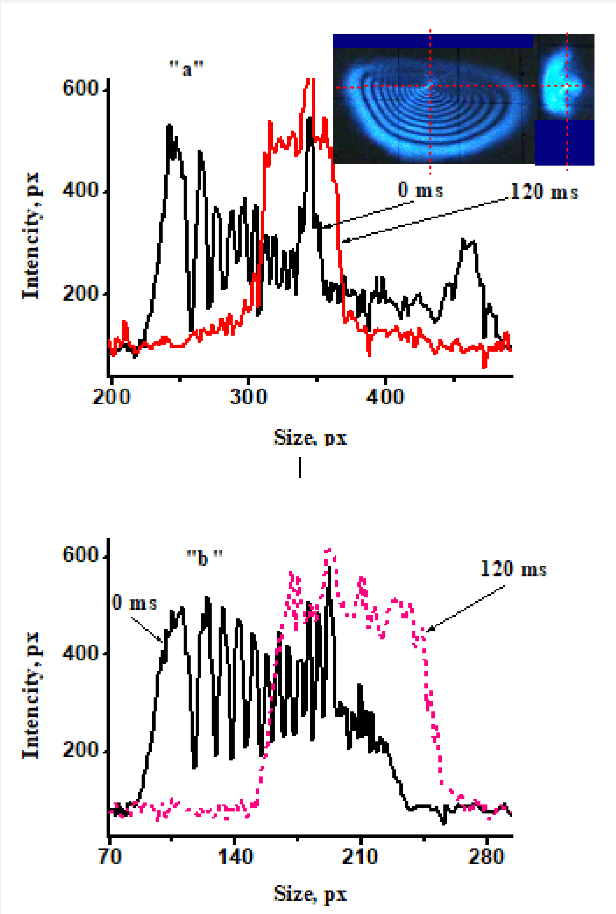

Figure 5: Digital profile of horizontal slice "a" and vertical slice "b" of the beam trace pattern 120 ms after the beginning of the movement (0 ms).

How to cite this article: Aatolii Isaev. Quantum Teleportation Under the Influence of Classical Mechanical Forces. Academ J Polym Sci. 2019; 3(2): 555607. DOI: 10.19080/AJOP.2019.03.555607

(Figures 2–5) contain information that shows that micro shaking of a QDs colloid transforms the pattern of the beam trace profile over a time that is significantly shorter than the characteristic exponential relaxation time of the steady state steady state of the QDs colloid. Here we recall that the pattern of the beam trace profile is a pattern of wave aberrations of the wave surface of the light-induced refractive index volume [13-15]. The photoinduced refractive index of a colloid QDs results from the accumulation of the concentration of QDs with a light-induced metastable exciton [7]. Consequently, the transformation of the pattern of the beam trace profile is the result of the transformation of the distribution of the concentration of QDs with a metastable exciton in the illuminated volume of the QDs suspension. Figure 5 convincingly shows that a substantial concentration of QDs with a metastable exciton, providing phase addition to the wave front of the input beam, for example, at 14π disappears without a trace for a time shorter than the characteristic relaxation time of the steady-state stationary concentration of QDs. In principle, this behavior of the QDs concentration is expected. Micro-shaking is a source of forces that can cause flows in a liquid, which mix the concentration of QDs. But the fact is that micro shaking causes forces with an arbitrary direction. It is obvious that such forces should cause arbitrary concentration flows in a liquid, which should cause an arbitrary geometric displacement of the optical beam, its axis, in the first place. The experiment shows that arbitrary QDs concentration fluxes with a metastable exciton really arise, but all these fluxes "spin" around the axis of the input optical beam. The axis of the input beam has "unshakable" directions and retains its direction for all mechanical perturbations of the cell with QDs colloid. This means only one thing: there are no real flows of QDs concentration in the liquid, and what we see is the result of teleportation of the quantum states of a metastable exciton. Quantum teleportation "transfers" only quantum states from one quantum object to another quantum object. The trajectory of the transfer, of course, is absent. We have implemented a unique situation where mechanical classical forces are small enough to cause a real disturbance of the fluid, but these forces easily cause quantum teleportation, which does not have a trajectory of movement in classical space. The lack of a trajectory of movement clearly means that there is no actual movement of objects in space. Obviously, there is no movement; therefore, there are no forces that prevent this movement. This means that what we see is the result of the direct action of the forces not "burdened" by the opposition of any other forces. The practical significance of these results is difficult to overestimate, since they open up the possibility of developing super sensitive sensors, for example, for recording gravitational waves, but in the size of a conventional laboratory table.

In conclusion, let us formulate the physics of the quantum teleportation process of entangled quantum states. The obvious condition of quantum teleportation is that entangled quantum states must occupy a macroscopic volume. It is the volume in which the geometric displacement of quantum states takes place. In this work, this volume determines the geometry of the input optical beam, as well as, for example, in [16]. This optical beam light induces a second stable quantum state (QDs with a metastable exciton) from the first state (QDs in the ground quantum state), in other words, the optical beam generates classical two-level qubits, which, at a sufficiently high concentration, self-organize into a quantum state of quantum superposition with 2N entangled quantum states. Decoherence takes place under the influence of both internal and external forces. It is under the action of these forces that the "disentangling" of 2N quantum states into one of the stable states $|0\rangle$ or $|1\rangle$ of each individual qubit from N classical qubits takes place. The concentration distribution of these particular qubits is easily measured, since they are already in the classical space. The specific geometrical place where the quantum states $|0\rangle$ or $|1\rangle$ all into is determined by internal forces (concentration compression as QDs accumulate with a metastable exciton) or external forces (whistle of the beam trace profile pattern). An analogue of the physics of such teleportation is the precipitation of raindrops (quantum states) from a macroscopic rain cloud (quantum superposition) under the action of internal forces (for example, the turbulent distribution of condensation centers) or external forces (for example, turbulent flows or wind gusts).

References

1. Bennett CH, Brassard G, Crepeau C, Jozsa R, Peres A, et al. (1993) Teleporting an unknown quantum state via dual classical and Einstein-Podolsky-Rosen channels. Phys Rev Lett 70(13): 1895-1899.
2. Horodecki R, Horodecki P, Horodecki M, Horodecki K (2009) Quantum entanglement. Rev Mod Phys 81: 865-942.
3. Eisert J, Plenio MB (2003) Introduction to the basics of entanglement theory in continuous-variable systems, Int J Quant Inf 1: 479.
4. Schrodinger E (1935) Die regenerative Situation in der Quantomechanic. Naturwissenschaften 23(48): 807-812.
5. Aspect A, Grangier P, Roger G (1981) Experimental Tests of Realistic Local Theories via Bell's Theorem. Phys Rev Lett 47: 460.
6. Aspect A, Dalibard J, Roger G (1982) Experimental Test of Bell's Inequalities Using Time-Varying Analyzers. Phys Rev Lett 49: 1804.
7. Isaev AA (2019) Two signs of superfluid liquid in a suspension of CdSe/ZnS quantum dots at room temperature. International Journal of Optics 2019.
8. Yoon SL (2008) Self-assembly and nanotechnology, John Wiley & Sons, Inc, Hoboken, New Jersey, USA.
9. Rabouw FT, Kamp M, Dijk RJM, Gamelin DR, Meijerink A, et al. (2015) Delayed Exciton Emission and Its Relation to Blinking in CdSe Quantum Dots. Nano Lett 15(11): 7718-7725.
10. Ramirez EVG, Carrasco MLA, Otero MM, Cerda SC, Castillo MD (2010) et al. Far field intensity distributions due to spatial self-phase modulation of a Gaussian beam by a thin nonlocal nonlinear media. Optics Express 18(21): 22067-22079.
11. Robert Boyd (2007) Nonlinear Optics, (3rd Edtn), Academic Press, New York, USA.
12. Isaev A (2013) Cumulative electronic non-linearity of CdSe/ZnS quantum dots. J Phys D: Appl Phys 46(21): 215301.
13. Akhmanov SA (1967) JETP (letters) 6: 209
14. Akhmanov SA, Krindach DP, Migulin AV (1968) Thermal Self-Actions of Laser Beams. IEEE J Quantum Electronics 4(10): 568-575.
15. Whinneru JR (1967) IEEE J. Quantum Electron. QE-3: 382.
16. Ma XS, Herbst T, Wang D, Naylor W, Kofler J, et al. (2012) Quantum teleportation over 143 kilometres using active feed-forward Nature 489(7415): 269-273.

How to cite this article: Aatolii Isaev. Quantum Teleportation Under the Influence of Classical Mechanical Forces. Academ J Polym Sci. 2019; 3(2): 555607. DOI: 10.19080/AJOP.2019.03.555607

How to cite this article: Aatolii Isaev. Quantum Teleportation Under the Influence of Classical Mechanical Forces. Academ J Polym Sci. 2019; 3(2): 555607. DOI: 10.19080/AJOP.2019.03.555607