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Review Article

Movement of Information and Its Carriers

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Abstract

In this paper we are trying to discuss some physical effects responsible for information transfer and nature of particles/waves - carriers of information.

Introduction

Last achievements of Informatics – Computer Science, which studies the structure of representation and transformation of information by machines, as well as quantum physics and modern mathematical approaches are shown that information (information particles "bits – qubits", and information field) has the properties of quantum matter [1, 2].

Today we divide the computer science and technology to two parts "Classical" and "Quantum", and we also divide it to theory of information and information technology. Thus we have Information theory and quantum information theory, and accordingly – information technology and quantum information technology. All this it is not enough correct because naturally we have theory of information, which includes the newton mechanics based approaches and quantum mechanics based ones. Above mentioned definition is clear If we call Newton's mechanics "classical" and Schroedinger's mechanics "quantum". In reality information as phenomena is based on probability and relativity, and we should say that non quantum approach to information is the rather weak because it is based on the rough estimations that probability of any action is 0 or 1 [3-5].

One of the most important part of information science and technology is information movement which can be described as data transfer via communication channels [6]. Transmission of information package, which contains the group of bits/qubits can be done by any known carriers, in the modern times by any known particles and relevant waves transferring the energy. So information transfer is the energy transfer and for this it is necessary to have field and particle. In the modern telecommunication we are using mainly the electrons and photons for information energy transfer. In the future for organization of information-communication process we can use not only magnetons (magnetic particles of magnetic field) but also gravitons (particles of gravity) and others [7].

According to above mentioned information could be measured in electronvolts ($1eV=1.60218^{-19}$ Joule) or in another energy units. By mass–energy equivalence, the electronvolt is also a unit of mass. It is common in particle physics, where units of mass and energy are often interchanged, to express mass in units of eV/c^2.

At the same time following existing definition: Matter is anything that has mass and takes up space. The amount of space an object takes up is its volume. Emotions, thoughts, and ideas are more examples of things that are not matter. They take up no space and do not have mass" [8]. But if we look deeper even those phenomenas are based on information (energy) flow and exchange between different parts of brain. So they also are information-communication processes. So it is clear that information is also matter.

The way to these solutions includes the R. Clausius observation that: "The energy the universe is constant the entropy of the universe tends toward a maximum"; C. Shannon's definitions of amount of information as logarithm of a probability of its occurrence from a given source over a given channel thus measuring in 'bits', which has become a household term. Actually, this notion fits with the physics tradition via one transformation. The total entropy of two independent systems is the sum of their individual entropies, while the total probability is the product of the individual probabilities.

While the preceding tandem view seems to highlight the dynamic processes, it equally well forces us to think more about the details of representation of information. It is symptomatic that I. Kolmogorov complexity can be viewed as a theory of string entropy, with random strings as systems in thermodynamic equilibrium. This suggest intriguing equivalence relations for translating between complexity theory and physics, for whose details we refer to connection and overlapping of computer science, and physics and information process is the relation between information field structure and information portions – bits motion [9]. The solution of this problem is lying in unification of the theory of information, computation, dynamic logics of epistemic update in one side, andspintronics, moletronics, memtronics, nanotronics – novel physical approaches for information processing on the other, looking to bits as a real particles together with information field - main actors in infodynamical processes.

We can examine the real process of information transfer by looking at the current main carrier of information – light particle, photon its behavior and properties. The term photon was coined by Gilbert Lewis in 1926, though the concept of light in the form of discrete particles had been around for centuries and had been formalized in Newton's construction of the science of optics. The early Greeks were the first to propose that energy is composed of particles. However, later experiments suggested that energy behaved more like waves than particles. In the 1860s, the physicist James Clerk Maxwell discovered that light was a form of electromagnetic waves. In 1900, Max Plank, a German physicist, suggested that light was made up of particles [10].

Under the photon theory of light, a photon is a discrete bundle (or quantum) of electromagnetic (or light) energy. Photons are always in motion and, in a vacuum, have a constant speed of light to all observers, at the vacuum speed of light (more commonly just called the speed of light) of c = 2.998 x 108 m/s. According to this theory photons have zero mass and carry energy and momentum, which are also related to the frequency ν and wavelength λ of the electromagnetic wave by $E = h\nu$ and $p = h/\lambda$.

Light has properties of both a wave and a particle. Just one of the effects of this wave-particle duality is that photons, though treated as particles, can be calculated to have frequency, wavelength, amplitude, and other properties inherent in wave mechanics.

Photons are electrically neutral and are one of the rare particles that are identical to their antiparticle, the antiphoton. Photons are spin-1 particles (making them bosons), with a spin axis that is parallel to the direction of travel (either forward or backward, depending on whether it's a "left-hand" or "right-hand" photon). This feature is what allows for polarization of light.

In both these cases, the information is communicated at or below the speed of light, in keeping with Einstein's axiom that nothing in the Universe can go faster.

Quantum mechanics allows for a third way to coordinate information. When two particles are quantum mechanically 'entangled' with each other, measuring the properties of one will instantly tell you something about the other. In other words, quantum theory allows two particles to organize themselves at apparently faster-than-light speeds.

Einstein called such behaviour "spooky action at a distance", because he found it deeply unsettling. He and other physicists clung to the idea that there might be some other way for the particles to communicate with each other at or near the speed of light [11, 12].

Albert Einstein claims that the speed of light is the "traffic law of the universe" or, otherwise put, that nothing can travel faster than light. Of course, humanity's dream of time travel has long relied on the hope that Einstein was wrong. We got a glimmer of hope back in the last century when scientists found superluminal (faster-than-light) propagation of optical pulses in some specific medium. Unfortunately, this was later revealed to be a visual effect, and the photons involved couldn't actually transmit information. Einstein's theory rests on two postulates, one of which is that electromagnetic radiation travels at the same speed. Light particles - photons have no mass, so a consequence is that no particle with mass can move at a velocity greater than light. These neutrinos have a tiny, but non-zero, mass and hence should not be able to travel faster than the speed of light [13].

There are two other experiments that shoot neutrinos over long distances that may have something to say about this result. One experiment is in the U.S., and the beam goes from Fermilab, near Chicago, to a detector called MINOS in northern Minnesota. The other shoots a neutrino beam across Japan to an experiment in a mine called Super-Kamiokande. The energies of the neutrinos in these experiments are much lower than the CERN beam, but they may have something to say very soon [14-16].

Since then, there has been a debate surrounding whether or not a single photon might actually be able to travel faster than the speed of light.

Few years ago researchers at the Joint Quantum Institute (JQI), a collaboration of the National Institute of Standards and Technology and the University of Maryland at College Park, can speed up photons to seemingly faster-than-light speeds through a stack of materials by adding a single, strategically placed layer. A single photon travels through alternating layers of low and high refractive index material more slowly or quickly depending upon the order of the layers. A strategically placed additional layer can dramatically reduce photon transit time. At the boundaries between layers, the photon creates waves interfering with each other, affecting its transit time. This experimental demonstration confirms intriguing quantum-physics predictions that light's transit time through complex multilayered materials not depend on thickness, as it does for simple structures but rather on the order in which the layers are stacked [17]. Strictly speaking, light always achieves its maximum speed in a vacuum or empty space, and slows down appreciably when it travels through a material substance. The same is correct for light traveling through a stack of dielectric materials and even nanostructures, which are electrically insulating and can be used to create highly reflective systems that are often used as optical coatings on mirrors or fiber optics or photovoltaic elements.

The rule that nothing can travel faster than the speed of light still is one of the most fundamental laws of nature. But since this speed limit has only been experimentally demonstrated for information carried by large groups of photons, physicists have recently speculated as to whether single photons and the information carried by them may be able to exceed the speed of light [18-21].

This experiment, conducted by a team at the Hong Kong University of Science and Technology and led by Professor Shengwang Du, measured the ultimate speed of a photon using controllable waveforms and published their study on the ultimate speed of a single photon in Journal of Physical Review Letters. The results have implications for the maximum speed of information transmission by confirming that single photons obey causality; that is, an effect cannot occur before its cause. They reported the direct observation of optical precursors of heralded single photons with step- and square-modulated wave packets passing through cold atoms. Using electromagnetically induced transparency and the slow-light effect, the single-photon precursor was separated, which always travels at the speed of light in vacuum, from its delayed main wave packet. In the two-level superluminal medium, experimental results suggest that the causality holds for a single photon [22].

It had been measured several properties of photons, such as phase, when they arrived at their havens and found that they did indeed have a spooky awareness of each other's behaviour. On the basis of their measurements, it had been concluded that if the photons had communicated, they must have done so at least 100,000 times faster than the speed of light - something nearly all physicists thought would be impossible. It was found that, as the fastest part of a single photon, the precursor wave front always travels at the speed of light in vacuum. The main wave packet of the single photon travels no faster than the speed of light in vacuum in any dispersive medium, and can be delayed up to 500 nanoseconds in a slow light medium. By showing that single photons cannot travel faster than the speed of light, last experimental results bring a closure to the debate on the true speed of information carried by a single photon. That indicates, in turn, that time travel is not possible, and that decades of beloved science fiction may not be entirely based on fact.

At the same time it is necessary to underline that in quantum field theory forces are mediated by virtual particles. Because of the Heisenberg uncertainty principle these virtual particles are allowed to go faster than light [23].

Is all above mentioned strongly correct? More less. For today it is more.

Conclusion

It is absolutely clear that speed of photons, which are particles of making a light cannot be higher than speed of light and information they are transferring also has the same speed. On the other hand the speed of information which might be transferred by the other particles/waves could travel by the higher/lower speed depending of its carrier.

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