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THE CONCEPT OF A QUANTUM AND ITS PHYSICAL MEANING

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ABSTRACT

This article discusses the development of views on the study of the concept of "quantum". Quantum theory describes three of the four fundamental types of interactions – electromagnetic, strong and weak. And currently, the active study of this field of physics continues. However, this work was based on the study of the history of the discovery of the concept of "quantum" and its physical meaning.

Keywords: quantum, quantum physics, elementary particles.

INTRODUCTION

Quantum refers to discrete units of matter and energy that are predicted and observed in quantum physics. Even space and time, which seem to be extremely continuous, have the smallest possible values. The birth of quantum physics is attributed to Max Planck's 1900 work on black body radiation. The field was developed by Max Planck, Albert Einstein, Niels Bohr, Richard Feynman, Werner Heisenberg, Erwin Schrödinger and other luminaries in this area. In the field of quantum physics, the main method that really affects the physical processes taking place is "observation". For example, it was he who made it possible to establish that light waves act like particles, and particles act like waves. Matter can move from one point to another without moving through the intermediate space, in this case, information instantly travels over great distances. In 1925, Werner Heisenberg formulated the theory of quantum mechanics. Heisenberg's method required working with matrices. Heisenberg's approach included two components [Yushkevich, p.24]: 1. The full set of frequencies at which an atom emits due to a quantum jump;

The probabilities according to which the jumps occur; The idea of matrix mechanics was that the physical quantities characterizing a particle are described by matrices that change in time. A completely different approach was proposed by Erwin Schrödinger, proposing a theory of wave mechanics. He said that any matter exists in the form of waves. The wave equation formulated by Schrödinger refers to an unobservable quantity. The square of the modulus of this quantity shows the probability distribution of detecting a particle at various points in space, that is, an individual particle is represented as a wave distributed throughout space [Shpolsky, p. 146]. From his method, the description of matter became statistical, that is, probabilistic. In quantum mechanics, the universe is a series of probabilities. However, this theory breaks down when working with large objects, as shown by Schrödinger's thought experiment with a cat [Faddeev, p. 67]. The essence of the experiment is as follows: One of the most famous experiments - "Schrödinger's Cat", was carried out by the Austrian theoretical physicist Erwin Schrödinger. With its help, the scientist wanted to show the incompleteness of quantum mechanics in the transition from subatomic systems to macroscopic systems. Since, following the basics of quantum mechanics, if no observation is made over the nucleus of an atom, then its state is described by the mixing of two states - a decayed nucleus and a non-decayed nucleus. It follows from this that the cat, which was placed in the box, personifies the nucleus of the atom - it is both alive and dead at the same time. Upon opening the box, the experimenter will see a specific state - "the nucleus has disintegrated, the cat is dead" or "the nucleus has not disintegrated, the cat is alive". This experience made it possible to reveal some significant flaws in quantum mechanics. The results of Schrödinger's research are actively used to this day. For example, a light signal in a superposition of two states sent over a fiber optic cable has found application in quantum cryptography. Consider a situation where intruders tap the signal in the middle of the cable (to eavesdrop on information). At the same moment, the wave function collapses, and the light passes into one of the states. This action helps to determine whether the light is still in a superposition of states, or whether it has already been observed over it, with the aim of transferring it to another destination. This solution allows you to create communication means that exclude the invisibility of signal interception. The results of Schrödinger's research are actively used to this day. For example, a light signal in a superposition of two states sent over a fiber optic cable has found application in quantum cryptography. 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"When we saw the results, we could hardly believe our eyes. We immediately wanted to check them with independent measurements, "says the head of the study, Professor Hele Savin. Experts from the National Metrological Institute Physikalisch-Technische Bundesanstalt were invited for verification, who confirmed that there was no mistake. "This is a major breakthrough - and at the same time, a long-awaited step forward for us, metrologists, who dream of higher sensitivity [of measuring instruments]," said a representative of the Lutz Werner Institute.

External quantum efficiency (IQE) is defined as the ratio of the number of generated pairs of electrons to the number of photons incident on the device. One hundred percent IVE means that one incoming photon generates one electron for the electrical circuit of the device. In a photodetector developed by Finnish physicists, there is an average of 1.3 electrons per photon.

The secret of this result lies in the unique silicon nanostructures that trigger the "process of multiplication of charge carriers." This phenomenon was not previously observed in real devices, since electrical and optical losses reduced the number of generated electrons and decreased the IQE index. In the new photodetector, losses have been reduced to almost zero.

Such results make it possible to improve the efficiency of almost any device based on the detection and registration of light flux: unmanned vehicles, mobile phone cameras, tracking devices. "Such detectors are attracting more and more attention, especially in the field of biotechnology and monitoring of industrial processes," summarize the authors of the development.

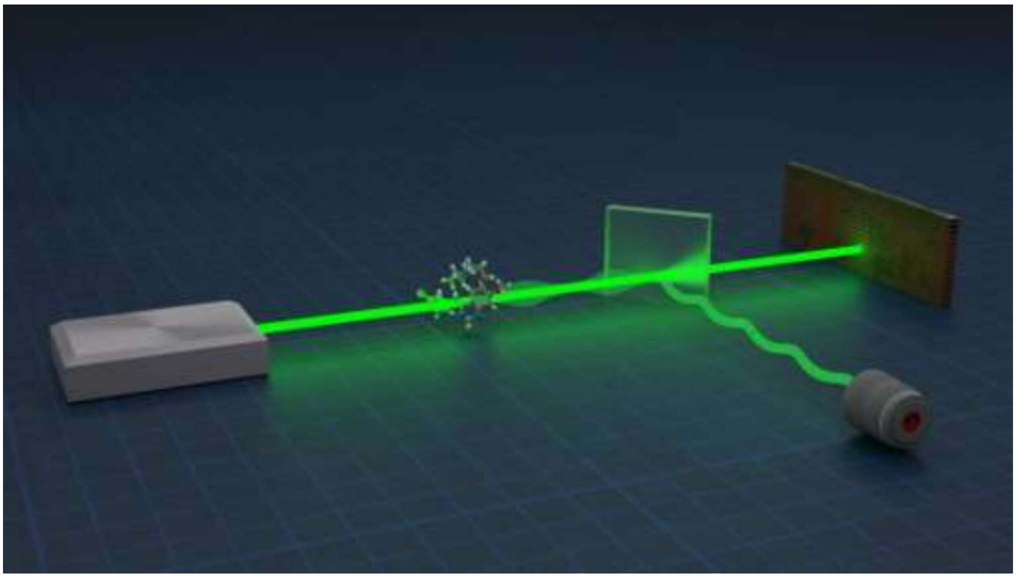
Scientists at Harvard and Cambridge Universities, along with their colleagues at MIT and the University of Toronto, have found that a physical property called "quantum negativity" can be used to make more accurate measurements. "Measurements of what?" - readers will ask. Scientists say literally everything: from molecular distances to gravitational waves.

An article about the results of their research scientists published in the journal Nature Communications. The use of a new phenomenon could revolutionize quantum metrology - a science that deals with the problems of measuring various quantities based on quantum effects.

Most people familiar with the concept of probability are accustomed to the fact that this value varies from 0 to 100% - or from 0 to 1. However, to explain the results from the quantum world, the concept of probability has to be expanded to include the so-called quasi-probability, which can be negative. ...

For example, the probability that an atom is in a certain position and moving at a certain speed can be -5%. And an experiment, the explanation of which requires the introduction of negative probabilities, has "quantum negativity."

In turn, the main instrument of metrology is sensors. Most often these are ordinary household appliances, such as scales and thermometers. But in quantum metrology, everything is different: here the role of sensors is played by quantum particles, which can be controlled at the subatomic level and which can be detected using special detectors.



An illustration of the principle of "quantum negativity" in metrology. A quantum laser irradiates the molecule to be measured. Then the light passes through a quantum filter, on which all useful information is condensed in a weak beam, reflected on the detector / H. Lepage
In theory, the more probing quantum particles are available for measurements, the more information the detector can eventually receive. But in practice, there is a limit to the speed at which the detectors are able to analyze particles. This can be illustrated by an example from everyday life: wearing sunglasses, we filter out excess light and see better, but too dark glasses harm our eyes and do not allow us to see the surrounding space normally.
“We have adapted tools from standard information theory to quasiprobabilities and have shown that filtering quantum particles can help collect information from a million particles into one,” says lead author Dr. David Arvidsson-Shukur. “This means that detectors can operate at the ideal particle flow rate, receiving information corresponding to higher processing rates. <...> Quantum negativity makes this possible. "
An experimental group at the University of Toronto has already begun to create technologies for the practical use of new theoretical results. The goal of the scientists will be to create a quantum device that uses single-photon laser light to provide incredibly accurate measurements of optical components. These measurements are critical to the creation of advanced devices such as photonic quantum computers.
In fact, this quantum approach allows us to extract more information from experiments than the methods and principles of classical physics. “Scientists often say that there is no free lunch. This means that you can’t get anything if you don’t want to pay the computational price, ”says study co-author Alexander Lazek. “However, in quantum metrology, this price can be made arbitrarily low. This is very illogical and really amazing! "
More accurate measurements in quantum metrology can not only lead to the creation of new advanced technologies, but also give impetus to research in the field of fundamental physics

and the Universe. Better alignment of mirrors and lenses will lead to more accurate microscopes or telescopes, and better ways to measure the earth's magnetic field will lead to better navigation instruments.

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