Physics – Uspekhi **66** (2) 219 – 220 (2023)

PHYSICS NEWS

PACS number: **01.10.–m**, **01.30.–y**, **01.90.+g**

Physics news on the Internet (based on electronic preprints)

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DOI: https://doi.org/10.3367/UFNe.2023.01.039315

1. Reactor antineutrino anomaly

Since 2011, the problem called the reactor antineutrino anomaly has been known: the measured spectrum of antineutrinos emitted from nuclear reactors in the energy range of 3–4 MeV is 6% lower than the spectrum obtained in theoretical calculations. This discrepancy, confirmed in several independent experiments, cannot be explained within the Standard Model with allowance for oscillations between the three ordinary types of neutrinos. It was hypothesized that the decrease in the number of antineutrinos is due to their oscillations into the fourth type of neutrino — sterile neutrinos with masses of ~ 1 eV. New spectrum measurements and tests of the sterile neutrino hypothesis have been performed in the STEREO experiment at the Institute Laue-Langevin (Grenoble, France) [1]. Six detectors based on a liquid gadolinium-containing scintillator were arranged in a row at distances of 9 to 11 m from a nuclear reactor. The differences among the spectra measured by them would make it possible to reveal the effect of oscillations. 10^5 antineutrinos were detected for three years. The spectrum of reactor antineutrinos from ^{235}U decays measured by the STEREO collaboration is currently the most precise. The obtained data confirm the presence of the antineutrino anomaly: the difference between the measured spectrum and the theoretical one makes up $5.5 \pm 2.1\%$. At the same time, the STEREO experiment has not revealed the oscillation effect, and thereby the reactor antineutrino anomaly is most likely not related to sterile neutrinos. The recent results of the BEST experiment carried out in the Baksan neutrino observatory of INR RAS [2] confirmed the presence of the gallium anomaly, pointing to the existence of a sterile neutrino. But the STEREO detector sensitivity in the range of gallium anomaly energy is low, and the STEREO data cannot be directly compared with the BEST results. For neutrino oscillations, see [3–5].

2. Spatial separation of wave and corpuscular photon properties

In quantum mechanics, the concept of the 'quantum Cheshire cat' exists, which consists in separating an object's physical properties from itself. Such an effect has already been realized to separate the spin of a particle from the particle itself in experiments with neutrons and photons. In their experiment, J-K Li (University of Science and Technology of China) and their co-authors spatially separated the wave and corpuscular properties of single photons for the first time [6]. This new version of separation was proposed in a theoretical paper by P Chowdhury and their co-authors in 2021. The wave property of a particle ('cat') passed along one arm of a Mach–Zehnder interferometer, and its corpuscular property ('smile') passed along the second arm. Superposition of wave-particle states was made preliminarily, and preselection and postselection of states were performed. A scheme called evolution in imaginary time was applied for weak quantum measurements. The results of measurements agree well with the theoretical description. One of the next goals is a triple separation ('quantum Cheshire supercat') into the particle itself, its wave property, and its corpuscular property.

3. Interaction-free quantum measurement

The problem of measurement remains one of the fundamental questions of quantum mechanics [7–9]. Measurement can also be interaction free, when, for example, the presence of a photon is registered without its absorption. Interaction-free measurement has already been demonstrated for different systems. S Dogra, J J McCord, and G S Paraoanu (Aalto University, Finland) have proposed and experimentally implemented a new type of interaction-free quantum measurement [10]. A three-level transmon qubit was used. By the population of its zeroth and first levels, one can judge the presence or absence of a microwave pulse with the frequency resonant for transition from the first level to the second. Given this, qubit excitation with a transition to the second level is not required, while the mere fact of the presence of the second resonant level is sufficient.

4. Quantum energy teleportation?

In previous experiments on quantum teleportation of particle states, information was actually teleported. However, in 2008, Hotta (Tohoku University, Japan) proposed a conception of energy teleportation. His idea is based on the fact that, when measuring the state of a certain local part of a quantum entangled system, the measuring device transfers energy to the system, and, owing to entanglement, this energy can be released in another distant part of the system. K Ikeda (Stony Brook University) has reported the first experimental implementation of the above-described effect [11] by performing quantum energy teleportation between superconducting qubits with an IBM quantum processor. The results of the experiment are exactly consistent with M Hott's theory. As with ordinary quantum teleportation, quantum energy teleportation requires local operations and information

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Translated by N A Tsaplin

transfer through a classical channel. For quantum technologies, see [12–15].

5. Baryonic clouds and galactic halo rotation

Extended galactic halos consisting largely of dark matter also contain several percent of gas and dust carried out to the halo by the stellar wind and gas streams. The presence of dust is also noticed in the intergalactic space [16]. F De Paolis and his co-authors assumed that the gas-dust medium in the halo may partially be in the form of cold virialized clouds, and their motion due to general halo rotation can be released from the Doppler shift of the relic radiation scattered by clouds. Galaxies begin rotating at the stage of their formation through their tidal interaction with the environment. The observation of several galaxies by the WMAP and Planck telescopes actually revealed shifts in the spectra, corresponding to halo rotation. In a new study by N Tahir et al. [17], different versions of composition, structure, and distribution of cold baryon clouds in the halo were considered for several galaxies. The results were compared with the data of the Planck space telescope. The presence of cold baryon clouds in rotating galactic halos explains well the observations, although other interpretations cannot be ruled out.

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