

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: https://doi.org/10.3367/UFNe.2017.06.038149

1. *CP* invariance violation in neutrino oscillations

In the T2K experiment, a combined analysis of muon neutrino (ν_μ) and antineutrino ($\bar{\nu}_\mu$) oscillations was performed, and the difference obtained in the rate of their oscillations testifies to *CP* violation in the lepton sector. The ν_μ and $\bar{\nu}_\mu$ beams were produced at the J-PARC acceleration complex (Japan) and were registered by a near detector complex deployed 280 m from the production target and a far Super-Kamiokande detector, at a distance of 295 km. Neutrino interactions were detected by Cherenkov light in Super-Kamiokande in order to measure neutrino oscillation parameters. Data were obtained on both the disappearance of ν_μ and $\bar{\nu}_\mu$ and the appearance of electron ν_e and $\bar{\nu}_e$ in the beams. Within the time of observation, the far detector registered 32 ν_e and 135 ν_μ in the original ν_μ beam, and 4 $\bar{\nu}_e$ and 66 $\bar{\nu}_\mu$ in the $\bar{\nu}_\mu$ beam. These data imply that the phase δ_{CP} responsible for *CP* violation covers the range of $(-3.13, -0.39)$. The observational data are best fitted in the case of direct mass hierarchy when $\delta_{CP} = -1.791$, which is close to the maximum *CP* violation value. Given this, the hypothesized *CP* conservation, when $\delta_{CP} = 0$ or π, is ruled out with 90% confidence. Russian researchers from INR RAS are also collaborating in the T2K experiment.

Source: *Phys. Rev. Lett.* **118** 151801 (2017)
https://doi.org/10.1103/PhysRevLett.118.151801

2. Quantum communication without particle transfer

R H Dicke pointed out in 1981 that quantum mechanics allows information transmission without the transfer of physical particles. A refined method was proposed by M S Zubairy (Texas A&M University, USA) and his colleagues in 2013. In their approach, the information is coded by the sender through a change to the interferometer configuration, and the recipient receives the message by analyzing the passage of auxiliary particles through the interferometer. An array of interferometers was considered, and it was proposed to perform measurements using the quantum Zeno effect, so that the number of transferred physical particles tends to zero with increasing the number of interferometers. Y Cao (University of Science and Technology of China) and colleagues were the first to realize a similar scheme in their experiment. Two Michelson–Morley interferometers were used through which particles passed many times. The recipient of information utilized photons from a single-photon source as test particles, and the sender could use a liquid-crystal modulator to open and close the additional interferometer arm linking him with the information sender. Even if photons did not pass through this arm, its presence in itself influenced the interference pattern observed by the recipient of the information. Thus, the information transmission proceeded without the transfer of particles. The method was illustrated by a monochromic image of 100×100 pixels with a transmission accuracy of 87%.

Source: *PNAS* **114** 4920 (2017)
https://doi.org/10.1073/pnas.1614560114

3. Self-testing of a quantum system

The question concerning the possibility of self-testing devices operating with quantum information in order to estimate the correctness of their work from the correlation of classical output signals for certain input signals without knowledge of the inner workings of the device has been under discussion for a long time. The result of self-testing can be obtained, for example, by verifying the violation of Bell type inequalities. In recent years, self-testing has been demonstrated for several simple systems, but the general situation remained unclear. Researchers from the California Institute of Technology (USA) and the National University of Singapore, A Coladangelo, K T Goh, and V Scarani, have studied this question theoretically as applied to bipartite systems consisting of two coupled qubits. They received an affirmative answer by proving the theorem on device self-testing by output correlations — self-testing of such systems was shown to be actually possible.

Source: *Nature Communications* **8** 15485 (2017)
https://doi.org/10.1038/ncomms15485

4. Quantum processor to solve a system of linear equations

Many computational problems will be solved exponentially faster on quantum than on classical computers. The quantum solution of linear equations has already been demonstrated on photon qubits and qubits based on atomic nuclei. Y Zheng (Institute of Physics, Chinese Academy of Sciences) and colleagues have done it for the first time using solid-state superconducting qubits. Josephson junctions made of aluminum on a sapphire substrate formed Xmon-qubits (a type of transmon qubit). The computer 'processor' consisted of four such qubits, and the whole device included 15 one- and two-qubit logic cells. A system of two linear equations was solved using the quantum algorithm proposed by A Harrow, A Hassidim, and S Lloyd. The quantum fidelity of the calculations restricted by decoherence and errors in the cells amounted to 0.837. Superconducting quantum schemes are a promising approach for creating scalable quantum computers that can be extended by increasing the number of qubits.

Source: *Phys. Rev. Lett.* **118** 210504 (2017)
https://arXiv.org/abs/1703.06613

5. Burst of gravitational waves GW170104

The LIGO interferometer has registered a burst of gravitational waves GW170104, the third reliably registered ones. Its

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DOI: https://doi.org/10.3367/UFNr.2017.06.038149
Translated by M V Tsaplina

registration confirms the conclusion that a new window for observations — gravitational waves — has appeared in astronomy. The burst came from a distance of 880 Mpc, where two black holes with masses of $31M_{\odot}$ and $19M_{\odot}$ merged to form a black hole with a mass of $49M_{\odot}$. The signal-to-noise ratio for this event is equal to 13. From the burst characteristics it was found that the angular momentum of at least one of the black holes before coalescence was not directed along the orbital angular momentum of the binary system, which evidences in favor of the model of formation of a pair of black holes in a star cluster. Immediately after the gravitational burst registration, a search for signals coincident with it began on 30 ground-based and space telescopes from the radio to gamma-ray electromagnetic wave ranges, and a search was undertaken for neutrino signals, but no accompanying signals were revealed. No deviations from the predictions of General Relativity were registered in the characteristics of the observed gravitational-wave signal, and the absence of visible signal dispersion restricted the graviton mass: $m_{\rm g} \leqslant 7.7 \times 10^{-23}$ eV$/c^2$.

Source: *Phys. Rev. Lett.* **118** 221101 (2017)
https://doi.org/10.1103/PhysRevLett.118.221101

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