Physics – Uspekhi **59** (11) 1161 – 1162 (2016)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: https://doi.org/10.3367/UFNe.2016.10.037926

1. Quantum *H*-theorem

Entropy nondiminishing theorems resembling Boltzmann's *H*-theorem in classical statistics were formulated in the quantum information theory. In particular, it was shown that the entropy of a quantum system does not diminish if its evolution proceeds in the so-called unital quantum channel. On the basis of this result, a team of researchers from the Landau Institute of Theoretical Physics (1), the Swiss Federal Institute of Technology, Zurich (2), the Argon National Laboratory (3), and the Moscow Institute of Physics and Technology (4), involving G B Lesovik [1,2], A V Lebedev [2], I A Sadovskyy [3], M V Suslov [4], and V M Vinokur [3], has formulated the quantum *H*-theorem in terms of physical observables referring to the system's interactions with its surrounding (reservoir). It was assumed that the system considered is quasi-isolated in energy, but its interaction with the reservoir changes the phases of quantum state. Under the conditions formulated in the theorem that restrict the character of admissible system's interactions with the reservoir, the entropy of the system must not diminish, which was demonstrated by a number of examples in the paper by Lesovik et al. The models of electron scattering by potential barriers and spins and by a two-level system, as well as the electron–phonon interaction at energies exceeding the Debye energy, were considered. It was demonstrated that in these cases the conditions of the theorem are met, and the entropy does not diminish. It was also shown that if the conditions of the theorem are not fulfilled, the entropy of an energy-isolated quantum system diminishes under certain conditions, i.e., the second law of thermodynamics may be locally violated. (See also G B Lesovik *JETP Letters* **98** 184 (2013).)

Source: *Sci. Rep.* **6** 32815 (2016);
https://dx.doi.org/10.1038/srep32815

2. Long-lived quantum coherence

Retention of quantum coherence for a long time is essentially important in fabricating setups processing and transmitting quantum information, but the external action typically provokes fast decoherence. In 2015, T R Bromley, M Cianciaruso, and G Adesso showed theoretically that coherence in a compound quantum system can be stored for an unlimited amount of time if the initial state of the system was specially prepared so that the decoherence acts in the space of states in the orthogonal direction. Then, no algorithms to correct mistakes or another external control system are needed. This effect was demonstrated experimentally for the first time in the new study by G Adesso (University of Nottingham, Great Britain) and his colleagues. A 'frozen' quantum coherence occurred for two- and four-qubit systems realized on spins of atomic nuclei in room-temperature molecules. Radio frequency pulses were applied to transfer the systems to the diagonal Bell state, and after a certain evolution their states were measured. The experiment confirmed that the coherence is retained on a time scale of order a second.

Source: *Phys. Rev. Lett.* **117** 160402 (2016)
https://dx.doi.org/10.1103/PhysRevLett.117.160402

3. Atomic gravimeter combined with magnetometer

K S Hardman (Australian National University) and colleagues have designed a high-precision atomic interferometer capable of measuring simultaneously the free-fall acceleration g and the magnetic field gradient. Bose–Einstein condensate of ^{87}Rb atoms was utilized in the interferometer. The atoms fell from the height of several meters, and g was measured employing the atomic interferometer method. Furthermore, the atoms resided in a superposition of three spin states, $m_{\mathrm{f}} = 1, 0, -1$, interacting differently with a magnetic field and thus inducing an additional phase difference that depended on the magnetic field gradient. This device was tested by measuring the gravitational field variations due to tide-dependent rises and falls of Earth's crust. The relative measurement error made up $\Delta g/g = 1.45 \times 10^{-9}$, this accuracy being restricted by laser system noises. The measurement precision of the magnetic field gradient, 1.2×10^{-10} T m^{-1}, is close to the level of sensitivity of solid-state magnetometers and SQUIDs. The new combined device may be applicable in prospecting for minerals through a simultaneous registration of gravitational and magnetic anomalies in Earth's crust.

Source: *Phys. Rev. Lett.* **117** 138501 (2016)
https://dx.doi.org/10.1103/PhysRevLett.117.138501

4. X-ray source with optical illumination of the X-ray focus

In the Laboratory of X-Ray Methods of Nanostructure Diagnostics of the Lebedev Physical Institute of RAS, a new compact X-ray tube that has a 10 mm in radius, 75 mm in length, and 20 g in mass and takes advantage of electrostatic focusing of electrons has been developed. In such a tube one and the same electron beam generates both X-ray and optical radiation. Used in the tube was a thin-film metallic anode layered onto an optically activated transparent diamond substrate. X-ray radiation is generated in the metal film, and optical radiation in the diamond substrate. The size of the X-ray focus equals ≈ 10 μm. The X-ray and optical foci appear to be superposed, which is very convenient in the practical application of the device, because the optical focus can readily be observed directly.

Source: SIA 'FIAN-inform'
http://www.fian-inform.ru/priborostroenie/item/537-xrayandoptic

Uspekhi Fizicheskikh Nauk **186** (11) 1264 (2016)
DOI: 10.3367/UFNr.2016.10.037926
Translated by M V Tsaplina

5. Isotropy of the Universe

On large scales, the Universe looks, on the average, the same in all directions; however, some small anisotropy cannot be ruled out. D Saadeh (University College London, Great Britain) and her colleagues are the first to allow for all possible modes of anisotropic perturbations of the Universe metric and have obtained the most general (without additional assumptions) restriction on the degree of Universe's anisotropy. The theoretical computations of the anisotropic mode evolution were compared with the ESA's Planck telescope data on cosmic microwave background fluctuations. No statistically significant deviation from the isotropic model of the Universe was found. In the vector mode corresponding to rotation, the relative anisotropy does not exceed 4.7×10^{-11} at a confidence level of 95%. This restriction is an order of magnitude better than that obtained in the previous work performed disregarding the Planck data on radiation polarization, which is very sensitive to anisotropy. Restrictions from above on the magnitudes of scalar and tensor anisotropic perturbations were also obtained in the new work. The restrictions on anisotropy reduce the number of models describing the Early Universe.

Source: *Phys. Rev. Lett.* **117** 131302 (2016)
https://dx.doi.org/10.1103/PhysRevLett.117.131302

Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)