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# Physics news on the Internet (based on electronic preprints)

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## 1. Entropic time-energy uncertainty relation

The quantum time–energy uncertainty relation has several versions and various interpretations. For example, the width of the energy level is related to its lifetime before decay. In 1945, L I Mandelstam and I E Tamm used the Schrödinger equation to establish the relation between the time of transition of a system from one state to another and the energy difference of those states. They obtained an expression that also had the form of an uncertainty relation. The difference in the interpretations is partly due to the fact that the time–energy uncertainty relation cannot be written out as a Robertson inequality, because, in general, no Hermitian operator corresponds to time. Attempts have already been made to formulate uncertainty relations in the entropic form, where instead of quantities themselves there appear an entropy of states or transition probabilities. This approach was successfully realized for coordinate–momentum variables, but for time and energy the entropy relation was only written out for almost periodic processes. P J Coles (Los Alamos National Laboratory, USA) and co-authors have obtained theoretically the time–energy entropic uncertainty relation for the general case of a time-independent Hamiltonian describing the system. The new relation has the form of an inequality in which the sum of conditional entropies related to the energy states is greater than or equal to the time measure logarithm (discrete or continuous). The entropic time–energy uncertainty relation can find application in quantum cryptography.

Source: *Phys. Rev. Lett.* **122** 100401 (2019)
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## 2. Quantum measurement cooling

The classical cooling of a system can be carried out due to the work done by an external force (as in a usual freezer) or by molecule sorting (Maxwell's demon). In the latter case, a feedback loop is needed through which the information on the molecule velocity is transmitted. M Campisi (University of Florence, Italy) and his colleagues have shown theoretically that a system can be cooled by performing quantum measurements on it, even without a feedback loop. A scheme with two qubits coupled with heat reservoirs was investigated. The cooling went in two stages. First, the qubit states were measured and then the energy exchange between the qubits and reservoirs was realized. The authors showed that measurements can be taken in such a manner that the energy goes from the cold reservoir to the qubits and, at the same time, from the qubits to the hot reservoir. That is, we are dealing with quantum cooling. Such a cooling engine will be possible to realize in practice using solid-state superconducting qubits.

Source: *Phys. Rev. Lett.* **122** 070603 (2019)
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## 3. Second sound in graphite

The second sound (a wave-like heat transport by phonons), the prospect of which had been predicted by L Tisza and L D Landau, was observed in liquid helium and in some solid substances. Calculations showed that the second sound is also possible in graphene and graphite in a rather wide temperature range. A group of researchers affiliated with the Massachusetts Institute of Technology have discovered the second sound in polycrystalline graphite with a natural isotopic composition at temperatures covering $\sim 85-150$ K. Short laser pulses induced sample heating and formed a spatially sinusoidal distribution of its temperature through the agency of light interference. The heat propagation was monitored by continuous laser light diffraction on sample surface oscillations with a high time resolution. The heating region propagated quickly along the sample without changing width. This implies that heat was transferred not in the usual diffusive manner but in a wave-like manner, i.e., by means of the second sound. The experimental data agree well with *ab initio* calculations (the solution of Boltzmann equations). In particular, the second sound velocity in graphite was confirmed to lie between the velocities of slow and fast transverse sound waves. The second sound may play an important role in cooling microelectronic devices.

Source: *Science*, online publication of 14 March 2019
https://doi.org/10.1126/science.aav3548

## 4. Coherent absorption in a disordered medium

The so-called 'antilaser', in which perfect coherent light absorption was observed, has been already realized experimentally in 2011. However, the antilaser was constructed on the basis of a regular medium, namely, a sapphire single crystal. K Pichler (Institute for Theoretical Physics, Vienna University of Technology, Austria) and colleagues have brcome the first to design an 'antilaser' in a disordered medium that operated in the microwave range. A medium of cylindrical teflon elements was placed in a rectangular metallic waveguide. These chaotic cylinders scattered electromagnetic waves. The incoming microwave signal was formed by a set of antennas at the input of the waveguide, and at the output the transmitted radiation was registered. A signal-absorbing monopole antenna (a metal rod) was placed in the center of the waveguide. To obtain perfect absorption, we

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need not know the position of all inhomogeneities of the medium, but it suffices only to find the components of the scattering matrix whose dimension corresponds in this experiment to eight waveguide channels. Information on the scattering matrix obtained through preliminary measurements allows configuring the incoming wavefront by phases and amplitudes so that the Umov–Poynting vector is aligned with the lines that finally enter the central antenna, with the result that almost all the energy is absorbed by this antenna. The absorption efficiency in the experiment reached 99.78%. For the history of the theoretical study of 'antilasers', see *Physics–Uspekhi* **60** 818 (2017).

Source: *Nature* **567** 351 (2019)
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## 5. Isotropy of the Universe's expansion

The isotropy of the early Universe is tested most exactly through observation of the relic radiation that decoupled from matter in early cosmological epochs. Of interest is also the Universe's isotropy in later time ($z \leqslant 1$), when dark energy began to dominate in density. J Soltis (University of Michigan, USA) and co-authors have worked out a new nonparametric test of the statistical isotropy of the Universe's expansion and applied it to about a thousand type Ia supernovae. For each supernova, information on its stellar magnitude depending on the redshift with a peculiar velocity correction was used. From the variations of supernova distributions over the celestial sphere one can judge the Universe's expansion isotropy. It was found that the rms spatial variation of the Hubble parameter does not exceed 1% for $z \leqslant 1$ at a confidence level of 99.7% — that is, the contemporary Universe is expanding isotropically with a high degree of accuracy.

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