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Physics news on the Internet (based on electronic preprints)

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1. CP asymmetry in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays

The difference ΔA_{CP} between the CP asymmetries in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays has been measured in the LHCb experiment. The asymmetry A_{CP} in each of the two above-mentioned channels is defined as the relative difference in the decay rates for particles and the corresponding antiparticles. In the Standard Model, A_{CP} is expressed through elements of the Kabibbo–Kobayashi–Maskawa matrix. The theoretically expected value is $\Delta A_{CP} \leqslant 1\%$, but an exact calculation is hampered by uncertainties in the parameters of the theory. CP symmetry violation was reliably measured earlier for K and B mesons, whereas for charmed particles the results remained ambiguous. In the LHCb experiment, pp collisions at center-of-mass energies of 7 TeV and 8 TeV were examined. For $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays, the value of $\Delta A_{CP} = [-0.10 \pm 0.08(\text{stat.}) \pm 0.03(\text{syst.})]$ was obtained for a time-integrated CP asymmetry in the charm sector from a singe experiment. This is the most precise value for today — that is, at the attained precision level, the difference in A_{CP} values was not found.

Source: *Phys. Rev. Lett.* **116** 191601 (2016)
http://dx.doi.org/10.1103/PhysRevLett.116.191601

2. One-way quantum steering

Two independent groups of researchers headed by C-F Li (University of Science and Technology of China) and G J Pryde (Griffith University, Australia) have demonstrated the effect of one-way Einstein–Podolsky–Rosen (EPR) quantum steering in qubit experiments on the basis of photon pairs. The conception of steering was introduced by E Schrödinger as applied to the reduction in the wave function of a distant system. The one-way steering effect occurs when measurements of the state of one of the two quantum-entangled particles suggest a conclusion about the state of the second particle, whereas the inverse is impossible — that is, the measured state of the second particle does not help in finding the state of the first one. The one-way steering effect, which was first experimentally demonstrated by D J Saunders et al. in 2010, had been observed before only in the case of a limited class of Gaussian states. However, Gaussian states alone are insufficient for practical applications, and in the two new experiments a wider class of states, including the Werner states of photons, was examined. The violation of 'steering inequalities' proving asymmetry was tested. The asymmetric quantum nonlocality may have potential applications in quantum communication networks when verification is only possible for one data transmission direction.

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3. Design of superconductors with desired properties

High-temperature superconductors are capable of transmitting giant electric current without thermal loss, but the maximum (critical) loss-free current is limited because of the motion of superconducting vortices and is practically completely determined by the defect-induced pinning of the superconducting vortices. The defect landscape in samples can in many cases be purposefully varied, which opens up the prospect of creating superconductors with prescribed characteristics. However, the complicated character of vortex–defect interactions, which can hardly be predicted in analytical calculations, presents a problem. I A Sadovskyy (Argonne National Laboratory, USA) and colleagues have worked out a new approach to the design of superconductors for targeted applications based on computer simulations of vortex–defect interactions with allowance for the experimentally known properties of superconductors. The time-dependent dynamics of vortices were modelled upon their scattering by defects within the framework of the Ginzburg–Landau vortex theory. The results of calculations carried out with graphical processors were compared with the experimental angular dependence of critical current in $REBa_2Cu_3O_{7-\delta}$ samples (where RE is a rare-earth element) with two sets of defects. In the first case, a sample with a chemically synthesized array of barium zirconid nanorods was employed. In the second case, the first sample was additionally exposed to heavy lead ions leaving through tracks at an angle to the existing defects. The results of calculations showed good quantitative agreement with experimental data, which became a successful verification of the new approach. In particular, the conclusion was confirmed that the contribution of defects is not additive. In the future, such simulations will be applied to calculate an optimal concentration of defects and their types to maximize the critical current in a superconductor. After that, samples with desired properties will be synthesized on the basis of given calculations.

Source: *Advanced Materials*, online publication of March 31, 2016
http://dx.doi.org/10.1002/adma.201600602

4. Half-integer total angular momentum of a photon

K E Ballantine, J F Donegan, and P R Eastham (Trinity College, Dublin, Ireland) have conducted an experiment demonstrating that the total angular momentum of a photon (a sum of spin and orbital angular momenta) can in some

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cases assume half-integer values in units of the Planck constant $\hbar$, because the character of electromagnetic field quantization may change with decreasing the system dimensionality. A similar effect was observed earlier in application to electrons in quasi-two-dimensional systems. The described experiment was aimed at examining photons in a beam of light in which the polarization vector was bounded by the plane of the beam cross section. The beam underwent certain transformations of phase and polarization with the aid of biaxial crystals and prisms. The light beam was transmitted through a Mach–Zehnder interferometer for singling out states with certain angular momenta, and the photons were registered at the output by photodiodes. The presence of photons with half-integer angular momenta was established by analyzing the characteristic spectrum of shot noise in the photodiode current, which corresponded with a high accuracy to the theoretical prediction.

Source: *Science Advances* **2** e1501748 (2016)
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5. History of reionization of the Universe

Using Planck Telescope data on the anisotropy of cosmic microwave background radiation, it has become possible to specify the time dependence of the Universe's reionization. Nearly 13 billion years ago, a repeated hydrogen ionization of the Universe took place. A possible reason for this process was radiation from the first stars. The Thompson optical depth $\tau = 0.058 \pm 0.012$ — an important parameter integrally characterizing reionization — was found by the Planck Telescope data. To investigate the reionization history, additional data were utilized on the kinematic Sunyaev–Zeldovich effect, obtained with the Atacama Cosmology Telescope and South Pole Telescope. The employment of these data made it possible to remove the existing degeneracy in the parameters of the cosmological model. The average redshift at which reionization occurred was found to lie between $z = 7.8$ and $z = 8.8$, and the reionization period duration ranged $\Delta z < 2.8$. The reconstruction of the time dependence of reionization is likely to provide better insight into the origin of its sources.

Source: http://arXiv.org/abs/1605.03507

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