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1. T-symmetry in neutron decays

A new checking of the T-symmetry in β decays of nuclei has been conducted at the Neutron Research Center of the National Institute of Standards and Technology (NIST) (USA). The experiment observed the correlation among the directions of neutron spins in the beam and the momenta of neutron decay products in the reaction $\mathrm{n} \rightarrow \mathrm{p} + \mathrm{e}^- + \bar{\nu}_\mathrm{e}$. Protons and electrons were detected by a coincidence technique in an array of proton and electron detectors. The value obtained of the parameter characterizing the T-symmetry was $D = (-0.96 \pm 1.89(\mathrm{stat}) \pm 1.01(\mathrm{syst})) \times 10^{-4}$. In other words, the two configurations of neutron decay with oppositely oriented neutron spins are equiprobable at the accuracy achieved in the experiment and, therefore, T-symmetry and CP-invariance are conserved within experimental errors. At the moment, this result has the best accuracy achieved in experiments with β decay of nuclei. It limits the applicability of some of the models suggested as a generalization of the Standard Model of elementary particles and attempting to explain the prevalence of matter over antimatter in the Universe.

Source: *Phys. Rev. Lett.* **107** 102301 (2011)
http://arXiv.org/abs/l 104.2778

2. Gamow–Teller transitions in ^{56}Ni nuclei

M Sasano (Michigan State University, East Lansing, MI, USA) and his colleagues have studied ^{56}Ni(p,n)^{56}Cu nuclear reactions involving the Gamow–Teller transitions, i.e., allowed transitions in which the spin of a nucleus changes by unity. Predictions by various theoretical models for these processes differ by about 30%. The energy distribution of Gamow–Teller transition strengths, $B(GT)$, obtained by M Sasano et al. is best reproduced by the software package GXPF1A based on the shell model of the nucleus. In accordance with the predictions of GXPF1A interactions, the $B(GT)$ distribution in the ^{56}Ni nucleus is fragmented over reaction channels in the same way this happens for other nuclei with similar masses, even though ^{56}Ni has a doubly magic nucleus. In this experiment, unstable ^{56}Ni isotopes collided with a liquid hydrogen target and the reaction fragments were studied using a nuclear spectrometer. What was observed in reality was the inverse Gamow–Teller transition converting a proton into a neutron [(p, n) charge-exchange reactions in inverse kinematics at intermediate energies on unstable isotopes]; however, the probability of this process for the ^{56}Ni nucleus equals the probability of direct transition involving electron capture, but the study of the inverse transition is considerably simpler. The obtained value of $B(GT)$ is important for predicting the rate of electron capture by nuclei which, in turn, is important for simulation of supernova explosions.

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3. Metallic hydrogen?

M I Eremets and I A Troyan (Max Planck Institute for Chemistry, Mainz, Germany) have conducted an experiment which allegedly produced metallic hydrogen at room temperature. The creation of metallic hydrogen at low temperatures ($T < 100$ K) was reported in the past, too, but the results remained ambiguous. In this new experiment, molecular hydrogen was compressed in a diamond anvil. The contacting facets of diamonds in the anvil were covered with a semitransparent metallic film which prevented diffusion of hydrogen into the diamond crystal and thus protected the diamond against destruction up to a record pressures of about 300 GPa. The electric resistance was measured directly using contacts placed in the anvil under an insulating layer. Hydrogen became opaque and semiconducting at pressures above 220 GPa; this followed from a decrease in resistance under laser irradiation. At 240 GPa, hydrogen remained electrically conductive even without irradiation, and at 260 GPa the gap in the electron spectrum disappeared and hydrogen transformed into a purely metal phase which was stable in the course of cooling from the initial room temperature to at least 30 K. The reverse transition to the molecular phase involved a hysteresis at about 200 GPa. The reported results need independent verification. The possibility of a metallic phase of hydrogen was predicted in 1935; conditions for its formation may exist in the depths of giant planets.

Source: *Nature Materials* **10** 927 (2011)
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4. Study of H_2^- anions

B Jordon-Thaden (Max-Planck-Institut für Kernphysik, Heidelberg, Germany) and his colleagues for the first time explored in detail the structure of H_2^- ions using the method of Coulomb explosion imaging. On passing through a very thin carbon foil, anions in the beam lost all electrons and electric repulsion made the resulting identically charged protons flow apart. The closer these protons were to one another initially, the greater was the kinetic energy with which they flew apart. This effect relates the initial wave function of the nucleus to the energy distribution of the ejected protons. The observed distribution revealed peaks corresponding both to H_2^- ions (at energy ≈ 5 eV) and to the neutral H_2 molecules. This result demonstrated that the distance between protons in the H_2^- anion equals approximately six atomic units, which is several times greater than separation in the neutral H_2 molecule. In addition, it was found that the H_2^- decay above all is driven by autoionization, not by spontaneous dissociation, and anions possess a high angular momentum $J = 25 \pm 2$, which gives a measure of their metastability caused by the minimum in their interaction potential. H_2^- anions are an intermediate state in a chain of important chemical reactions, for example, $H^+H^- \to H_2^- \to H_2 + e^-$.

Source: *Phys. Rev. Lett.* **107** 193003 (2011)
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5. Kneelike structure in the spectrum of cosmic rays

The KASCADE-Grande detector data revealed for the first time a kneelike bend in the spectrum of the heavy component of primary cosmic rays (nuclei with $Z > 13$ up to iron) at an energy of about 8×10^{16} eV, where the slope changes jumpwise: $\Delta\gamma = -0.48$. This bend, referred to as a 'knee' was well known for some time in the spectrum of the light component at an energy of about 4×10^{15} eV. Predictions were made of the position of the knee as a function of the mass of primary nuclei, but detection of this peak in the spectrum of heavy nuclei has so far been elusive. KASCADE-Grande is located at the Karlsruhe Research Center (Germany) and was built as a combination of two detectors covering an area of 700×700 m^2, which also include the muon tracker and a calorimeter. Independent measurements of various components of cosmic rays were conducted in extensive air showers — cascades of secondary particles generated in collisions between primary cosmic rays and atoms of the atmosphere. Observation of extensive air showers offer a method of testing models of hadron interactions at high energies, which remain inaccessible to particle accelerators.

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