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1. Multimuon processes

New results have been obtained at the Tevatron collider at Fermi National Accelerator Laboratory (Batavia, USA) which, if their validity is confirmed, may point to the occurrence of new particles or interactions beyond the Standard Model of elementary particles. Researchers studied proton – antiproton collisions with an energy of 1.96 TeV in a vacuum beam pipe 1.5 cm in radius. Collisions generated mesons which decayed into, among other things, muons, which were recorded by the CDF II detector. Previous experiments revealed a discrepancy between the number (and the distribution) of muons and the predictions of the Standard Model. The aim of the new experiment was to identify the causes of discrepancies. By installing additional detectors it was possible to establish exactly where muons were created. Complete agreement with theoretical predictions has been found for those muons whose tracks originated at the points within the colliding beams. However, it was unexpectedly found that a significant fraction of muons were created outside the beams and even outside the vacuum beam pipe at a distance of several centimeters from the location of $p\bar{p}$ collisions. Also, multiple cascade creation processes (creating up to eight particles) were observed in which both μ^- and μ^+ muons in various combinations were produced with equal probability, and the trajectories of their flight were remote from the axis of the $p\bar{p}$ beam; several muons formed a 'muon jet'. One possible explanation of the observed exotic processes could be the existence of unknown particles which were created in collisions within the beam, flew out far from the beam edge, and there decayed into other particles and muons. According to the computations of P Giromini and his colleagues, cascades need at least three new particles for an explanation, with masses of 3.6 GeV, 7.3 GeV, and 15 GeV, and they are absent from the Standard Model. Further checking and clarification of these results require new independent experiments.

Sources: http://arXiv.org/abs/0810.5357,
http://arXiv.org/abs/0810.5730

2. Nanocluster transports electrons

S Gordeev (University of Bath, UK) and his co-workers implemented experimentally the transfer of electrons between two electrodes via metallic nanoclusters. Such a hypothetical 'nanoshuttle' was theoretically predicted 10 years ago by L Yu Gorelik and colleagues, and attempts to implement the 'nanoshuttle' were undertaken using semiconductors and fullerene molecules, with ambiguous results. In the successful experiment by S Gordeev and his colleagues, a gold nanocluster 20 nm in diameter was fixed to two electrodes by a monolayer of elastic organic molecules. An electric field forced the nanocluster to rapidly vibrate between the two electrodes, transferring four electrons per cycle. The current flowing between the electrodes depends on the frequency of vibrations of the nanocluster (it reached 10^{11} Hz in the experiment), which in turn depends on the nanocluster mass and the elasticity of organic molecules. The current–voltage characteristics of the device agree well with those calculated in the theory devised by L Yu Gorelik et al. The method allows development of a new generation of nanoelectromechanical (NEM) devices with unique properties; for instance, a similar device with three electrodes may become a nanoelectromechanical analog of the transistor, with the third (gate) electrode controling the number of electrons transferred by the shuttle in one cycle.

Source: http://arxiv.org/abs/0810.2430

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3. Nanorotor

H Gao and colleagues of the University of Liverpool (UK) and the Chinese Academy of Sciences designed a molecular nanorotor characterized by a number of useful differences from other molecular rotors developed to date. Complex tetra-tert-butyl zinc phthalocyanine molecules were evaporated onto gold substrate and their nitrogen atoms bonded the molecules to single atoms of gold. The point of attachment — the axis of rotation — did not coincide with the center of the molecule, so that the molecule rotated as a whole around a point on its boundary. Rotation was driven by the energy of thermal degrees of freedom of the molecule. An important achievement was that the rotation axis was fixed in space. The investigation of nanorotors was carried out using a scanning tunneling microscope. The researchers also created an array of such rotating molecules on an area of several square microns. If an atom of a magnetic metal is placed at the molecular center, it becomes possible to control the angular velocity of rotation by means of an electric current passing through the molecule and inducing a magnetic field.

Source: *Phys. Rev. Lett.* **101** 197209 (2008)
http://dx.doi.org/10.1103/PhysRevLett.101.197209

4. Study of inner orbitals in molecules

A technique called high harmonic generation, or HHG, has been developed by a team of researchers at SLAC National Accelerator Laboratory (Stanford, USA), which makes it possible to study inner electron levels of molecules. A beam of nitrogen molecules was irradiated with laser light. Molecules were thus raised to an excited state and on reverse transitions emitted photons whose spectrum permitted reconstruction of the electron structure of molecules. In contrast to earlier similar experiments, it became possible for the first time to observe radiative transitions for electrons not only of the outer electron orbital but also of a deeper orbital corresponding to the next energy level. The data from this study is important for understanding the mechanism of chemical reactions at their early stages, in which electron bonds in molecules are restructured.

Source: *Physics News Update*, Number 876
http://www.aip.org/pnu/2008/split/876-2.html

5. Nearby source of cosmic rays

The Advanced Thin Ionization Calorimeter (ATIC) balloon experiment measured the intensity of cosmic rays and gamma photons in upper layers of the atmosphere over Antarctica. The data obtained revealed a curious feature of the electron spectrum: an excessive abundance in the energy range 300 – 800 GeV, and sharp decline towards higher energies. The excess is observed relative to the background level that corresponds to a very carefully developed model of generation of electrons in supernova remnants and the model of electron propagation in galactic magnetic fields. Since electrons are absorbed quite easily by interstellar matter, this excess can be produced only by a source in relative proximity to the Earth. It was found, however, that spectra of electron emission from ordinary sources, such as neutron stars or microquasars, cannot explain the observed energy spectrum. At the same time, good agreement between calculations and observations is achieved in the model with annihilation of dark matter particles with a mass near 620 GeV in Kaluza – Klein type field-theory models with compactified extra dimensions. It is not impossible, therefore, that the ATIC experiment detected a dense clump of dark matter in the neighborhood of the solar system, in which annihilation occurred. An alternate hypothesis assumes that particles may annihilate one another in a high-density peak near an intermediate-mass black hole.

Source: *Nature* **456** 362 (2008)
http://dx.doi.org/10.1038/nature07477

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