Physicists to discuss largest parity violation, other adventures in table-top physics

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(PhysOrg.com) -- Exploring the fundamental laws of physics has often required huge accelerators and particles colliding at high energies. But table-top experiments, usually employing exquisitely tuned lasers and sensitive detectors, have also achieved the precision necessary for exploring the basic laws of physics at the heart of relativity and quantum mechanics.

Several of these cutting-edge table-top experiments will be discussed at Frontiers in Optics (FiO) 2010/Laser Science XXVI -- the 94th annual meeting of the Optical Society (OSA), which is being held together with the annual meeting of the American Physical Society (APS) Division of Laser Science at the Rochester Riverside Convention Center in Rochester, N.Y., from Oct. 24-28.

Dmitry Budker and his colleagues at the University of California, Berkeley, for example, have used collimated beams of atoms to study parity violation, possible changes in the fine structure constant, and even the question of whether photons are exclusively bosons.

Parity violation, the property by which nature tells left from right, was discovered first in the 1950s by watching the decay of cobalt nuclei. The weak nuclear force, unlike the other known forces of nature, brings about reactions that would look different when observed in a mirror. Years later, parity violation was observed in atoms. Now, Budker uses atoms of the rare Earth element ytterbium to observe the largest extent of parity violation ever seen in atoms, larger by a factor of 100 compared to previous tests. His goal is to improve the precision of this measurement so that researchers could begin to use the parity-violating process to help measure the distribution of neutrons in nuclei.

In another setup, Budker and his colleagues use atoms of the rare Earth element dysprosium to see whether the fine structure constant (denoted by alpha) is changing over time. The fine structure constant is a measure of the intrinsic strength of the electromagnetic force. Some observations of distant galaxies have provided credible evidence that the fine structure "constant" may not really be constant. In Budker's terrestrial experiment, dysprosium atoms are used since they have several very closely spaced atomic energy levels. By shining several laser beams at the atoms and applying radio waves, they measure the rate at which the atoms absorb energy, exploiting the fact that the absorption has a dependence on the size of alpha. “The new measurement shows that alpha is not changing by more than one part in 10^{15} per year,” says Budker. “Our eventual goal is a part in 10^{18}, and we are making rapid progress.”

The third tabletop experiment recently performed by Budker and his colleagues concerns photons, which are considered bosons--particles that possess an integral value of spin (0, 1, 2, etc.). The other type of basic particle is a fermion-- a particle such as an electron or quark that possesses a half-integral amount of spin (1/2, 3/2, etc.). A conspicuous property of fermions is that two of them can never occupy the same quantum state if they possess identical quantum states (such as energy, position, or spin). This property, known as the Pauli exclusion principle, accounts for a lot of chemistry since it dictates how electrons inside atoms are distributed in their quantum orbitals.

If photons (which are supposed to be bosons and free from the Pauli exclusion principle) were to have even a small fermionic component, then situations would arise in which some selection rules for atomic transitions would no longer be strict. Budker and his colleagues exposed atoms to two coordinated laser beams, the goal being to have the atoms absorb two identical photons simultaneously, promoting an electron in the atoms from energy state to a higher state in such “forbidden” transition. No absorption was observed which signified there was no deviation from normal statistics. The new limitation on a possible fermion component of photons is now established to be less than 4 parts per 10^{11}.

More information: The talk, "Results of Table-Top Fundamental Physics Experiments at Berkeley" is at 2 p.m. on Thursday, Oct. 28.

Provided by Optical Society of America

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