Research overturns accepted notion of neutron's electrical properties

September 17 2007

For two generations of physicists, it has been a standard belief that the neutron, an electrically neutral elementary particle and a primary component of an atom, actually carries a positive charge at its center and an offsetting negative charge at its outer edge.

The notion was first put forth in 1947 by Enrico Fermi, a Nobel laureate noted for his role in developing the first nuclear reactor. But new research by a University of Washington physicist shows the neutron's charge is not quite as simple as Fermi believed.

Using precise data recently gathered at three different laboratories and some new theoretical tools, Gerald A. Miller, a UW physics professor, has found that the neutron has a negative charge both in its inner core and its outer edge, with a positive charge sandwiched in between to make the particle electrically neutral.

"Nobody realized this was the case," Miller said. "It is significant because it is a clear fact of nature that we didn't know before. Now we know it."

The discovery changes scientific understanding of how neutrons interact with negatively charged electrons and positively charged protons. Specifically, it has implications for understanding the strong force, one of the four fundamental forces of nature (the others are the weak force, electromagnetism and gravity).

The strong force binds atomic nuclei together, which makes it possible for atoms, the building blocks of all matter, to assemble into molecules.

"We have to understand exactly how the strong force works, because it is the strongest force we know in the universe," Miller said.

The findings are based on data collected at the Thomas Jefferson National Accelerator Facility in Newport News, Va., the Bates Linear Accelerator at the Massachusetts Institute of Technology and the Mainz Microtron at Johannes Gutenberg University in Germany.

The three labs examine various aspects of the properties and behavior of subatomic particles, and Miller studied data they collected about neutrons. His analysis was published online Sept. 13 in *Physical Review Letters*. The work was funded in part by the U.S. Department of Energy.

Since the analysis is based on data gathered from direct observations, the picture could change even more as more data are collected, Miller said.

"A particle can be electrically neutral and still have properties related to charge. We've known for a long time that the neutron has those properties, but now we understand them more clearly," he said.

He noted that the most important aspect of the finding confirms that a neutron carries a negative charge at its outer edge, a key piece of Fermi's original idea.

The strong force that binds atomic nuclei is related to nuclear energy and nuclear weapons, and so it is possible the research could have practical applications in those areas.

It also could lend to greater understanding of the interactions that take place in our sun's nuclear furnace, and a greater understanding of the

strong force in general, Miller said.

"We already know that without the strong force you wouldn't have atoms -- or anything else that follows from atoms," he said.

Source: University of Washington