Moving Quarks Help Solve Proton Spin Puzzle

September 11 2008

(PhysOrg.com) -- New theory work at the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility has shown that more than half of the spin of the proton is the result of the movement of its building blocks: quarks. The result, published in the Sept. 5 issue of *Physical Review Letters*, agrees with recent experiments and supercomputer calculations.

It was thought that the spin of the proton would come from its quarks, but experiments beginning with the European Muon Collaboration in the 1980s have established that the quarks' spin accounts for only one third of the proton's spin. Researchers thus began investigating other sources of the proton's spin.

This research concerns one theoretical model, proposed by Jefferson Lab Chief Scientist Tony Thomas and University of South Carolina Professor Fred Myhrer, that suggests that some of the proton's spin is actually generated as orbital angular momentum by its quarks.

“Rather than the way the quarks are spinning, it's the way they're moving in orbital motion. In fact, more than half of the spin of the proton is orbital motion of the quarks. That's a really fascinating thing,” Thomas said.

In this paper, Thomas explored the model's predictions further by extracting more detailed information, including how the orbital angular momentum is generated by the different quarks inside the proton, which has two up quarks and one down quark.

He found that the model seemed to contradict experimental results and the results from highly sophisticated supercomputer calculations of quark behavior, called lattice QCD. The model showed that up quarks carried most of the proton's spin, whereas experiment and lattice QCD point to down quarks.

Thomas said it turns out that the disagreement is only a matter of resolution. The only way to relate such models to the underlying theory of quark interactions is to assume the model's predictions are made at low resolution. However, experiment and supercomputer calculations are made at high resolution.

"In the past, there's been tremendous success starting with the quark model at some very low scale, and then evolving to a higher scale, where you can compare with experiment," Thomas explained. "If you make that generally accepted assumption, then the resulting high-resolution values are in surprisingly good agreement with state-of-the-art lattice QCD calculations, as well as with recent experiments conducted at Hermes and Jefferson Lab. There is a remarkable degree of consistency."

The next step is to compare the model with results from upcoming, more detailed measurements of the orbital angular momentum of the quarks in the proton.

Article: link.aps.org/abstract/PRL/v101/e102003

Provided by Jefferson Lab

Citation: Moving Quarks Help Solve Proton Spin Puzzle (2008, September 11) retrieved 2 May 2024 from https://phys.org/news/2008-09-quarks-proton-puzzle.html