Protons spin a surprise for quantum chromodynamics theory

Spin is an important characteristic of subatomic particles. It is a quality that has the dimension of angular momentum, that is, the same unit that measures the spin of macroscopic bodies such as baseballs or planets. However, the naive picture of a particle as a little spinning ball (served up even in graduate school textbooks) may be a little too naive. Spin in subatomic particles may be more subtle than that. Indeed, in experiments being done at Brookhaven National Laboratory in Upton, N.Y., the spin of protons seems to be serving up a subtle surprise for the current theory of how protons are built and act, which is central to much of current particle physics theory.

An experiment done May 11 struck protons in a stationary target with polarized protons accelerated in Brookhaven's Alternating Gradient Synchrotron (AGS).

The U.S. and Swiss physicists, headed by Alan Krisch of the University of Michigan, expect to commence a more refined experiment this week.

"Polarized" means that the spins of the protons in the accelerated beam were all aligned in the same direction. The protons in the target were unpolarized. A collision of this kind is governed by a force that acts over a short distance, and which can be affected by a number of factors in the properties of the two protons. It is thus much more complicated than the contact forces involved in the crash of two billiard balls, for example, even when they have spin on them. Whether the incoming proton is deflected and at what angle, can be affected by many things.

At the energy at which this experiment was done, spin was not expected to be a factor. At very low energies spin does affect the collision of two protons, but the theory of proton structure and behavior — quantum chromodynamics — expects that at high energies the effect of spin should be about zero, and that seemed to be borne out by experiments done at the Fermi National Accelerator Laboratory in Batavia, Ill., and at the CERN laboratory in Geneva with protons having energies around 200 billion and 300 billion electron volts (200 to 300 GeV).

The Brookhaven experiment was done around 10 GeV, and yielded large, surprising spin effects. There appears to be an effect on the probability that the incoming proton will be deflected that arises from the interaction between the spin of the incoming proton and the "orbit," the path of one proton around the other during the close approach. This effect is particularly strong for wide angles of deflection, that is, for nearly head-on collisions.

"We had a hint of it last fall," Krisch told SCIENCE NEWS. At a fairly wide deflection angle, a 16 percent spin-orbit effect appeared but with poor statistics. The present result involves a wider angle, almost a head-on collision, and all of a sudden a 50 percent effect appeared. Near head-on collisions are quite rare — after all from the incoming proton's point of view the target is nearly all empty space — but this time the statistics are good.

What the result means is that wide-angle scattering, that is, violent head-on collisions, occur three times as often when the spin of the incoming protons is up as when it is down. Theory had expected no such selection process. According to quantum chromodynamics, these large-angle deflections should be caused mainly by direct interactions between the quarks that make up one proton and those that make up the other. Such essentially quark-quark interactions should not take notice of the directions of the protons' over-all spin. Now it seems they do. Theoreticians' comments are eagerly awaited.

The experiment was almost a throwaway. Back in 1977, Krisch and colleagues did an experiment at Argonne National Laboratory in Argonne, Ill., in which they found strong spin effects in proton-proton collisions when both protons had polarized spins. At the AGS they have the opportunity to repeat the experiment at higher energies than they could get at Argonne, potentially as high as 30 GeV. Krisch has been supervising the installation of a polarized proton beam in the accelerator. There are many things that could depolarize a beam in such an accelerator, he says, and so the laboratory management authorized a quick experiment with an unpolarized target just to see if the polarized beam really worked. The result was a double surprise because, says Krisch, "the physics community, even us, didn't expect any large 'one-spin' effects."

They are now doubly eager to see what the "two-spin," double polarized experiment will bring. A polarized target is available, and, Krisch says, on June 26 they achieved in the AGS the world's most energetic beam of polarized protons, 14 GeV. They intend to commence the two-spin experiment this week.

—D.E. Thomsen

Mt. Wilson 100-inch telescope facing a future in mothballs?

In the 1920s, the big 100-inch telescope built only a few years before at Mt. Wilson Observatory in California made major news when it showed astronomer Edwin Hubble that the universe is expanding, and that there are in fact whole galaxies beyond our own Milky Way. More than half a century later, the telescope is still at work, but a year from now it may be shut down, perhaps along with other key instruments at the observatory.

Part of the reason is that the Carnegie Institution of Washington, which owns the observatory, plans to shift much of its work to its other astronomical facility, Las Campanas Observatory in Chile. There, the extremely dark skies are far more suitable to the study of faint, extragalactic sources than is the firmament over Mt. Wilson, "polluted" by the lights of nearby Los Angeles.

Yet the 100-incher is not a useless antique. Astronomer Allan Sandage of Mt. Wilson, for example, has been using it intensively in recent years in a study of the "halo stars" surrounding the Milky Way, thought to be among the oldest in the galaxy. It also helped lead the way to a previously unrecognized stage of stellar evolution, found in the Pleiades by Mt. Wilson's Douglas Duncan and colleagues (SN: 6/23/84, p. 388).

The problem in a broader sense is money, with the costs of advanced instrumentation, for example, rising against Carnegie's fixed endowment. The observatory's second-largest telescope, a 60-incher, has independent support, but the 100 is supported by Carnegie itself, as are two others mounted atop a pair of high towers for solar studies (including detailed recent work on the rotation and pulsations of the sun).

Carnegie's hope is that some other organization will step forward to take on Mt. Wilson's operation. There has been no active solicitation, says Assistant Director Robert Howard (who will soon depart to become director of the National Solar Observatory in Tucson, Ariz.), but he notes that several groups have expressed interest. If such interest is too slow to appear, the plan is to "mothball" the 100 (and perhaps the solar facilities), but Howard is optimistic. "I think there's a fairly good chance," he says, that the mothball period could be short or even nonexistent.

Meanwhile, however, new projects are being undertaken this year, such as a Very Long Baseline Amplitude Interferometry effort headed by Douglas Currie of the University of Maryland and an infrared interferometer under the direction of Charles H. Townes of the University of California at Berkeley. *—J. Eberhart*