Exotic Needle Found in Particle Haystack

In an experimental triumph that helps validate the standard theory of the particles and forces of matter, physicists have found evidence of a rare particle known as an exotic meson.

"We think we are the first group to have finally identified such a particle," says Suh-Urk Chung of the Brookhaven National Laboratory in Upton, N.Y. Chung and his collaborators report their results in the Sept. 1 PHYSICAL REVIEW LETTERS.

"This is a very important observation," says theoretical physicist Ted Barnes of the Oak Ridge (Tenn.) National Laboratory. "It's the first evidence of a new combination of quarks and gluons."

A meson is a particle made up of a quark paired with an antiquark. The pion, for example, consists of a down quark and an up antiquark. The quarks are tied together by gluons, which embody the so-called strong force.

The mathematical relationships of the theory of quantum chromodynamics describe the behavior of quarks and gluons. However, quark-gluon interactions are so complicated that physicists have invented simple models that capture the main features of the phenomena in different energy ranges without requiring them to tangle with the full theory's mathematical details (SN: 8/27/94, p. 140).

When pions crash into protons at an energy of about 18 gigaelectron-volts (GeV), the gluons holding the quarks together behave as if they were elastic strings stretched between the quarks. In contrast, electrons colliding with protons at much higher energies reveal that, in this range, gluons act much more like particles than strings (SN: 9/6/97, p. 158).

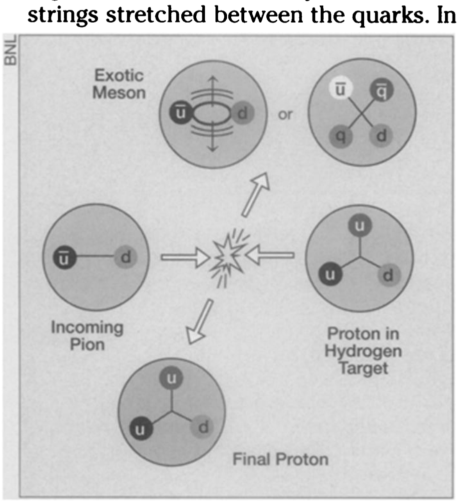
In the 1970s, theorists used simplified models to predict the existence of what they called exotic mesons, in which the quark-antiquark pair is linked by gluon strings that vibrate at particular frequencies as if plucked. Another possibility is that the exotic meson contains extra quark-antiquark pairs. Finding evidence of such particle states, however, proved extraordinarily difficult.

Chung and his collaborators analyzed data obtained at Brookhaven's Alternating Gradient Synchrotron in collisions of fast-moving pions with protons in a liquid hydrogen target. Out of the billions of particles created in the crashes, they found 47,200 instances in which the interaction produced a particle known as an eta meson.

The unexpectedly high yield of the eta meson suggests that it formed via an intermediate stage in which the pion is excited into a very short-lived state—the exotic meson. From the data, the researchers determined the exotic meson's mass, expressed in energy units, to be about 1.4 GeV. "It required a lot of sophisticated analysis, so it took a long time," Chung notes.

At the 7th International Conference on Hadron Spectroscopy, held last week at Brookhaven, members of the Crystal Barrel collaboration at the European Laboratory for Particle Physics (CERN) in Geneva presented preliminary findings that appear to confirm the Brookhaven discovery. Taking a different approach, the physicists used the Crystal Barrel detector to study the products created when antiprotons and protons collide and annihilate each other, and they also found evidence of an exotic meson with a mass of 1.4 GeV.

Theorists still have some puzzles to ponder. For example, the newly discovered exotic meson is less massive than they had predicted. "This is all a little worrying," Barnes says. —*I. Peterson*



An incoming pion, made up of an up (u) antiquark and a down (d) quark, hits a proton in a hydrogen target. The gluons holding the quarks together in each particle can be pictured as strings. The collision leaves the proton essentially unchanged, but the pion is excited into the exotic meson state, including either a vibrating gluon string or an additional quark-antiquark pair (q-$\bar{q}$).

Dead whales tell tales of sea ice decline

By delving deep into whaling records going back to the 1930s, an Australian scientist has discovered evidence of a major decline in the amount of sea ice surrounding Antarctica.

The ice-covered sea around Antarctica measures about twice the size of the United States, and oceanographers regard it as a climatic canary in a coal mine—a sensitive measure of changing conditions.

Because satellite records of sea ice only go back to the 1970s, climate scientists have no direct means of assessing long-term changes in the amount of polar sea ice. Whaling data, however, can provide a roundabout technique for studying the ice, reports William K. de la Mare of the Australian Antarctic Division in Tasmania in the Sept. 4 NATURE.

The International Whaling Commission has 1.5 million records of whale catches since the 1930s. They include the date, the ship's position, and the species captured. De la Mare surmised that he could use these data to track sea ice because many whales congregate around the ice's edge, an area rich in food.

For the period 1930 through 1950, de la Mare finds that the sea ice boundary remained stable, averaging around 61.5°S. During the early 1950s, the positions of the southernmost catches started drifting south, indicating a reduction in sea ice coverage.

Between 1957 and 1971, whalers moved farther north because they had depleted populations of large whales. In the early 1970s, whalers returned to the south to pursue the smaller minke whales, which accumulate at the sea ice edge.

De la Mare found a big change in whaling reports between the 1940s and the 1970s. During the later period, ships made their southernmost catches on average 2.8° farther south than in the earlier period.

"This suggests a decline in the area of sea ice of some 25 percent," which equals a loss of 5.65 million square kilometers of sea ice, says de la Mare.

Some sea ice researchers remain unconvinced. "I find it hard to believe," says H. Jay Zwally of NASA's Goddard Space Flight Center in Greenbelt, Md. Zwally notes that whalers pursued different prey in the 1970s than they did earlier, perhaps explaining some of the change. Furthermore, de la Mare lacks data for the critical interval during the late 1950s and 1960s, when whalers worked away from the ice edge.

De la Mare counters that changes in whaling practice cannot explain the observed southward shift. The ultimate cause of the sea ice decline, he says, remains uncertain. Some computer climate models predict that greenhouse warming should increase the amount of Antarctic sea ice, although other models indicate a decline. —*R. Monastersky*