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New Matter May Have Been Found

■ Physicists detect what could be a five-quark particle. The data are said to be convincing, but the interpretation remains a question.

By K.C. Cole, Times Staff Writer

It's not every day that physicists discover nature singing an entirely unknown tune, but that's what physicists in the U.S. and Japan appeared to have detected in two sets of quite different experiments on opposite sides of the world.

They believe they have discovered a five-quark particle, or "pentaquark." If it holds up to further experiment scrutiny, it would be the first time that such a strange form of matter has been seen.

Because fundamental particles are essentially waves, what the physicists have discovered is actually a surprisingly long-lived resonance — a sustained hum of the kind a person might produce by blowing over the top of a Coke bottle.

In the music of the subatomic sphere, elementary particles bond together like barbershop quartets in precisely determined patterns — and the "pentaquark" simply hasn't been one of them.

Quarks are the fundamental particles that make up familiar protons and neutrons, the anchors at the center of every atom. In protons and neutrons, quarks always hang in gangs of three. Supremely cliquish, they never wander outside their own group. Equally exclusive partnerships also form between quarks and anti-quarks — marriages called mesons.

For 25 years, physicists have tried in vain to see whether stable four- or five-quark particles could exist, with no convincing results. At least until now.

"It's a real milestone," said MIT physicist Frank Wilczek, one of the physicists who discovered how quarks bond together. "There have been a lot of candidates for [these exotic particles] over the years, but none so clear-cut."

While not expressly forbidden by current theories, no one has ever seen a two-quark meson bonding with a three-quark neutron to form a pentaquark. Understanding how this bonding works should shed light on a far larger problem, said Wilczek: why quarks are so cliquish to begin with — and so quirky.

Unlike other familiar forces such as electricity or gravity, the force between quarks does not get weaker as distance between the quarks increases. Surprisingly, it gets stronger, as if the quarks were held together by a tightly wound spring. Quarks can rattle around within their subatomic sacks, but they can never get out.

And there's no good way to understand that, Wilczek said. "When you have a really big nucleus, you have lots and lots of protons and neutrons that can get as close together as they want to be. So why don't they share their quarks?" he asked.

But the pentaquark results suggest that quarks are actually getting shared outside their usual boundaries, which could shed some light on the nature of force that binds quarks. "This would seem to be the first molecule made of quarks," he said.

Since quarks aren't visible to the naked eye, this five-quark state could not be seen directly, and it's possible that what the physicists saw was merely a meson and a neutron hanging out in close proximity — cuddling as opposed to intermingling.

But physicist Peter Barnes at the Los Alamos National Laboratory, who is not associated with the experiment, offered two pieces of evidence for an actual merger. First, the bonded state sticks around far longer than most subatomic particles of this type (longer in this context amounts to a fraction of a second so small that the denominator would contain 22 zeros).

"That's a fairly long lifetime," said physicist Volker Burkert, of the Jefferson National Accelerator Laboratory in Newport News, Va., the U.S. lab reporting the results.

Second, a certain property of the two-quark meson state, known as "strangeness," also appears in the final pentaquark state, suggesting that a true — if brief — melding has taken place.

However, experimental physics being what it is — which is to say, extremely messy, with lots of extraneous signals clouding even the best experiments — it will take a great deal of further study to pin down exactly what the physicists have seen.

"Does this thing really exist?" asked Barnes. "The data [are] quite convincing, but is the interpretation of the data right? We could be fooled." Still, he said, "they are clearly seeing something. And it has the potential for being really important."

As MIT physicist Robert Jaffe summed it up, physicists do not understand how quarks fit together into the particles that make up 99% of the familiar matter in the universe.

"Looking at these exotic states," he said, "is one of the ways we can learn the subtleties of the structure of matter."