The trick, Owen admits, is to build a core and add layers of volatiles without heating the growing planet to the point where the water is driven off as well.

In the fourth possibility, Jupiter started out with a water-enriched atmosphere but somehow withdrew its water deeper into the planet, beyond the probe's reach. That possibility intrigues Stevenson. "In this scenario, you imagine that in addition to water forming a cloud deck at some depth, something else happens at much, much higher pressures that is specific to water," he says. What that something might be is hard to say because laboratory experiments on Jovian materials at such megabar pressures have only recently become practical. Perhaps water is raining out of the upper parts of Jupiter despite fiery temperatures, as helium is, speculates Stevenson. Or, under extreme pressure in the depths of Jupiter, water might be forged into a metal that prefers the company of the metallic hydrogen of the deep interior.

"It's going to be difficult to choose between the [possibilities] except on plausibility grounds," says Donahue. "As usual, it seems we may have raised more questions than we answered."

–Richard A. Kerr

PHYSICS

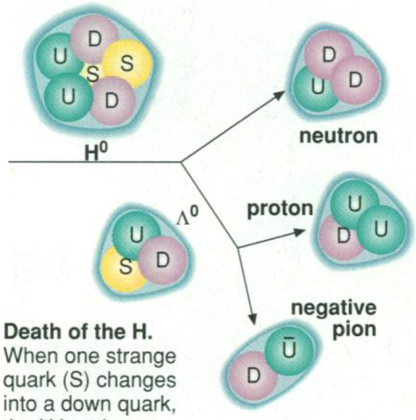
A First Glimpse of Strange Matter?

Strange as the world of quantum physics might seem at times, to some theorists it is not nearly as strange as it might be. The problem is that all matter in the universe seems to be composed of just two of the six available kinds of quarks, the up and the down. Theoretical calculations suggest that mixing in a fair share of strange quarks, the next heaviest type, or "flavor," should yield another family of stable particles—strange matter—that might exist in such exotic crannies of the universe as the interiors of neutron stars. But every effort to create strange matter in accelerators on Earth has come up empty—until now, perhaps.

In the 29 April issue of *Physical Review Letters*, a team of physicists working at the Brookhaven National Laboratory reported that by sifting through a beam of neutral particles, they had recorded two possible sightings of the lightest form of strange matter, known as an H dibaryon—a package of six quarks, two of which are strange. Two events constitutes a signal so weak that it allows the physicists only to set an upper limit on how often these particles can be produced. "With 20 events you can learn something," says Princeton University physicist Alan Schwartz, who led the analysis. "With two, you're neither here nor there." Theorists, however, are tantalized, because they have been speculating about strange matter—and puzzling over its absence—for nearly 2 decades.

Theorist Bob Jaffe of the Massachusetts Institute of Technology, who proposed the H in 1977, explains that it is the offspring of quantum chromodynamics, the theory describing the strong force that binds quarks. Just as the electromagnetic force acts on particles carrying electrical charge, the strong force responds to a kind of "charge" known whimsically as color. Ordinary protons and neutrons, for instance, are bags of three up and down quarks stabilized mainly by their combinations of color. But theorists have realized that the strong force should have an even tighter grip on collections of quarks that include wide combinations of flavors as well as colors, says Jaffe. "This tendency cannot be fully realized among the usual states made of three quarks," Jaffe says, because of what he calls the "Chinese puzzle" of allowed and forbidden combinations of color, flavor, and other quantum-mechanical parameters. "But it can in a system of six quarks." In this sense the H—made of two up, two down, and two strange quarks—is the most stable quark combination imaginable.

Even though the H would be a paragon of strong-force binding, it could still decay via so-called weak interactions, which would transform one of its strange quarks into a down quark. The H would then break up into a neutron and an unstable particle called the lambda, which has one up, one down, and one strange quark. But that process would take a relatively long time: a billionth of a second, long enough for it to be observed in an accelerator experiment. The trick would be to create showers of short-lived particles consisting of quarks—including strange quarks—and their antimatter counterparts. On rare occasions the right combination might come together to form an H.



Death of the H. When one strange quark (S) changes into a down quark, the H breaks up.

SOURCE: JAFFE

Until recently, nothing has worked. But in 1992, Val Fitch, a Nobel laureate at Princeton, contacted the leaders of a Brookhaven experiment that had been set up to look for rare decays of particles known as kaons, suggesting an H search. By slamming protons into a copper target and then sweeping away the charged debris with magnets, Brookhaven's Alternating Gradient Synchrotron was producing the highest intensity beam of neutral particles anywhere in the world. Because H particles would themselves be neutral, Fitch argued, such a beam would be the natural place to look for them. And he pointed out that the kaon detector could do double duty, searching for decays that might signal the brief appearance of an H particle.

The Brookhaven administration was quick to approve the project, and Schwartz, Fitch, and their collaborators then spent a hectic 6 weeks setting up the experiment. In the spring and early summer of 1992, they took a month's worth of data, an episode University of California, Los Angeles (UCLA), physicist Bob Cousins, who was also involved, calls "just a blip in our lives tacked onto the kaon thing."

The analysis, however, was definitively less bliplike. The physicists looked for H's in two different ways: Fitch, Cousins, and two graduate students—Josh Klein at Princeton and Karl Ecklund at Stanford—followed Fitch's original idea, which was to look for H's that jumped into an excited state in the detector and broke up into two lambda particles. Schwartz and Brent Ware, a University of Texas graduate student, looked for H's that spontaneously decayed into a lambda and a neutron.

Fitch and his colleagues came up empty, but Schwartz and Ware were more successful. After spending 3 years on what everyone describes as an extraordinarily painstaking and conservative analysis, Schwartz and Ware were left with two candidates that had all the features expected of the decay of an H particle and no other natural explanation. "But we all know that with only two events," says Cousins, "there could be all kinds of unnatural explanations that aren't the H."

The next few years should help distinguish the strange from the unnatural. At Brookhaven, one experiment is already looking for other forms of strange matter besides the H, and another, which Cousins describes as "the definitive experiment," is currently under construction by a group from Berkeley, UCLA, and Brookhaven. The experiment, says Berkeley physicist and co-spokesperson Hank Crawford, should have 1000 times the sensitivity needed to settle the question. "We fully expect to find the H if it exists," says Crawford. "We'll nail it tight."

–Gary Taubes