Muons, deuterium, and cold fusion

It would be in the national interest for all those involved in the cold-fusion controversy to read a 1957 paper by Luis Alvarez and his coworkers. During the 1950s Alvarez, of the University of California, Berkeley, invented a new kind of particle detector. Called a hydrogen bubble chamber, it was the subject of one of the 40 patents he held. It was vastly superior to other detectors then available, and it permitted experiments that would not otherwise have been possible.

Using his detector, in 1957 Alvarez observed the capture of μ^- mesons by deuterium molecules, immediately followed by the nuclear fusion of the two deuterium atoms. He reported his discovery in one of the 168 scientific publications he wrote; he described the process as the chemical catalysis of nuclear fusion.[1] The force holding two atoms together in a diatomic molecule is linear in the mass of the electron. Substituting a μ^- meson for an electron effectively increased that force more than 200 times, allowing the fusion to occur.

Although Alvarez used cyclotron-produced μ^- mesons, Earth is continually bathed in cosmic rays that produce μ mesons and other particles. By showing that a μ^- meson will induce fusion of two deuterons if it is captured in their electric field, Alvarez proved that a molecule of deuterium exposed to the terrestrial cosmic-ray background has a small but finite probability of undergoing fusion.

In 1989 Martin Fleischmann and Stanley Pons also discovered the fusion of deuterium without the use of great heat and called a press conference to announce their "cold fusion" results. The media was quick to pounce on the promise of nearly unlimited power from such small equipment, but the scientific community was much more skeptical. The fusion of two deuterons requires hundreds of thousands of eV, whereas Pons and Fleischmann's experiment involved only a few volts, a fact that rendered their explanation of the effect impossible. Still, since 1989 the Pons–Fleischmann experiment has been repeated over and over,[2] often with the result that rather more energy is released than can be explained by the equipment used. The 24 April 2009 segment of the CBS TV show *60 Minutes* rehashed those experiments and again mentioned the potential for nuclear-powered vehicles and other wonderful applications.

It takes hundreds of MeV to make a meson, which has a half-life of only microseconds and produces at most only a few tens of MeV of energy during the fusion reaction. Had any viable energy-producing application come out of the effect he discovered, Alvarez would have patented it. If those involved in the cold-fusion controversy read Alvarez's paper, they will recognize that deuterium does undergo fusion if exposed to cosmic-ray secondaries. Can the cold-fusion results be explained merely in terms of fusion induced by naturally occurring cosmic-ray muons, or is something else going on in those experiments?

References

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Anachrony in decoherence

In a Search and Discovery news item (PHYSICS TODAY, September 2009, page 16), we are faulted for not couching our work of the early 1980s "in terms of the then-nascent decoherence theory." Well, we're sorry about that, and can only offer the excuse that the term "decoherence" hadn't yet been coined. We called it "quantum damping" and "tunneling friction." The reader may agree that those are perhaps not such bad descriptions.

Anyone bothering to read the articles[1,2] or those we have written since[3] will find the solutions to Hund's paradox and the ideas presently in circulation concerning decoherence, like "decoherence by the environment," clearly and quantitatively explicated.

The situation is amusingly reminiscent of the case of Ramses II. Apparently, some people claim the pharaoh couldn't have died of tuberculosis[4] because the disease wasn't discovered until the 19th century.

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A reader asks: No classical electroweak theory?

Here is a question I have been pondering for some time. Is there a *fundamental* reason why there is no *classical* electroweak theory? Is there a factor of $\hbar$ hidden in the definition of the weak currents, for example? Of course, one might ask why anyone would consider looking for a classical theory; the standard model seems to provide whatever theoretical structure is needed. My answer is that most of the machinery that provides the foundation for physics research and engineering is based on classical electromagnetic theory. It would be difficult, for example, to design an efficient electric motor if the only theory available were quantum electrodynamics. A classical theory of the electroweak interaction might provide similar practical insight.

Of course, the coupling constant is small, and the weak currents and fields are largely confined to the nucleus by the mass of the intermediate vector bosons. However, if the coupling between the weak and electromagnetic currents does not vanish in the classical limit, then the possibility exists of observable macroscopic effects, particularly if some sort of collective behavior can be exploited. The speculative possibilities are intriguing: electromagnetic control or initiation of weak interactions, electroweak generation of electric currents for power, and so on.

Is there a possible lacuna in our current understanding of the electroweak interaction? I would be interested in knowing what the experts have to say about this.

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