The Upsilon: The Heaviest Particle Yet

The poker game in the saloon in the old-time western movie was always a focus of melodramatic tension. The participants kept raising each other's bets until, as a hush punctuated by the cocking of pistols settled over the barroom, the audience wondered when, if ever, the hand would be called and they would see who held what and know the pattern of the cards.

The particle physicists' current charmed-particle game seems to be getting like this. The energy stakes keep rising, and the speculations as to which cards are in what hand get more and more feverish. The latest raise, a new particle with a rest mass about six billion electron-volts, is reported from the Fermi National Accelerator Laboratory. The experiment that found it is a collaboration of physicists from Columbia University, Fermilab and the State University of New York at Stony Brook.

The new particle, designated upsilon, was reported at the meeting of the American Physical Society in New York by Leon Lederman of Columbia University. The upsilon particle is six times as heavy as a proton, three times as heavy as any known uncharmed particle, and one and a half times as heavy as any previously discovered charmed particle. Its lifetime may be less than 10^{-18} seconds.

The previous charmed particles have mostly been discovered in colliding-beam experiments that bang electrons and positrons together. Six billion electron-volts lifts the ante a bit above what these experiments can momentarily produce, and the Fermilab experiment uses the accelerator's highly energetic protons to make the upsilon. These protons are directed against targets of beryllium nuclei, and the result is a kind of matter-assisted materialization of energy. The presence of the beryllium helps the energy carried by the protons to materialize itself as new particles. The lifetime of the upsilons is too fleeting to be detected, and their properties are inferred from their decay products.

So new are the data that no hint of the discovery appeared in the abstract of Lederman's talk, which was published about six weeks before the meeting. The upsilons are also rare. A Fermilab spokesman indicates that the experiment has recorded only 11 upsilon events from the billions of protons fired. A confirming experiment will be necessary.

But, if confirmed, the upsilon may change the game somewhat. Some physicists have suggested it means the betting could go on forever—that there is a multitudinous if not perhaps infinite series of these particles. Upsilon may also indicate the need for another new quantum number. (A quantum number is a property of particles that helps determine their behavior.) The addition would raise the number of necessary quarks (the subparticles out of which particles are made according to theory) from the three contemplated when the theory was originally published to six. (Four- and five-quark theories have already been put forth in connection with other charm-particle developments.) The next question is where to go from here. Anybody want to bet? □

Laser uranium separation: A leap forward

The laser, with its emission of a precise frequency of light, has opened new possibilities in chemistry. It is possible to excite a single energy transition of an atom or molecule and use this excitation to effect chemical changes. One thing laser chemistry can sometimes do that other chemical methods cannot is to separate one isotope of a given element from another.

The isotopes of an element differ in nuclear structure and therefore in atomic weight. But their classical chemical properties are identical, so the older chemistry could not separate them. The new methods make use of the slight difference in light-absorption spectra between isotopes. The difference in weight shifts the spectrum of one isotope from that of another. If the shift is large enough, a given laser may be able to excite one isotope and make it chemically reactive while leaving others alone.

Isotope separation has many practical applications, but the most important now is the separation of fissionable uranium from nonfissionable uranium for the manufacture of reactor fuel and bomb charges. Both these uses require uranium samples richer in the fissionable isotope U-235 than are natural deposits. So it comes not so much as a surprise as a confirmation of suspicions to learn that the laser chemistry group at the Los Alamos Scientific Laboratory is working on laser-chemical methods to separate uranium.

This was admitted last week at the meeting of the American Physical Society in New York by C. Paul Robinson and Reed J. Jensen, leaders of the group. When Los Alamos first publicized its laser-chemical isotope-separation work in the spring of 1975, the talk was all about sulfur hexafluoride, and the separation of sulfur isotopes. Sulfur hexafluoride is a compound that seems very similar to uranium hexafluoride, the form in which natural uranium comes, and observers at the time immediately suspected that uranium hexafluoride might be in the background somewhere. At that time SCIENCE NEWS asked Robinson whether the separation method applied to uranium hexafluoride. "If it did," he replied, "nobody would be talking about it in public." The argument was that the spectrum of a heavy element like uranium is so complex that the isotope shift is not unambiguous enough for selective excitation.

Well, perhaps it is not the same method, but Robinson and Jensen now report that a method to simplify uranium hexafluoride's complex spectrum has been found. Furthermore, they admit that they were working on uranium even a year ago and that in some cases "sulfur hexafluoride" was indeed a cover for "uranium hexafluoride."

The method of simplifying the spectrum, which promises to open a large new field in pure and applied chemistry, is similar to the way gas-dynamic lasers are made. Uranium hexafluoride gas at room temperature (300 degrees K) is passed through a special nozzle that makes it expand adiabatically and cool. It gets down to 20 degrees K, and—what is important—it does not solidify; it remains a gas.

The big discovery is that at such low temperatures (this is about the temperature of liquid air), the complex spectra become simplified. The isotope shift works for uranium, and a laser beam can excite one isotope and not another.

What should follow is a chemical reaction to bring out the desired isotope. Asked what that was, Robinson refused to reply. "We come here as physicists, not chemists."

Questions about the technological steps that follow were parried with the explanation "classified." However, Robinson and Jensen did estimate that if the method works technologically, plants producing enriched uranium by laser could be in operation by the early 1980's. The method promises cheaper and more efficient uranium enrichment and conservation of uranium resources because it will get more fuel out of a given amount of natural uranium hexafluoride.

The next question was whether the literature of other countries, in particular the Soviet Union, shows evidence of being on the same track. It seems the Russian literature does show such indications.

While the hawks and doves will jump all over the uranium aspects of the report, each group from its own side, the most important part of the presentation should not be obscured. It is the method of pro-