Neutrino mass: A tritium disagreement

Back around 1930, difficulties in balancing energy in beta decay of atomic nuclei led Wolfgang Pauli to postulate the existence of a subatomic particle that had no rest mass, which Enrico Fermi named "little neutral one" or neutrino. Today, experiments with beta decay are trying to find out whether perhaps Pauli was a little bit wrong, and the neutrino does have a very small rest mass. A neutrino mass would have two important implications: It is required in some current attempts to unify all of particle physics in a single framework, and it would also be one way to make the universe closed, as a lot of cosmologists would like it to be.

Technical difficulties in evaluating the energy data in the different experiments have led to a disagreement over whether a mass exists. The two latest results, published in the May 18 PHYSICAL REVIEW LETTERS, still disagree. One says yes, the other a kind of maybe.

In beta decay, a neutron inside an atomic nucleus decays into a proton emitting an electron (which in radiology is often called a beta ray). The beta decay experiments that are searching for neutrino mass all use tritium, the heaviest, rarest and only radioactive isotope of hydrogen, which is also the simplest nucleus susceptible to beta decay. The disagreements seem related to how they take their tritium.

One of the two current experiments, which is being conducted at the Institute of Theoretical and Experimental Physics in Moscow by S. Boris and 10 others, uses tritium that is part of the solid amino acid valine. The other, at Los Alamos (N.M.) National Laboratory, in which John F. Wilkerson, Thomas J. Bowles and R. G. Hamish Robertson are principal participants, uses gaseous tritium. A third experiment, being conducted in Zurich by M. Fritschi et al., uses tritium embedded in solid carbon.

The Moscow group reports a "central" – that is, most probable – value for the neutrino mass of 30 electron-volts (eV), but it says the number could lie anywhere in the range from 17 to 40 eV, depending on assumptions made in the data evaluation. The Los Alamos experimenters say their result contradicts the Soviets' central figure, but does not rule out the lower end of their range – that is, a neutrino mass less than 26.8 eV could exist, but the Los Alamos group currently is not capable of determining the existence of a mass below that point.

These are all experiments with good statistics, Wilkerson told SCIENCE NEWS. Therefore the disagreement has to arise from how the experiments are set up. One reason for using gaseous tritium, Wilkerson says, is that it makes it easier to account for the effects of the final state of the decayed nucleus (which becomes helium 3). After decay the nucleus does not always go to its ground state or least-energy state, and this can have an effect on the energy spectrum of the beta rays that is similar to the effect a small neutrino mass would have. In the solid, the final-state effects are "impossible to calculate," Wilkerson says. They are more manageable in the gas.

However, gaseous tritium is in very short supply, and so are people who know how to work with it – it is both radioactive and poisonous. Los Alamos does a lot of nuclear fusion work, and so has both tritium and people experienced in working with it. In the experiment, molecular tritium moves down a pipe, 3.7 meters long and 3.8 centimeters in diameter. The entire experiment is inside a room-sized tank that chills it to 160 kelvins to increase the incidence of beta decays as the gas moves along. As electrons are emitted, a magnetic field running along the pipe constrains them to spiral their way down the pipe without bouncing off the walls. As they leave the pipe they are counted by spectrometers.

The experimenters believe the statistics of the apparatus are so good that, after making some adjustments, they can now try to push the limit on neutrino mass closer to zero, down to 10 eV. As to whether there really is a neutrino mass, Wilkerson says, "We have no bias one way or the other." *– D. E. Thomsen*

Cleaning up with a smokestack's siren song

A siren's painfully loud wail may someday signal the cleansing of minute particles from gases escaping a coal-fired power plant's smokestack. The idea is to use high levels of acoustic energy to force micron-sized particles to collide and stick together. The resulting increase in particle size means that conventional cleanup techniques, normally inefficient for removing particles less than five microns across, can be used more effectively to reduce pollutant emissions from power plants.

Although the concept of acoustic agglomeration is almost a century old, only in the last decade or so have researchers, funded by the Department of Energy, taken a close look at the process and come up with an approach that appears to be technically and economically feasible. Gerhard Reethof of Pennsylvania State University in University Park heads one group involved in this research, and David T. Shaw of the State University of New York at Buffalo in Amherst, N.Y., leads another. They discussed the status of their work in Indianapolis at a recent Acoustical Society of America meeting.

One of the biggest difficulties has been obtaining a reliable, high-efficiency sound source. Reethof has developed a 2,000-watt siren that generates a 160-decibel sound at a frequency between 1,000 and 2,000 hertz. In contrast, a typical air-raid siren, which operates at a lower frequency, has a power of only a few hundred watts. Reethof is now designing a 4,000-watt siren. Other types of sound sources are also being developed.

The siren's loudness isn't likely to create a noise problem, because the siren would be encased within a large, thick-walled structure through which gases and entrained fly ash from the combustion of coal would pass on their way to cleanup devices such as electrostatic precipitators, baghouses and cyclones. The level of noise escaping from this chamber would be lower than the noise level in the rest of the power plant.

"The research results . . . show conclusively that acoustic agglomeration of fly ash can be accomplished," says Reethof. However, before a large-scale demonstration can be attempted, he says, further research on several important aspects of the coagulation process is needed. One scientific question concerns whether agglomerated particles can, without falling apart, withstand the rigors of cleansing devices such as cyclones. Another concerns whether the particles are truly spherical, as theoretical models of the process assume (but which may or may not be necessary for trapping).

Nevertheless, says Reethof, "I think we are ready to try it on a small scale." He proposes testing the effectiveness of the process by diverting and treating a portion of the gas flow at an existing power plant.

Shaw is interested in using acoustic agglomeration to control dust particles in high-temperature, high-pressure, highly corrosive environments where other control methods are ineffective. Acoustic agglomeration, he suggests, may serve as a "preconditioner" for removing dust from hot gases used to run a gas turbine or for decontaminating an airstream after an accidental radioactivity release. The chemical industry may also find the process useful for quickly separating chemical products from a gas stream.

Osman K. Mawardi of Case Western Reserve University in Cleveland is investigating the possibility of using much lower levels of sound energy to separate solid particles suspended in a gas. He suggests combining the sound field with an electric or magnetic field to achieve either particle agglomeration or removal. This method eliminates the need for generating high-intensity sound fields and considerably lowers the potential cost of the process. "On paper," he says, "it looks very encouraging." *– I. Peterson*