Physics

Unraveling the details of beta decay

Many radioactive atoms decay by emitting beta particles, or electrons, thereby transforming themselves into new elements. For each atomic isotope, these beta particles emerge from nuclei with a characteristic distribution, or spectrum, of energies. Theorist Steven E. Koonin of the California Institute of Technology in Pasadena has now shown that electrons surrounding an atomic nucleus have a discernible but hitherto overlooked effect on a given radioactive isotope's beta-decay spectrum. Reporting in the Dec. 12 NATURE, he notes that this newly identified quantum-mechanical effect would typically produce a sequence of minute oscillations that slightly distort a low-energy beta-particle spectrum.

The existence of this quantum effect and the "fine structure" it produces in a spectrum may have important consequences in the search for heavy neutrinos (SN: 4/27/91, p.260). Each beta decay produces not only an electron but also an invisible neutrino, and researchers have long relied on measurements of beta-decay spectra for information about the accompanying neutrinos. Koonin cautions that the presence of fine structure could change the interpretation of certain experiments designed to search for heavy neutrinos.

This characteristic spectral fingerprint may also serve as a means of gleaning information about the chemical, or electronic, environment surrounding an atomic nucleus, Koonin suggests. For example, he says, by precisely measuring the shape and size of the fine-structure spectrum resulting from tritium (a radioactive hydrogen isotope) embedded in a crystal, researchers could map the location of hydrogen in solids.

Recipe for liquid-nitrogen SQUID

SQUIDs, or superconducting quantum interference devices, are extremely sensitive, ring-shaped detectors of magnetic fields. However, the rings typically consist of materials that become superconducting only when cooled to 4.2 kelvins, the temperature of liquid helium, and this requirement limits the applications of SQUID technology.

Researchers at Biomagnetic Technologies, Inc., in San Diego have now fabricated SQUIDs from ceramic copper-oxide materials that superconduct at 77 kelvins, the temperature of liquid nitrogen. Although several other groups have constructed such "high-temperature" SQUIDs, the Biomagnetic Technologies team has developed a practical manufacturing process that significantly reduces the electrical noise that interfered with the performance of earlier devices.

"These [low-noise] SQUIDs are sensitive enough for many of the applications presently possible only with liquid helium devices," Mark S. DiIorio and his co-workers report in the Dec. 19/26 NATURE.

Switching to a laser record

A year ago, Lester F. Eastman and his collaborators at Cornell University surprised the scientific community by reporting that they had built a laser that could turn on and off 15 billion times a second (15 gigahertz). Using a tiny, newly designed and fabricated "strained quantum well" laser, the Cornell scientists have now pushed the rate up to a breathtaking 28 gigahertz, the fastest ever for any laser. Theorists had doubted that quantum well lasers would ever approach such rates.

The Cornell laser consists of several extremely thin layers of indium gallium arsenide separated by gallium arsenide barriers. These layers — no more than 40 atoms thick — serve as quantum wells, which confine electrons within their boundaries. The laser appears to owe its superior switching rate to the presence of indium atoms, which distort, or strain, the orderly gallium arsenide crystal structure.

Science & Society

Dioxin cleanup: Status and options

Dioxins — toxic by-products of waste incineration and several industrial processes involving chlorine — are nearly ubiquitous throughout the industrial world, mostly in small quantities (see story, p.24). However, some 100 waste sites in the United States alone "contain serious dioxin contamination," according to a report released last month by the congressional Office of Technology Assessment. Of the 500,000 metric tons of these wastes reported to EPA, more than 98 percent consist of tainted soil — mostly from facilities that produced chlorophenols, chlorobenzenes and chlorophenoxyl pesticides.

To date, high-temperature incineration remains the only effective technology for destroying dioxin in soil, according to the OTA report. Indeed, with properly managed incineration, "one can be assured that dioxins will be broken down" into nontoxic by-products, the report says. But this technology, requiring temperatures in excess of 1,200°C, has proved expensive, currently costing an estimated $1,200 per ton of treated wastes. And even after a dioxin destruction technique has won government approval, obtaining a permit to use it at a particular waste site can take more than a year. The result, OTA notes: "Sites with dioxin-contaminated soil have been studied for a long time, but no actual cleanup work has begun."

The OTA report highlights several promising alternatives to incineration. Base-catalyzed decomposition, for instance, uses hydrogen and temperatures of just 250°C to 350°C to remove dioxin's chlorine atoms — and toxicity. Price: $250 to $500 per ton of wastes. Thermal gas-phase dechlorination uses temperatures at or above 850°C to encourage hydrogen reactions with organic chemicals such as dioxin — probably at a cost of $350 to $500 per ton. However, OTA observes, "In light of the relatively small number of contaminated sites, there appears to be little incentive for the private sector to [commercialize such] new technologies for destroying dioxin in soil."

Women on the verge of an athletic showdown

The same year Roger Bannister ran the first 4-minute mile, Diane Leather became the first woman to run the 5-minute mile. If the two had raced against each other in 1954, Leather would have finished 320 meters behind Bannister. Today, Paula Ivan, the women's champion 1-mile runner, would finish only 180 meters behind men's champion Steve Cram.

Female track athletes are improving their performances at faster rates than men and, if the trend continues, should be running marathons as fast as men by 1998, says Brian J. Whipp, a physiologist at the University of California, Los Angeles. He and UCLA co-worker Susan A. Ward predict that women will catch up with men in most track events by early next century.

Whipp and Ward plotted the mean running velocity of world champion runners over the past 100 years for men and the past 70 years for women. They expected that improvements in mean running velocity would show signs of leveling off as athletes approached physiological limits. "To our complete surprise, we found there were no limits evident," Whipp says. Women appeared to be increasing their top speeds at twice the rate of men, the researchers report in the Jan. 2 NATURE.

Advances in running shoes, tracks, training and sports nutrition all contribute to faster running speeds, Whipp suspects. And an ever-expanding pool of athletes — broadening fastest among women — heightens the chance that those genetically best suited to an event will join the race, he adds.

But so far, explanations for the findings remain pure speculation, Whipp laments. He hopes physiological studies of champions will bring further enlightenment. And while he can't predict whether women will actually *outrun* men, he says there's no hint that their progress will slow.