Trophy from a hunt for exotic decay

For nearly a century, physicists have known that naturally occurring elements that are excessively heavy sometimes decay into more stable species by casting out some of their mass in the form of a helium ion, or alpha particle. Quantum mechanics shows that decay by the emission of ions somewhat heavier than the alpha particle is theoretically possible, but so improbable that no one has ever actually observed this rare, more exotic breed of natural radioactivity. Now two nuclear physicists believe they have. H. Jurgen Rose and G. Arnold Jones, both of Oxford University in England, report in the Jan. 19 NATURE the observation of carbon 14 emission from radium 223. (The mass numbers, 14 and 223, are the number of nucleons (protons and neutrons) in the nucleus). If their results are confirmed — and scientists at Michigan State University (MSU) in East Lansing, are already planning experiments to test their observation — their discovery could spawn a new wave of experiments hunting for other unusual decay modes in order to learn more about how nucleons cluster together inside the nucleus.

Rose and Jones examined the decay modes of radium, which decays sequentially into a series of unstable daughter nuclei by emitting either an alpha particle or an electron at each step. This radioactive chain continues through several generations until a stable lead nucleus is reached. Decay from radium 223 to lead 207, for example, emits a total of four alphas and two electrons. Rose and Jones looked for a decay mode that bypassed this step-wise decay by coughing up the excess mass in one neat package: A carbon ion.

In classical physics, this kind of behavior — particles being expelled from a larger nucleus — is simply not allowed. Even if two protons were brash enough to join up with two neutrons to form an alpha particle inside the parent nucleus, the alpha particle would never escape the nuclear forces that bind it to its sibling nucleons for all eternity. In quantum mechanics, however, the etiquette is not quite so strict. There is a small, but finite, possibility that the alpha particle can escape by what is known as "tunneling" through the captive nuclear barrier. In theory almost any combination of nucleons can form a group inside the parent and tunnel through the nuclear potential. But while the probability of this occurring for alpha particles is small, the chance of this happening for a heavier, more complex nucleus, such as carbon, is very much smaller indeed.

This is why Rose and Jones found only a handful of carbon ions among the throngs of alpha particles collected by their silicon detectors. In their most recent experiments, which ran for over six months, they observed a billion alpha particles for every carbon ion counted. By comparing this observed counting ratio, as well as the measured energy of the expelled carbon ions, with the corresponding theoretical values, they concluded that they had detected just what they were looking for: Carbon 14, an unstable iostope of carbon 12.

This came as a surprise to Walter Loveland, professor of chemistry at Oregon State University in Corvallis, who is among a number of scientists who have searched for exotic decay modes, but have focused on the emission of extremely stable carbon 12. Carbon 14, on the other hand, itself decays by emitting an electron. So why would anyone expect that in the most likely decay scenario the renegade particle that forms in the parent is energetically unstable? The apparent answer is that it is the stability of the daughter nucleus that drives the decay the most. The closer in structure the daughter is to lead 208 — called the doubly magic nucleus because it is the most stable nucleus in that region of the periodic table — the better. The carbon 14 emission results in lead 209 whereas far less stable lead 211 is produced in the carbon 12 emission scheme. So when all the competing factors are taken into account, the carbon 14 decay mode is energetically more favorable (by 4 million electron-volts) than the carbon 12 scenario.

"This is something most of us missed," says Loveland. "It's a very fascinating experiment. It wasn't done so much by patience or brute force as by being a little clever in their choice of decay mode ... There are going to be a lot of chagrined people."

The next step, say Loveland and others, is to verify that what Rose and Jones actually caught in their detectors was carbon 14. MSU scientists are considering an experiment using a magnetic spectrograph that will determine the mass of the emitted ions and deflect away the deluge of alphas that can confuse the results.

According to Loveland, if Rose and Jones are proved correct then "the whole question of heavy particle radioactivity opens up. Maybe there's nitrogen or oxygen radioactivity. Maybe there's something between the alphas and the carbons." A lot of people will be looking for other decay modes, he says, and this will increase understanding of how nucleons lump together inside the nucleus.

— *S. Weisburd*

U.S. space station sought by Reagan

"I am directing NASA to develop a permanently manned space station," President Reagan said in his State of the Union address last week, "and to do it within a decade."

The National Aeronautics and Space Administration (NASA) has been considering such an idea for most of its 25-year history, and has had a special task force at work on it since May 1982, but there is more to getting it underway than the president's go-ahead. The agency says that the basic version should cost about $8 billion (some estimates run higher). The administration's proposed 1985 budget includes $150 million for defining the mission in detail, a phase that will probably continue another year before the really big numbers start. "I'd expect a steep upward curve," says one NASA official, "probably in the '87 budget."

Support has been less than unanimous. A National Academy of Sciences panel found "no scientific need for this space station during the next 20 years," and the Defense Department, admits NASA Administrator James M. Beggs, has "so far ... shown very little interest." The White House and the space agency, however, cite the potential for encouraging commercial utilization of space, as well as opportunities for international participation in the space station itself.

A variety of configurations for the station are being studied, but all would be constructed of separate modules that could be modified or augmented as the station's purposes evolved. A typical version would include one section for living quarters, another to serve as a laboratory or processing facility, another to house power-supply and other equipment, and a fourth with room for exercise, changing into spacesuits and other activities. Also planned are one or more "free-flying" platforms, orbiting close to the station but not connected to it, for such functions as astronomical and earth-pointing observations with sensors that must be kept free of any station-caused pollutants or vibrations.

The obstacles are more than just technological, however. Attracting commercial involvement, for example, involves thorny legal matters such as ensuring proprietary rights to products and processes developed and conducted on what would be a national facility. Another issue is tax credits, which could require radical revision to cover endeavors whose costs are high, but which are not spread over the years or decades of some ground-based projects.

NASA speaks of the station as being operational only "by the early 1990s," although 1992 has been bandied about as a 500th anniversary commemoration of Columbus' arrival in the New World. Says Beggs, "We had trouble with the shuttle when we set a fixed date." —*J. Eberhart*