You say diplon, I say deuton

In 1934, Ernest Rutherford published an essay in *Nature* reviewing experiments involving the new 'heavy hydrogen', and ending with a suggestion for its name. He and his colleagues at the Cavendish Laboratory in Cambridge, favoured the term 'diplogen' for the atom, and 'diplon' for its nucleus, taking the root from the Greek *διπλος*, for double. He suggested that a proposed alternative, 'deuton', might easily be confused with the neutron. A stream of subsequent papers by Cavendish physicists carried titles such as *Disintegration of the diplon*.

None of this sat particularly well with American physicist Harold Urey, who, with Ferdinand Brickwedde and George Murphy, had found the initial evidence for heavy hydrogen in spectroscopic measurements showing a shift of 1.79 Å in the wavelength of the hydrogen alpha line. By tradition, of course, the discoverer of some new substance earns the honour of giving it a name, and Urey preferred deuton. Diplogen, he countered, would lead to some rather confusing nomenclature: the compound $N^1H^2H_2$, for example, would be called di-diplogen mono-hydrogen nitride.

Looking back at these early papers, more than the odd names stand out. Equally prominent are the question marks still hanging over fundamental matters, such as whether electrons reside in the nucleus, whether the 'diplon' was made of two protons and one electron, or whether physical conditions such as pressure and temperature influence the rates of nuclear decay. Most of these questions were settled long ago, but, surprisingly, not the latter — at least not if we consider some more 'exotic' influences. Indeed, recent analyses point to significant variations in nuclear decay rates being apparently correlated with the Earth's distance from the Sun, and suggest that we still have some basic physics to learn.

In the early 1930s, only electrons and alpha particles had been detected in radioactive decays. These particles seemed to emerge from the atomic nucleus, and it made perfect sense to suppose that these particles might reside there. One *Nature* author at the time, George Todd, tried to get to grips with the possibilities of the nuclear interior through algebraic means. He noted that if one allows nuclei to be populated by any of the then-conceivable candidates — alpha particles, protons, neutrons, electrons and positrons — then the problem is under-determined: there are many combinations that can account for the atomic mass and charge of most nuclei. Significantly, he observed that a unique combination can be found if one disallows electrons and positrons in the nucleus.

In his review of 1934, Rutherford emphasized the value of the clues turned up by small discrepancies in experimental measurements. After the relative abundances of the isotopes of oxygen had been measured, R. T. Burge and D. H. Menzel had noticed that distinct methods (chemical versus atomic) for determining the ratio of hydrogen and oxygen masses gave results differing by one part in 5,000. This suggested in turn that hydrogen must also have an isotope naturally present at the level of about one part in 4,000. If Rutherford were alive today, he might well point out that similar discrepancies still have the potential to drive nuclear science.

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Indeed, as he, James Chadwick and Charles Ellis reported in 1930, "the rate of transformation of an element has been found to be a constant under all conditions." But Jere H. Jenkins and colleagues now report systematic variations, of the order of one part in a 1,000, in data gathered on the half-lives of two radionuclides (arXiv:0808.3283v1; 2008). Some of this evidence comes from measurements made by D. E. Alburger and co-workers at Brookhaven National Laboratory between 1982 and 1986. They measured the counting rate for ^{32}Si decays as a function of time, and found an unexpected annual variation of the half-life that could not be explained by any known influence, such as temperature or humidity, on the detecting equipment. Data gathered over 15 years at the Physikalisch-Technische Bundesanstalt in Germany show similar annual variations in the half-life of ^{226}Ra.

Even more interesting, Jenkins and colleagues point out, is the fact that both of these data sets also show a strong correlation with annual variations in the inverse square of the Earth–Sun distance. If these findings stand up, and can be replicated with other nuclei, it would suggest that many nuclear decays may be responding to some influence coming from the Sun. Whatever that influence might be, it must operate on very different decay processes, given that ^{226}Ra decays by alpha decay and ^{32}Si by beta decay.

Jenkins and colleagues point to two possibilities. First, theorists John Barrow and Douglas Shaw have outlined a mechanism by which the Sun might influence the rates of both alpha- and beta-decays through a scalar field, which would act to modulate the electromagnetic fine-structure constant. A second possibility is more obvious — that the neutrino flux issuing from the Sun may exert some novel influence over radioactive nuclei here on Earth. Of course, the neutrino flux varies in direct proportion to the inverse square of the Earth–Sun distance, a variation that has been detected in experiments at Japan's Super-Kamiokande facility. This hypothesis finds some additional support in the possible detection of a brief change in the decay rate of ^{54}Mn during a solar flare on 13 December 2006.

Whether either of these mechanisms lies behind the detected variations in decay rates, or whether it is due to some as yet unknown principle, remains to be seen. It will take further experiments to find out — perhaps, as Jenkins and colleagues propose, with radionuclides on spacecraft travelling to other planets, where variations in the solar influence can be made much larger. With time we'll no doubt find that some of the current speculation will come to be seen as prescient, and some as rather off-base — the modern equivalent of that once seemingly plausible idea that the 'diplon' might be made of two protons and one electron.

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