TASC

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TASC's mission is to rebuild and strengthen the foundation of the Christian faith by increasing awareness of the scientific evidence supporting the literal Biblical account of creation and refuting evolution.

Dan Reynolds, PhD, Chairman

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RADIOACTIVE DECAY RATES MAY CHANGE

By David Plaisted

In 1 Corinthians 13 the Bible says, "For we know in part, and we prophesy in part." Our knowledge is imperfect in this life, and we are continually learning more. This is also true in the scientific realm, and theories that were once held often have to be given up. We may see scientific theories change again very soon due to new discoveries concerning rates of radioactive decay, the speed of light, and the degree of ape-human similarity. All of these areas are significant for theories of the origin of life on earth, so it is helpful to examine them in more detail. Here there is only space to examine the first of these areas, namely, the rate of radioactive decay.

Introduction

For a long time it has been claimed that the rate of radioactive decay does not change, except in highly unusual circumstances. This means that, for example, when uranium decays to lead, it always does so at a fixed rate, so one can use the amount of uranium and lead in a sample to estimate its age, under certain assumptions. The ages obtained in this way are frequently in the hundreds of millions of years range. However, recently evidence has come to light that rates of radioactive decay are constantly changing. Though the measured changes are small, this is significant because in the past the changes in decay rates could have been much greater, calling into question the use of radioactive decay to estimate the ages of rocks and fossils. If the rates of decay were much faster in the past, then these rocks and fossils dated at hundreds of millions of years old could really be much younger than this. A faster rate of decay might also provide a cause for the biblical Flood. In fact, there has been some evidence in this direction for quite a while now.

Types of decay

There are actually many different kinds of radioactive decay. One is alpha decay, in which a helium nucleus is ejected from the nucleus of an atom. Another kind of decay is beta minus decay, in which an electron is ejected from the nucleus, changing a neutron to a proton. Another is beta plus decay, in which a positron, a positive electron, is emitted, changing a proton to a neutron. Electron capture is a fourth kind of decay, similar to beta plus decay, except that an electron joins with a proton to produce a neutron in the nucleus of an atom. These last three are together called beta decay. Then there is gamma decay, in which energy similar to X rays is emitted from a nucleus, but no protons or neutrons in the nucleus change. There are other kinds of decay, as well.

Old results about change in decay rates

For a long time unusual statistical properties of decay have been observed, and the decay constants (the rates of decay) did not always seem to be the same. Slusher reports: "Anderson and Spangler maintain that their several observations of statistically significant deviations from the (random) expectation strongly suggest that an unreliability factor must be incorporated into age-dating calculations."[1] Such irregularities were observed for carbon 14, cobalt 60, and cesium 137. The source for this information is a paper by Anderson and Spangler.[2] Even Dalrymple recognizes such irregularities:

> Under certain environmental conditions, the decay characteristics of 14C, 60Co, and 137Ce, all of which decay by beta emission, do deviate slightly from the ideal random distribution predicted by current theory…, but changes in the decay constants have not been detected."[3]

Dalrymple cites a couple of references.[4,5] Though Dalrymple claims no changes in the decay constants have

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[1] Slusher HS (1981) Critique of Radiometric Dating. Institute for Creation Research, Technical monograph 2 (2nd ed.), Master Books, Green Forest, AK
[2] Anderson J, Spangler G (1974) Radiometric Dating: Is the "Decay Constant" Constant? *Pensee* **4**(4)
[3] Dalrymple GB (1984) How Old is the Earth?: A Reply to "Scientific" Creationism. *Proceedings of the 63rd Annual*
[3] Dalrymple GB (1984) How Old is the Earth?: A Reply to "Scientific" Creationism. *Proceedings of the 63rd Annual Meeting of the Pacific Division, American Association for the Advancement of Science* **1**(3):66–131.
[4] Anderson JL (1972) Non-Poisson distributions observed during counting of certain carbon-14-labeled organic (sub) monolayers, *Phys Chem J* **76**:3603–3612
[5] Anderson JL, Spangler GW (1973) Serial statistics: Is radioactive decay random? *Phys. Chem. J.* **77**:3114–3121

been detected, he admits to puzzling irregularities in decay. The simplest explanation for these observations is that the rates of decay vary slightly from one time to another.

Recent work of Jenkins and Fischbach

Eprhaim Fischbach is a physics professor at Purdue, and Jere Jenkins is a nuclear engineer at Purdue. They were recently looking into decay processes as a possible source of random numbers for statistical purposes.[6] While examining the data on radioactive decay, they found several unusual observations. First, the measured rates of decay did not always agree. Second, the decay rate of silicon-32 and radium-226 seemed to be slightly faster in winter than in summer. Then while measuring the decay rate of manganese-54, Jenkins found a drop in the decay rate during a solar flare on December 13, 2006. This happened in the middle of the night, so whatever particle was causing it must have traveled through the earth. This led Jenkins and Fischbach to suspect that it was neutrinos causing this effect, because neutrinos can travel through matter with little effect. The Purdue researchers submitted a paper on this result to *Physical Review Letters,* but it was rejected, they say, because there was no mechanism to back it up.[7] Next Peter Sturrock, Stanford professor emeritus of applied physics, saw some of the articles written by Jenkins and Fischbach. Sturrock is an expert on the sun, and he suggested that they look for patterns in decay related to the rotation of the sun because he knew that the intensity of neutrinos from the sun varies with its rotation. The three of them did this and found a recurring pattern of 33 days. In addition, they found another variation in decay rate with a cycle of about half a year. In general, the fluctuations that Jenkins and Fischbach and their collaborators have found are around a tenth of a percent from what is expected, as they've examined available published data and taken some measurements themselves. All of these patterns, including the annual one, are related to known properties of the sun, suggesting that the behavior of the sun is responsible for these changes in decay rates.

Relation to the Sun

Concerning the 33-day cycle, the fact that the period is 33 days is surprising because the rate of solar rotation at the surface of the sun is not 33 days but instead 28 days. However, total solar irradiance varies with a period of about 33 days. Apparently the core of the sun, where neutrinos are produced, rotates more slowly than the surface. Since rotation rate estimates derived from irradiance data have been found to be closely related to rotation rate estimates derived from low-energy solar-neutrino data, this result supports the conjecture that solar neutrinos may be responsible for variations in nuclear decay rates.

Interestingly, P.A. Sturrock et al. found that the phase of the annual variation in decay rates was a little off from the phases in the change in the earth-sun distance and conjectured that this is due to a possible North-South asymmetry in the solar emission mechanism.[8] The observed data are consistent with this hypothesis.

There is even a solar phenomenon that can explain the observed cycle of about half a year that Fischbach et al. observed.[9] This is the Rieger periodicity discovered in 1984 by Rieger and his colleagues in gamma-ray–flare data. It has a period of about 154 days.

The dependence of decay rates on solar radiation may explain discrepancies in various half-life determinations reported in the literature.[10] Examples are ^{32}Si, ^{44}Ti and ^{137}Cs, among many others. If nuclides such as ^{32}Si, ^{36}Cl, and ^{226}Ra respond to changes in the solar neutrino flux due to the time-dependence of the distance from the sun, then they can also respond to changes in solar activity, which are known to occur over time scales both longer and shorter than one year. Thus, depending on when half-life measurements were made and on the specific techniques employed, it is possible that some of the half-life discrepancies reported in the literature could be reconciled if appropriate data on solar activity become available. Note that solar activity can change from year to year, possibly influencing decay rates from one year to the next.

Kinds of Decay Affected

The kinds of decay that appear to exhibit such small variations in decay rate are beta minus, beta plus, and electron capture. Radioactive nuclei are unstable, so a very small input of energy from a passing particle could

6 Stober D (2010 Aug 23) Stanford Report: The strange case of solar flares and radioactive elements <http://news.stanford.edu/news/2010/august/sun-082310.html> Accessed 2011 Nov 19

7 Cartwright J (2008 Oct 02) The mystery of the varying nuclear decay <http://physicsworld.com/cws/article/news/36108> Accessed 2011 Nov 19

8 Sturrock PA, Buncher JB, Fischbach E, Javorsek II D, Jenkins JH, Mattes JH (2011) Concerning the phases of the annual variations of nuclear decay rates. *Astrophys. J.* **737**(2):65

9 Fischbach E, Sturrock PA, Jenkins JH, Javorsek II D, Buncher JB, Gruenwald JT (2011) Evidence for solar influences on nuclear decay rates. *Proceedings of the Fifth Meeting on CPT and Lorentz Symmetry*, V.A. Kostelecky, editor. World Scientific: Singapore, 168–172

10 Jenkins JH, Fischbach E, Buncher JB, Gruenwald J, Krause DE, Mattes JJ (2009) Evidence of correlations between nuclear decay rates and earth-sun distance *Astropart. Phys.* **32**:42–46

be enough to cause them to decay. This could be caused by a neutrino or a neutrino-like particle, though this would be unexpected because neutrinos react very little with matter. The observed changes in decay rate are very small, much less than one percent, but if the sun acted up or a nearby star exploded, the change in decay rate could have been much larger in the past.

Lindstrom et al. tried some direct measurements to see if the flux of neutrinos could change decay rates.[11] In particular, radioactive decay itself produces neutrinos, so depending on the shape of the sample, the flux of neutrinos can vary. A sphere should have a greater flux of neutrinos than a thin foil sample, for example, and these two shapes were examined to see if there was a difference in decay rates. The maximum neutrino flux proproduced by decay in the sphere was several times greater than the flux of solar neutrinos at the surface of the Earth. A small difference in decay rate between the shapes was detected, but not enough to be statistically significant, indicating that if neutrinos are responsible for this effect, a larger quantity of them is needed. The authors write:

> These results thus leave open the possibility that the half-life of a radioactive nuclide could in fact depend on its shape (due to the internal flux of neutrinos, photons, or electrons), and hence suggests that additional experiments are necessary.

It is also possible that a different energy or type of neutrinos is responsible, or possibly a different particle.

Substances they used which exhibited an annual periodicity

The substances that were measured and for which variations in decay rate were found are ^{54}Mn for solar flares and ^{56}Mn, ^{32}Si, ^{36}Cl, and ^{226}Ra for annual cycles. ^{54}Mn has a half-life of 312 days and decays by electron capture. ^{56}Mn has a half-life of about 2.6 hours and decays by beta minus decay. ^{32}Si has a half-life of 104 years and decays by beta minus (electron emission) decay. ^{36}Cl has a half-life of 301,000 years and decays mostly by electron emission and 2 percent by electron capture. ^{226}Ra has a half-life of 1600 years and decays by alpha decay, but its decay products have beta decay and thus may exhibit an annual cycle. This information illustrates the tremendous variation in properties among these various substances. The annual dependence of decay rate for ^{32}Si and ^{36}Cl was reported by an experiment performed at the Brookhaven National Laboratory (BNL), ^{56}Mn decay was reported by the Children's Nutrition Research Center, but also performed at BNL, and ^{226}Ra decay was reported by an experiment performed at the Physikalisch–Technische Bundesanstalt in Germany.[12]

Though ^{226}Ra decays by alpha decay, an annual variation in decay rate was observed for it. However, decay products of ^{226}Ra that decay by beta decay rapidly accumulate; when equilibrium is reached, in about 200 years, 42% of the photon emissions are due to beta-decaying daughters of ^{226}Ra. The ionization chamber utilized in the experiment cannot discriminate between either (alpha or beta) type of decay: the chamber measures only the total energy deposited by the incident photons, which have their origins in both types of decay from several different isotopes.[8]

Objections to these results

Most of the results of these researchers were based on radioactivity measurements done by others. What Jenkins and Fischbach and their collaborators did was to apply standard statistical tests to these data to see what kinds of patterns were in them, and what the probability of these patterns happening was. They found recurring patterns that statistical tests showed had an extremely low probability of appearing in random data. This kind of work is repeatable by anyone who has access to the data, so the fact that the measurements were done by others is not a problem. However, some people on the web have criticized Jenkins and Fischbach for this. In fact, some have gone so far as to call these results pseudo-science, without any justification.

Some people have criticized these results for another reason, saying that the variations in decay rate might have been caused by changes in the behavior of the experimental apparatus between summer and winter. Jenkins and Fischbach and their collaborators considered this possibility but could not find any correlation between decay rate and any environmental influence such as temperature, pressure, or humidity.[12] This suggests that the changes in decay rate were not due to the influence of temperature or humidity or some other influence on the measuring equipment. Also, there does not seem to be any environmental influence with a 33-day or a half-year period, further calling this possibility into question. Furthermore, it is curious that the same patterns do not reveal themselves for alpha decay if they are caused by the equipment or the environment.

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[11] Lindstrom RM, Fischbach E, Buncher JB, Greene GL, Jenkins JH, Krause DE, Mattes JJ, Yue A (2010) Study of the dependence of ^{198}Au half-life on source geometry. *Nuclear Instruments and Methods in Physics Research Section A* **622**(1):93–96

[12] Sturrock PA, Buncher JB, Fischbach E, Gruenwald JT, Javorsek II D, Jenkins JH, Lee RH, Mattes JJ, Newport JR, (2010) Power spectrum analysis of Physikalisch-Technische-Bundesanstalt decay-rate data: Evidence for solar rotational modulation. *Solar Phys.* **267**(2):251–265

Another objection to these results is that the distance from the sun did not influence the power output of NASA's Cassini satellite, whose orbit went as close to the sun as Venus and as far from the sun as Saturn. This analysis was done by Cooper.[13] The Cassini satellite was launched in 1997 and reached Saturn in 2004. It had a radioisotope thermoelectric power generator using the decay of ^{238}Pu with a half-life of 88 years to supply the power. The reason for this lack of dependence on the distance from the sun appears to be that ^{238}Pu decays by alpha decay, while the observed variations in decay rate all occur with beta decay. Some decay products of ^{238}Pu do decay by beta decay, but their buildup is very slow and would not have had a significant influence during the time period of the satellite. This issue was discussed by Jenkins et al.[14]

Norman et al. also looked for an annual variation in decay rates and did not find it.[15] They calculated the ratios between the rates of two kinds of decay, to cancel out any changes in the equipment between summer and winter, and found that the ratios did not change much annually. They assumed that if there were an annual variation, it would affect different decay processes differently, so the ratios would change. They looked at the ratios between ^{241}Am and ^{121}Sn^{m}, ^{133}Ba and ^{108}Ag^{m}, and ^{22}Na and ^{44}Ti. The "m" indicates a nuclear isomer, which is an excited state of a nucleus with a different spin from the ground state.

In response to this, of course, the ratios of decay rates might not change much even if there were an annual variation in rate of decay. Also, ^{241}Am decays primarily by alpha decay, but it is possible that its decay products decay by beta decay and are subject to an annual influence. Another point is that different substances are very different, and some of them, even with beta decay, may not be influenced by the sun as much as others. Javorsek et al. write:

> The inference from our analysis that different nuclei may be affected differently by an external source could help to explain recent papers by Norman et al. and Cooper who have set limits on possible variations in the decay rates of several nuclides. […]it is reasonable to suppose that the same complex details of nuclear structure (e.g. nuclear wavefunctions, angular momentum selection rules, etc.), which are responsible for the fact that half lives vary from fractions of a second to tens of billions of years, could also affect the response of different nuclei to some external influence.[16]

For example, the effect may depend on the half-life, on the method of decay, on the nuclear cross section, and what kind of a nucleus it is. In general, one might expect substances with a short half-life to require lower energies to decay than substances with a long half life. Sub-Substances with a long half-life, on the other hand, have fewer decays per unit time, so each additional decay caused by a particle from the sun would have a much larger proportional effect on the decay rate. Some substances are nuclear isomers; these can take a long time to decay to the ground state of the nucleus.

Here are facts about the substances used in the study of Norman et al. to show their variation in properties: ^{22}Na has a half life of 2.6 years and decays by beta plus and electron capture decay.[15] ^{44}Ti has a half-life of 60 years and decays by electron capture. ^{108}Ag^{m} (a nuclear isomer) has a half-life of 130 years and decays 90 percent by electron capture or beta plus and about 10 percent by isomeric transitions. Sometimes electron capture is included as a type of beta decay. ^{121}Sn^{m} (a nuclear isomer) has a half-life of about 55 years and decays by beta plus decay and possibly also by other methods. ^{133}Ba has a half-life of 10.51 years and decays exclusively by electron capture. This illustrates the wide variation in the properties of these substances. Another issue is that the annual variation of different substances can vary with a different phase. Finally, when Sturrock et al. analyzed the data of Norman et al., they did find a small annual variation in the ratios.[8]

Of course, there is additional evidence that decay rates were accelerated in the past; this has to do with helium retention in zircons. For a discussion of this, see Plaisted.[17] In fact, the flood may have been caused by such an acceleration in the decay rate, heating the earth and causing catastrophic effects. Another interesting aspect to this is that some excited states of nuclei, such as nuclear isomers, can last for hundreds or thousands of years. If decay were accelerated in the past due to a

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[13] Cooper PS (2009) Searching for modifications to the exponential radioactive decay law with the Cassini spacecraft. *Astropart. Phys.* **31**(4): 267–269

[14] Jenkins JH, Mundy DW, Fischbach E (2010) Analysis of environmental influences in nuclear half-life measurements exhibiting time-dependent decay rates. *Nuclear Instruments and Methods in Physics Research Section A*, **620**(2-3):332–342

[15] Norman EB, Browne E, Shugart HA, Joshi TH, Firestone RB (2009) Evidence against correlations between nuclear decay rates and Earth-Sun distance. *Astropart. Phys.* **31**:135–137

[16] Javorsek II D, Sturrock P, Lasenby RN, Lasenby AN, Buncher J, Fischbach E, Gruenwald T, Hoft A, et al. (2010) Power spectrum analyses of nuclear decay rates. Astropart. Phys. **34**(3):173–178

[17] Plaisted D (2005) Evidences for a recent creation: Part 1 <http://www.tasc-creationscience.org/content/evidences-recent-creation-part-1-0> Accessed 2011 Nov 19

blast of radiation of some sort, then there might still be an excess of excited nuclei, and detecting these could give an evidence for such an accelerated rate of decay in the recent past.

Conclusion

There are other recent discoveries that also illustrate the imperfection of our knowledge; for example, there is a possible observation that neutrinos can travel faster than light.[18] Another recent discovery is that the difference in DNA between apes and humans is much larger than had been thought and appears to be 30 percent or more, instead of one percent, as had been claimed in the past.[19,20,21] However, there is not space here to discuss these very interesting discoveries and possibilities. Let us hope that these recent discoveries will underline how little we know and how much remains to be discovered, leading us to humility and a greater appreciation for God's revelation in His word.

COMING EVENTS

Thursday, December 8, 7:00 P.M., Providence Baptist Church, 6339 Glenwood Ave., Raleigh, Room 631
Dave Plaisted, PhD will present recent evidences in the physics literature that the rate of radioactive decay may not be a constant but may vary in response to some influence from the sun. Of course, these findings have implications for age dating methods based on radioactive decay.

[18] The OPERA Collaboraton: Adam T, Agafonova N, Aleksandrov A, Altinok O, Alvarez Sanchez P, Anokhina A, Aoki S, Ariga A, et al. (2011) Measurement of the neutrino velocity with the OPERA detector in the CNGS beam. <http://arxiv.org/abs/1109.4897v2> Accessed 2011 Nov 19

[19] Hughes JF, Skaletsky H, Pyntikova T, Graves TA, van Daalen SKM, Minx PJ, Fulton RS, McGrath SD, et al. (2010) Chimpanzee and human Y chromosomes are remarkably divergent in structure gene content. *Nature* **463**(7280):536–539

[20] The Chimpanzee Sequencing and Analysis Consortium (2005) Initial sequence of the chimpanzee genome and comparison with the human genome. *Nature* **437**:69–87

[21] Cheng Z, Ventura M, She X, Khaitovich P, Graves T, Osoegawa K, Church D, Pieter-DeJong P, et al. (2005) A genome-wide comparison of recent chimpanzee and human segmental duplications. *Nature* **437**:88–93