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SCIENCE

Radioactive Decay Rates May Not Be Constant After All

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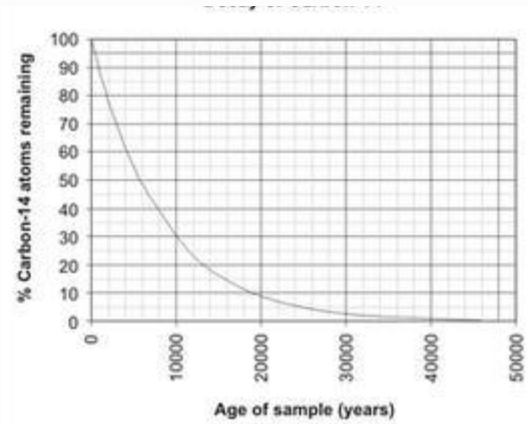

This chart of Carbon-14 decay may turn out to be inaccurate. Image via Wikipedia

One of the first things that Physics students learn when they study radioactivity is the idea of the half-life. A half-life is the period of time in which it takes one-half of a given amount of a radioactive substance to decay. Radioactive decay happens when a radioactive substance emits a particle. It's impossible to predict exactly when a given atom of a substance will emit a particular particle, but the decay rate itself over a long period of time is constant.

Or, at least, that's what we thought. But if physicists at Stanford and Purdue are correct in their findings, the whole theory of constant radioactive decay rates could be thrown out the door.

The story begins, as scientific discoveries often do, randomly. Literally, in this case. The team of physicists was investigating the possibility of using radioactive decay rates to generate random numbers, since the rate is constant but the emission of individual atoms is unpredictable, it seemed like a perfect fit.

Then came the problem:

As the researchers pored through published data on specific isotopes, they found disagreement in the measured decay rates – odd for supposed physical constants.

Checking data collected at Brookhaven National Laboratory on Long Island and the Federal Physical and Technical Institute in Germany, they came across something even more surprising: long-term observation of the decay rate of silicon-32 and radium-226 seemed to show a small seasonal variation. The decay rate was ever so slightly faster in winter than in summer.

Was this fluctuation real, or was it merely a glitch in the equipment used to measure the decay, induced by the change of seasons, with the accompanying changes in temperature and humidity?

As it turns out, they probably aren't.

After poring over the data, engineers and physicists noted a recurring pattern 33 days long that affected the decay rates of the various radioactive substances. That's a pattern that corresponds to the rotation of the Sun's core. Which got the physicists to thinking that maybe the sun was involved. But the only explanation that makes sense would be solar neutrinos -- which leads to a result that means, as one of the researchers observed, "What we're suggesting is that something that doesn't really interact with anything is changing something that can't be changed."

If it's not neutrinos, then it may be that the sun is emitting some other mystery particle heretofore unknown and unpredicted.

In the meantime, it remains to be seen how these findings will affect the use of radioactive decay in technological applications. For example, if radioactive decay isn't constant, then adjustments will have to be made for its use in dating materials, especially in the case of Carbon-14 dating. And doctors may need to look into adjusting radiation doses for cancer therapies, as they are, in part, based on radioactive decay rates.

This finding is just one more reason why I love reading about physics. Just when you think you're starting to get a handle on the universe, the universe lets you know that reality is stranger than you thought.

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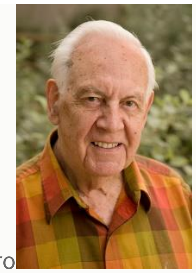
The strange case of solar flares and radioactive elements (stanford.edu)
https://news.stanford.edu/news/2010/august/sun-082310.html

Stanford Report, August 23, 2010

The strange case of solar flares and radioactive elements

When researchers found an unusual linkage between solar flares and the inner life of radioactive elements on Earth, it touched off a scientific detective investigation that could end up protecting the lives of space-walking astronauts and maybe rewriting some of the assumptions of physics.

BY DAN STOBER

L.A. Cicero 

Peter Sturrock, professor emeritus of applied physics

It's a mystery that presented itself unexpectedly: The radioactive decay of some elements sitting quietly in laboratories on Earth seemed to be influenced by activities inside the sun, 93 million miles away.

Is this possible?

Researchers from Stanford and Purdue University believe it is. But their explanation of how it happens opens the door to yet another mystery.

There is even an outside chance that this unexpected effect is brought about by a previously unknown particle emitted by the sun. "That would be truly remarkable," said Peter Sturrock, Stanford professor emeritus of applied physics and an expert on the inner workings of the sun.

The story begins, in a sense, in classrooms around the world, where students are taught that the rate of decay of a specific radioactive material is a constant. This concept is relied upon, for example, when anthropologists use carbon-14 to date ancient artifacts and when doctors determine the proper dose of radioactivity to treat a cancer patient.

Random numbers

But that assumption was challenged in an unexpected way by a group of researchers from Purdue University who at the time were more interested in random numbers than nuclear decay. (Scientists use long strings of random numbers for a variety of calculations, but they are difficult to produce, since the process used to produce the numbers has an influence on the outcome.)

Ephraim Fischbach, a physics professor at Purdue, was looking into the rate of radioactive decay of several isotopes as a possible source of random numbers generated without any human input. (A lump of radioactive cesium-137, for example, may decay at a steady rate overall, but individual atoms within the lump will decay in an unpredictable, random pattern. Thus the timing of the random ticks of a Geiger counter placed near the cesium might be used to generate random numbers.)

As the researchers pored through published data on specific isotopes, they found disagreement in the measured decay rates – odd for supposed physical constants.

Checking data collected at Brookhaven National Laboratory on Long Island and the Federal Physical and Technical Institute in Germany, they came across something even more surprising: long-term observation of the decay rate of silicon-32 and radium-226 seemed to show a small seasonal variation. The decay rate was ever so slightly faster in winter than in summer.

Was this fluctuation real, or was it merely a glitch in the equipment used to measure the decay, induced by the change of seasons, with the accompanying changes in temperature and humidity?

"Everyone thought it must be due to experimental mistakes, because we're all brought up to believe that decay rates are constant," Sturrock said.

The sun speaks

On Dec 13, 2006, the sun itself provided a crucial clue, when a solar flare sent a stream of particles and radiation toward Earth. Purdue nuclear engineer Jere Jenkins, while measuring the decay rate of manganese-54, a short-lived isotope used in medical diagnostics, noticed that the rate dropped slightly during the flare, a decrease that started about a day and a half *before* the flare.

If this apparent relationship between flares and decay rates proves true, it could lead to a method of predicting solar flares prior to their occurrence, which could help prevent damage to satellites and electric grids, as well as save the lives of astronauts in space.

The decay-rate aberrations that Jenkins noticed occurred during the middle of the night in Indiana – meaning that something produced by the sun had traveled all the way through the Earth to reach Jenkins' detectors. What could the flare send forth that could have such an effect?

Jenkins and Fischbach guessed that the culprits in this bit of decay-rate mischief were probably solar neutrinos, the almost weightless particles famous for flying at almost the speed of light through the physical world – humans, rocks, oceans or planets – with virtually no interaction with anything.

Then, in a series of papers published in *Astroparticle Physics*, *Nuclear Instruments and Methods in Physics Research* and *Space Science Reviews*, Jenkins, Fischbach and their colleagues showed that the observed variations in decay rates were highly unlikely to have come from environmental influences on the detection systems.

Reason for suspicion

Their findings strengthened the argument that the strange swings in decay rates were caused by neutrinos from the sun. The swings seemed to be in synch with the Earth's elliptical orbit, with the decay rates oscillating as the Earth came closer to the sun (where it would be exposed to more neutrinos) and then moving away.

So there was good reason to suspect the sun, but could it be proved?

Enter Peter Sturrock, Stanford professor emeritus of applied physics and an expert on the inner workings of the sun. While on a visit to the National Solar Observatory in Arizona, Sturrock was handed copies of the scientific journal articles written by the Purdue researchers.

Sturrock knew from long experience that the intensity of the barrage of neutrinos the sun continuously sends racing toward Earth varies on a regular basis as the sun itself revolves and shows a different face, like a slower version of the revolving light on a police car. His advice to Purdue: Look for evidence that the changes in radioactive decay on Earth vary with the rotation of the sun. "That's what I suggested. And that's what we have done."

A surprise

Going back to take another look at the decay data from the Brookhaven lab, the researchers found a recurring pattern of 33 days. It was a bit of a surprise, given that most solar observations show a pattern of about 28 days – the rotation rate of the surface of the sun.

The explanation? The core of the sun – where nuclear reactions produce neutrinos – apparently spins more slowly than the surface we see. "It may seem counter-intuitive, but it looks as if the core rotates more slowly than the rest of the sun," Sturrock said.

All of the evidence points toward a conclusion that the sun is "communicating" with radioactive isotopes on Earth, said Fischbach.

But there's one rather large question left unanswered. No one knows how neutrinos could interact with radioactive materials to change their rate of decay.

"It doesn't make sense according to conventional ideas," Fischbach said. Jenkins whimsically added, "What we're suggesting is that something that doesn't really interact with anything is changing something that can't be changed."

"It's an effect that no one yet understands," agreed Sturrock. "Theorists are starting to say, 'What's going on?' But that's what the evidence points to. It's a challenge for the physicists and a challenge for the solar people too."

If the mystery particle is not a neutrino, "It would have to be something we don't know about, an unknown particle that is also emitted by the sun and has this effect, and that would be even more remarkable," Sturrock said.

Chantal Jolagh, a science-writing intern at the Stanford News Service, contributed to this story.