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## Purdue-Stanford team finds radioactive decay rates vary with the sun's rotation

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WEST LAFAYETTE, Ind. - Radioactive decay rates, thought to be unique physical constants and counted on in such fields as medicine and anthropology, may be more variable than once thought.

A team of scientists from Purdue and Stanford universities has found that the decay of radioactive isotopes fluctuates in synch with the rotation of the sun's core.

The fluctuations appear to be very small but could lead to predictive tools for solar flares and may have an impact on medical radiation treatments.

This adds to evidence of swings in decay rates in response to solar activity and the distance between the Earth and the sun that Purdue researchers Ephraim Fischbach, a professor of physics, and Jere Jenkins, a nuclear engineer, have been gathering for the last four years. The Purdue team previously reported observing a drop in the rate of decay that began a day and half before and peaked during the December 2006 solar flare and an annual fluctuation that appeared to be based on the Earth's orbit of, and changing distance from, the sun, Jenkins said.

"If the relationship between solar activity and decay rates proves to be true, it could lead to a method of predicting solar flares, which could help prevent damage to satellites and electric grids, as well as save the lives of astronauts in space," Jenkins said. "Finding that the decay rates fluctuate in a pattern that matches known and theoretical solar frequencies is compelling evidence for a solar influence on decay rates."

Jenkins and Fischbach collaborated with Peter Sturrock, a professor emeritus of applied physics at Stanford University and an expert on the inner workings of the sun, to examine data collected at Brookhaven National Laboratory on the rate of decay of the radioactive isotopes silicon-32 and chlorine-36. The team reported in the journal *Astroparticle Physics* that the decay rate for both isotopes varies in a 33-day recurring pattern, which they attribute to the rotation rate of the sun's core.

In general, the fluctuations that Jenkins and Fischbach 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.

The team has not yet examined isotopes used in medical radiation treatments or for dating of ancient artifacts.

"The fluctuations we're seeing are fractions of a percent and are not likely to radically alter any major anthropological findings," Fischbach said. "One of our next steps is to look into the isotopes used medically to see if there are any variations that would lead to overdosing or underdosing in radiation treatments, but there is no cause for alarm at this point. What is key here is that what was thought to be a constant actually varies and we've discovered a periodic oscillation where there shouldn't be one."

Jenkins and Fischbach suggest that the changes in the decay rates are due to interactions with solar neutrinos, nearly weightless particles created by nuclear reactions within the sun's core that travel almost at the speed of light.

It is estimated that about 60 billion solar neutrinos pass through a person's fingernail every second, but they are so weakly reactive that they pass right through the body without disturbing or changing anything, Jenkins said.

"We haven't known the solar neutrino to interact significantly with anything, but it fits with the evidence we've gathered as the likely source of these fluctuations," he said. "So, what we're suggesting is that something that can't interact with anything is changing something that can't be changed."

The Purdue team has ruled out the possibility of experimental error or an environmental influence on the detection systems that track the rate of decay as being responsible for the fluctuations and published a series of papers in the journals *Astroparticle Physics*, *Nuclear Instruments and Methods in Physics Research*, and *Space Science Reviews*.

Sturrock said it is an effect that no one yet understands and that if it is not neutrinos that are responsible, then perhaps there is an unknown particle interacting with the atoms.

"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," he said.

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## ABSTRACT

### Power Spectrum Analysis of BNL Decay Rate Data

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Evidence for an anomalous annual periodicity in certain nuclear decay data has led to speculation concerning a possible solar influence on nuclear processes. As a test of this hypothesis, we here search for evidence in decay data that might be indicative of a process involving solar rotation, focusing on data for  $^{32}\text{Si}$  and  $^{36}\text{Cl}$  decay rates acquired at the Brookhaven National Laboratory. Examination of the power spectrum over a range of frequencies ( $10\text{--}15\text{ year}^{-1}$ ) appropriate for solar synodic rotation rates reveals several periodicities, the most prominent being one at  $11.18\text{ year}^{-1}$  with power 20.76. We evaluate the significance of this peak in terms of the false-alarm probability, by means of the shuffle test, and also by means of a new test (the "shake" test) that involves small random time displacements. The last two tests are the more robust, and indicate that the peak at  $11.18\text{ year}^{-1}$  would arise by chance only once out of about 107 trials. However, the fact that there are several peaks in the rotational search band suggests that modulation of the count rate involves several low-Q oscillations rather than a single high-Q oscillation, possibly indicative of a partly stochastic process. To pursue this possibility, we investigate the running-mean of the power spectrum, and identify a major peak at  $11.93\text{ year}^{-1}$  with peak running mean power 4.08. Application of the shuffle test indicates that there is less than one chance in 1011 of finding by chance a value as large as 4.08. Application of the shake test leads to a more restrictive result that there is less than one chance in 1015 of finding by chance a value as large as 4.08. We find that there is notable agreement in the running-mean power spectra in the rotational search band formed from BNL data and from ACRIM total solar irradiance data. 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 recent conjecture that solar neutrinos may be responsible for

variations in nuclear decay rates. We also carry out a similar comparison with local temperature measurements, but find no similarity between power spectra formed from BNL measurements and from local temperature measurements.