New system could predict solar flares, give advance warning

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(Phys.org) -- Researchers may have discovered a new method to predict solar flares more than a day before they occur, providing advance warning to help protect satellites, power grids and astronauts from potentially dangerous radiation.

The system works by measuring differences in gamma radiation emitted when atoms in radioactive elements "decay," or lose energy. This rate of decay is widely believed to be constant, but recent findings challenge that long-accepted rule.

The new detection technique is based on a hypothesis that radioactive decay rates are influenced by solar activity, possibly streams of subatomic particles called solar neutrinos. This influence can wax and wane due to seasonal changes in the Earth's distance from the sun and also during solar flares, according to the hypothesis, which is supported with data published in a dozen research papers since it was proposed in 2006, said Ephraim Fischbach, a Purdue University professor of physics.

Fischbach and Jere Jenkins, a nuclear engineer and director of radiation laboratories in the School of Nuclear Engineering, are leading research to study the phenomenon and possibly develop a new warning system. Jenkins, monitoring a detector in his lab in 2006, discovered that the decay rate of a radioactive sample changed slightly beginning 39 hours before a large solar flare.

Since then, researchers have been examining similar variation in decay rates before solar flares, as well as those resulting from Earth's orbit around the sun and changes in solar rotation and activity. The new findings appeared online last week in the journal Astroparticle Physics.

"It's the first time the same isotope has been used in two different experiments at two different labs, and it showed basically the same effect," Fischbach said. The paper was authored by Jenkins and Fischbach; Ohio State University researchers Kevin R. Herminghuysen, Thomas E. Blue, Andrew C. Kauffman and Joseph W. Talnagi; U.S. Air Force researcher Daniel Javorsek; Mayo Clinic researcher Daniel W. Mundy; and Stanford University researcher Peter A. Sturrock.

Data were recorded during routine weekly calibration of an instrument used for radiological safety at Ohio State's research reactor. Findings showed a clear annual variation in the decay rate of a radioactive isotope called chlorine 36, with the highest rate in January and February and the lowest rate in July and August, over a period from July 2005 to June 2011.

The new observations support previous work by Jenkins and Fischbach to develop a method for predicting solar flares. Advance warning could allow satellite and power grid operators to take steps to minimize impact and astronauts to shield themselves from potentially lethal radiation emitted during solar storms.

The findings agree with data previously collected at the Brookhaven National Laboratory regarding the decay rate of chlorine 36; changes in the decay rate were found to match changes in the Earth-sun distance and Earth's exposure to different parts of the sun itself, Fischbach said.

Large solar flares may produce a "coronal mass ejection" of highly energetic particles, which can interact with the Earth's magnetosphere, triggering geomagnetic storms that sometimes knock out power. The sun's activity is expected to peak over the next year or so as part of an 11-year cycle that could bring strong solar storms.

Solar storms can be especially devastating if the flare happens to be aimed at the Earth, hitting the planet directly with powerful charged particles. A huge solar storm, called the Carrington event, hit the Earth in 1859, a time when the only electrical infrastructure consisted of telegraph lines.

"There was so much energy from this solar storm that the telegraph wires were seen glowing and the aurora borealis appeared as far south as Cuba," Fischbach said. "Because we now have a sophisticated infrastructure of satellites, power grids and all sort of electronic systems, a storm of this magnitude today would be catastrophic. Having a day and a half warning could be really helpful in averting the worst damage."

Satellites, for example, might be designed so that they could be temporarily shut down and power grids might similarly be safeguarded before the storm arrived.

Researchers have recorded data during 10 solar flares since 2006, seeing the same pattern.

"We have repeatedly seen a precursor signal preceding a solar flare," Fischbach said. "We think this has predictive value."

The Purdue experimental setup consists of a radioactive source - manganese 54 - and a gamma-radiation detector. As the manganese 54 decays, it turns into chromium 54, emitting a gamma ray, which is recorded by the detector to measure the decay rate.

Purdue has filed a U.S. patent application for the concept.

Research findings show evidence that the phenomenon is influenced by the Earth's distance from the sun; for example, decay rates are different in January and July, when the Earth is closest and farthest from the sun, respectively.

"When the Earth is farther away, we have fewer solar neutrinos and the decay rate is a little slower," Jenkins said. "When we are closer, there are more neutrinos, and the decay a little faster."

Researchers also have recorded both increases and decreases in decay rates during solar storms.

"What this is telling us is that the sun does influence radioactive decay," Fischbach said.

Neutrinos have the least mass of any known subatomic particle, yet it is plausible that they are somehow affecting the decay rate, he said.

English physicist Ernest Rutherford, known as the father of nuclear physics, in the 1930s conducted experiments indicating the radioactive decay rate is constant, meaning it cannot be altered by external influences.

"Since neutrinos have essentially no mass or charge, the idea that they could be interacting with anything is foreign to physics," Jenkins said. "So, we are saying something that doesn't interact with anything is changing something that can't be changed. Either neutrinos are affecting decay rate or perhaps an unknown particle is."

Jenkins discovered the effect by chance in 2006, when he was watching television coverage of astronauts spacewalking at the International Space Station. A solar flare had erupted and was thought to possibly pose a threat to the astronauts. He decided to check his equipment and discovered that a change in decay-rate had preceded the solar flare.

Further research is needed to confirm the findings and to expand the work using more sensitive equipment, he said.

Jenkins and Fischbach have previously 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 on the decay rate of radioactive isotopes silicon-32 and chlorine-36. The team reported in 2010 in 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.

The group found evidence of the same annual and 33-day effect in radium-226 data taken at the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, Germany, and those findings were published in 2011. They also found an additional 154-day recurring pattern in both the Brookhaven and PTB data, published in 2011, which they believe to be solar related and similar to a known solar effect called a Rieger periodicity.

More information: Additional Experimental Evidence for a Solar Influence on Nuclear Decay Rates, www.sciencedirect.com/science/ … 927650512001442?v=s5

Abstract
Additional experimental evidence is presented in support of the recent hypothesis that a possible solar influence could explain fluctuations observed in the measured decay rates of some isotopes. These data were obtained during routine weekly calibrations of an instrument used for radiological safety at the Ohio State University Research Reactor using 36Cl. The detector system used was based on a Geiger-Müller gas detector, which is a robust detector system with very low susceptibility

to environmental changes. A clear annual variation is evident in the data, with a maximum relative count rate observed in January/February, and a minimum relative count rate observed in July/August, for seven successive years from July 2005 to June 2011. This annual variation is not likely to have arisen from changes in the detector surroundings, as we show here.

Provided by Purdue University

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