Elusive patterns seen in solar neutrino data

For 20 years, a detector deep in the Homestake gold mine near Lead, S.D., has recorded the arrival of neutrinos apparently produced by thermonuclear reactions at the sun's core. Three new analyses of the accumulated data now reveal that month-to-month and year-to-year variations in the number of neutrinos detected show intriguing correlations with changes in solar activity.

Because neutrinos are the only known particles that reach Earth directly from the sun's core, they provide a unique window on the sun's inner workings. By establishing correlations between neutrino detection and solar phenomena, researchers hope to obtain a more complete picture of solar activity, enabling them to test theoretical explanations for why the number of solar neutrinos detected on Earth falls short of the sun's predicted rate of neutrino production.

Reporting in the Nov. 29 NATURE, Todor Stanev of the University of Delaware in Newark and his colleagues describe a "strong" correlation between the neutrino detection rate and the monthly sunspot number. Their statistical analysis indicates that the detection rate decreases as the number of sunspots increases (SN: 4/21/90, p.245).

In the same issue, Lawrence M. Krauss of Yale University reports an apparent link between the number of neutrinos detected and small shifts in the frequencies of certain types of solar oscillations. Previously, measurements made from 1977 into 1988 of the frequencies at which the sun's surface rises and falls had revealed that these frequencies increase slightly as the solar cycle shifts from a minimum to a maximum (SN: 7/7/90, p.7).

In a statistical analysis to appear in ASTROPHYSICAL JOURNAL, John N. Bahcall of the Institute for Advanced Study in Princeton, N.J., and William H. Press of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., also found significant patterns, similar to Stanev's, in the Homestake data. But their analysis reveals that only the last two-thirds of the data set show a clear time variation that may be connected with the solar cycle.

In addition, because the detection rate appears to follow a pattern that changes more smoothly and regularly than the actual sunspot count and tends to lag behind surface activity, Bahcall and Press postulate that the neutrino detection rate may be directly related not to sunspot number but to an unrecognized effect coupled to the solar cycle.

The significance of all these proposed correlations remains unclear. "There's a consistent view that there's something statistically very peculiar going on," Press says. "But people have different ideas about what it all means."

And statistical analyses are fraught with uncertainties. "Searching for correlations between any *a priori* unrelated phenomena can be both subtle and dangerous," Krauss warns in the introduction to his paper.

One key problem is the paucity of data. "We're stuck with the fact that all the [neutrino detection] experiments have low counting rates," says Kenneth Lande of the University of Pennsylvania in Philadelphia.

"You can get a number for the average rate over many years, but if you want to get time variations or correlations with sunspots or anything else, you need a much higher counting rate. Until we build better detectors with higher counting rates, we're stuck with large uncertainties in the statistics."

Moreover, recent results from the Kamiokande detector in Japan and ambiguous preliminary data from the Soviet-American gallium experiment in the Soviet Union provide little help in solving the solar-neutrino puzzle (SN: 9/1/90, p.141).

"Right now, it's a puzzle with no single good answer because at least two unlikely things have to happen to make it work out," Press says. "In other words, any explanation that I can think of requires two coincidences, and that seems one too many for me." *– I. Peterson*

Satellite secrecy doesn't sink scientists

The U.S. Department of Defense last March began "degrading" information coming down from its Global Positioning System (GPS), a network of precise navigational satellites. The long-expected change – which involves adding bogus data to prevent exploitation by unauthorized users such as enemy forces – worried many scientists who rely on the satellite signals for hints of impending earthquakes and volcanic eruptions, among other types of information.

Now, after months of working with the degraded data, scientists say they can largely sidestep the problem, although some worry about Defense Department plans for tinkering further with GPS signals.

At this week's meeting of the American Geophysical Union in San Francisco, geoscientists debated the research ramifications of the recent change. Thomas P. Yunck of NASA's Jet Propulsion Laboratory in Pasadena, Calif., maintains that "the effect on precise scientific users ranges from zero to a minor inconvenience." But other researchers contend that GPS signals have become more difficult to interpret.

The U.S. military created the GPS network in the late 1970s to provide instantaneous and accurate navigational information for its troops, ships and missiles. Scientists soon realized they could use the signals to gauge distances on Earth with extraordinarily high precision. Because the GPS can measure the distance between two points 1,000 kilometers apart with an accuracy of better than 1 centimeter, it has enabled geoscientists to monitor subtle warpings of the crust along the San Andreas fault. The military satellites have also provided navigational guidance for commercial ships, and in the future could allow aviation engineers to outfit commercial planes with automated landing systems.

After several brief experimental periods, the Defense Department activated its data-degrading system, called selective availability (SA), on a full-time basis in March. SA inserts false information about the orbits and the precise timing systems used by each GPS satellite. Ironically, officials had to turn SA off after the Iraqi invasion of Kuwait in August because U.S. troops in Saudi Arabia do not carry receivers capable of correcting the altered signals.

Unlike navigators, who use the GPS to fix their location, geophysicists circumvent many of the problems associated with SA because they instead measure distances between two points, each with its own receiver. But some geophysicists say they have had difficulty using combinations of old-style and new receivers, which do not detect the GPS signals at exactly the same time. Kurt L. Feigl of the Massachusetts Institute of Technology reports that SA reduced measurement precision by 10 to 50 percent in experiments using a combination of newer and older receivers.

Even with synchronized receivers, some investigators have found they must spend two to three times as long analyzing the satellite information in order to weed out the bogus data. "It's made life more difficult for us," says Yehuda Bock of the Scripps Institution of Oceanography in La Jolla, Calif.

Yunck, on the other hand, asserts that "with the techniques we use [at the Jet Propulsion Laboratory], it doesn't take any longer to edit the data [with SA on]."

Many geophysicists voice concern over the Defense Department's plan to degrade other parts of the GPS signal through a process known as anti-spoofing. Air Force Lt. Col. Jules G. McNeff told scientists at this week's meeting that the Pentagon will activate anti-spoofing by 1993. Yunck acknowledges that the program will make it more difficult to process GPS data, but he contends that researchers with sophisticated receivers and editing programs can nonetheless maintain their current precision levels.
– R. Monastersky