Added Noise Keeps Waves Going

Usually a nuisance, noise sometimes aids the transmission of a signal.

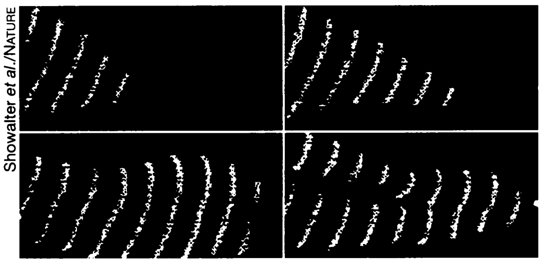
Researchers have now demonstrated in the laboratory that random fluctuations in the concentration of a chemical across a surface can enhance the propagation of waves of another chemical's activity in a thin gel. "Noise actually helps," says chemist Kenneth Showalter of West Virginia University in Morgantown.

Showalter and his coworkers Sándor Kádár and Jichang Wang report their results in the Feb. 19 NATURE.

The observation of enhanced wave propagation in a chemical medium represents a new avenue in the study of a phenomenon called stochastic resonance (SN: 2/23/91, p. 127), in which the addition of noise can boost a weak signal to detectable levels.

"This is the first experimental demonstration of stochastic resonance that occurs in a system spread over a surface [and changing with time]," says Frank Moss of the Center for Neurodynamics at the University of Missouri-St. Louis. The findings also provide a model of how internal noise may sustain long-range chemical waves in networks of brain cells (SN: 11/23/96, p. 330).

Showalter and his coworkers studied a photosensitive version of a chemical system known as the Belousov-Zhabotinsky reaction, in which rising and falling chemical concentrations appear as visible waves traveling through a thin layer of silica gel. Shining light on the gel produces a chemical that quenches wave propagation.



Sequence of images showing the influence of noise—in the form of a speckled pattern of varying light intensity illuminating a surface—on the propagation of waves in a specially prepared silica gel. At low noise levels, the wave dies out (top left and right). An optimal amount of noise facilitates wave propagation (bottom left), whereas excessive noise causes the wave to break up (bottom right).

The researchers initially adjusted the light intensity to suppress wave activity. They then replaced that uniform illumination with a grid in which intensity varied from cell to cell and from time to time in each cell, yet maintained an average intensity across the grid that inhibited activity.

By increasing the amplitude of the random fluctuations, "you get qualitative changes in the wave behavior," Showalter says. "As the [optical] noise increases, the wave propagates farther and farther [along] the medium until there is sustained wave propagation." Eventually, however, the noise overwhelms the system and the waves break up.

The waves represent a kind of order that emerges out of the background of flickering light and reaches a maximum at a particular level of noise, Moss remarks.

Moss and his collaborators have detected a similar phenomenon in networks of glial cells, which fill the spaces between neurons in the brain. The researchers studied the passage of waves of calcium ions from cell to cell in cultured glia under the influence of local fluctuations in the concentration of a neurotransmitter. Where the concentration of the neurotransmitter reaches a threshold, calcium waves begin to form, Moss says.

Moss, Peter Jung of Ohio University in Athens, Ann Cornell-Bell of Viatech Imaging in Ivoryton, Conn., and Kathleen S. Madden of the Foundation for International Nonlinear Dynamics in Bethesda, Md., describe their results in the February JOURNAL OF NEUROPHYSIOLOGY.

"There seems to be a definite link between our chemical system and this network of brain cells," Showalter says. "Calcium waves could represent some sort of long-range, noise-mediated signaling in brain tissue." —*I. Peterson*

Icy signs of warming emerge in Arctic

Satellite measurements of Arctic sea ice reveal evidence of increased melting since 1979 in the far north—the strongest sign yet that temperatures are climbing across the region.

"There has definitely been a warming and it's been a large-scale one, but we can't say whether it will continue," says Douglas M. Smith of the United Kingdom Meteorological Office in Bracknell. He reports his findings in the Feb. 15 GEOPHYSICAL RESEARCH LETTERS.

Sea ice, which can reach a thickness of 4 meters or more, forms when temperatures drop enough for the surface of the ocean to freeze. A blanket of permanent ice covers the central Arctic Ocean year round, but the surface layer melts during summer and refreezes in winter. Climate researchers are watching sea ice closely because they regard it as a bellwether of greenhouse warming—and one that may sound an alarm before changes in the rest of the globe grow obvious.

Annual surface melting shows up clearly in satellite recordings taken by microwave-sensing instruments, says Smith. When the top of the ice gets moist, it emits more microwave radiation than unmelted sea ice.

Smith exploits these signals to look for changes in the length of the summer melt season.

From 1979 through 1996, summer melting has gradually begun somewhat earlier in the year and autumn freezing somewhat later, he has found. Overall, the period each summer during which melting occurs has increased at the rate of 5.3 days per decade.

The findings corroborate other satellite studies of the Arctic's periphery, which show a decline in the area of ocean covered by sea ice. Researchers have treated such measurements with caution because the data are sensitive to subtle degradations in the satellite sensors. This so-called instrumental drift could introduce artificial trends into the satellite readings.

The changes in the sensors do not significantly skew the estimates of melting, however, so the new measurements offer the clearest sign so far of warming in the Arctic, says Smith.

"This is an important addition to the other studies," says Claire Parkinson, a climatologist who investigates sea ice at NASA's Goddard Space Flight Center in Greenbelt, Md. "His results, which avoid the instrument drift issue, help confirm the other results where people have had to worry about instrument drift."

It is difficult to draw conclusions about the future from such a short period of measurements, says Smith. His findings are consistent with the theory that greenhouse gases are warming the planet, but they may also reflect natural cycles in the Arctic climate.

Since 1991, he notes, the number of days with melting has actually decreased, indicating a cooling over this span. One explanation is that sunlight-blocking sulfur from the eruption of Mount Pinatubo in 1991 temporarily halted the greenhouse warming trend in the Arctic, says Smith. Another possibility is that a natural warming cycle peaked in the late 1980s and has since given way to a cooling cycle in the north. —*R. Monastersky*