Physical Science

Ivars Peterson reports from Arlington, Va., at the 2nd Experimental Chaos Conference

Chaotic flashes of bubble-light

It sounds more like magic than physics: Sound waves traveling through water momentarily compress an air bubble to produce a brief, bright flash of light—one flash with each cycle of the sound wave. Researchers have known about this phenomenon, called sonoluminescence, for more than 50 years, but they have yet to come up with a complete, convincing explanation of how the temporary collapse of a bubble can concentrate the energy of a sound wave more than a trillion times and excite atoms and molecules into producing light (SN: 5/11/91, p.292).

Generally, these flashes occur at a specific sound wave frequency and pressure for a given bubble diameter, and researchers have found they can generate an extremely steady train of flashes under these conditions. Now R. Glynn Holt of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and his co-workers have probed the effect of slightly shifting the sound wave frequency and pressure away from their optimal values for producing flashes. They observed changes in the timing of the flashes, suggesting that acoustically driven bubble collapse may involve chaotic dynamics.

Holt and his colleagues studied this effect by using a special electrical circuit to measure slight variations in the timing of the flashes coming from a single bubble. They discovered that by altering the sound wave frequency and pressure appropriately, they could produce a pattern of flashes in which every second flash was slightly delayed. For other values of frequency and pressure, they observed timing delays that appeared to vary randomly. "We believe we have chaos going on here," Holt says.

Holt and his colleagues argue that bubble-wall motion by itself is insufficient to produce the observed effects. By studying how timing variations depend on pressure and frequency, researchers may have a better chance of pinning down the mechanism responsible for sonoluminescence.

Noisy messages for crayfish

The addition of a certain level of noise — any randomly varying sound or other signal—can sometimes make it easier to detect a weak, information-carrying signal. Although the overall level of noise in the detector rises, the intensity of the meaningful signal goes up even more. Researchers call this effect stochastic resonance (SN: 2/23/91, p.127). First demonstrated in electronic circuits, this effect may also play an important role in biological settings (SN: 8/31/91, p.143).

Frank Moss and his colleagues at the University of Missouri at St. Louis have now shown that an optimal level of external noise can indeed enhance weak signals traveling along individual sensory neurons in a crayfish. These particular neurons convert small motions of tiny hair cells situated on the tail of the red swamp crayfish into electrical pulses. The researchers worked with intact, excised hair cells, each one mounted on a little post that could be moved back and forth through a liquid. An electronic-noise generator coupled with a source of periodic signals controlled the post's movements.

"Crayfish live in an incredibly noisy environment," Moss notes. And they have to be able to sort out from this clamor of background sounds the approach of such predators as largemouth bass, which arrive with rapidly wiggling tails. "This is the kind of thing we were trying to mimic, but in a very controlled sort of way," he says.