Bubble Light in the Blink of an Eye

Like a miniature lighthouse beacon, an oscillating gas bubble driven by sound waves can emit a remarkably steady stream of light flashes. Immersed in a liquid, the bubble extracts energy from the surrounding sound field, concentrating this energy more than a trillion times to generate light.

Researchers have now determined that each light flash lasts less than 100 picoseconds, a time interval considerably shorter than the duration of a sound-wave cycle. "This is a spectacular phenomenon," says physicist Seth Putterman of the University of California, Los Angeles, who led the team that established this upper limit. Putterman described his group's findings at last week's meeting in Baltimore of the Acoustical Society of America.

"What we're talking about is the turning on of a switch very quickly," says chemist Kenneth S. Suslick of the University of Illinois at Urbana-Champaign. He compares the bubble's surprising performance to the influence of ocean waves rocking a rowboat sufficiently to toss a passenger up into the air. An oscillating bubble focuses energy so effectively and imparts such a sharp jolt that an analogous rowboat passenger would shoot into the air with the speed of a jet aircraft, then instantly drop back down, in which time the wave would barely crest. "The effect is at least 10,000 times faster than one would naively expect," Suslick says.

Researchers have known about sonoluminescence — the conversion of sound energy into light by acoustically driven gas bubbles — for more than 50 years. Although readily observed, the phenomenon was for a long time poorly understood.

The recent development of a technique for observing the oscillations of a single bubble has helped provide new insights into bubble dynamics. Pioneered by D. Felipe Gaitan and Lawrence A. Crum of the University of Mississippi in Oxford, the technique clearly established that light emission occurs at the moment a bubble collapses to its smallest size. Moreover, the bubble light blinks on and off in synchrony with the sound field.

"The bubble will just sit there for hours or days and stably turn on and off for reasons no one can yet explain," Crum says.

Using a similar approach, Putterman and his co-workers observed light emission from a single nitrogen bubble trapped by a 20-kilohertz sound field in a mixture of water and glycerine. Their goal was to determine how much time it takes the light pulse to build up, how long it is on, how it turns off, and what it looks like. "We wanted to measure the footprint of the pulse," Putterman says.

From this and related work, a picture emerges of a bubble that absorbs sound energy as it expands to a radius of roughly 100 microns. Then the bubble shrinks to a radius of just a few microns, in the process somehow delivering much of its energy of collapse to a small number of atoms or molecules enclosed in the bubble. These atoms become excited and radiate a very short pulse of light, consisting of about one million photons.

"The amazing thing is that once the implosion occurs, it doesn't destroy the bubble," Putterman says. "The bubble goes back for another helping." Indeed, the bubble "bounces" — expanding again, then shrinking — three or four times during each sound-wave cycle. Because a bubble emits light only on the largest of the bounces during each cycle, the light flashes appear synchronized with the frequency of the sound waves.

The question of exactly what happens during the bubble's collapsed phase remains unresolved. Some researchers suspect that the bubble's collapse causes intense local heating, which initiates chemical reactions that produce light (SN: 10/10/87, p.229). Suslick's investigations of light emissions from hydrocarbon-containing gas bubbles reveal a spectrum of light similar to that responsible for the blue color of flames.

From such spectra, Suslick has deduced that sonoluminescence occurs at 5,000 kelvins, close to the temperature at the sun's surface. "This is the first direct determination of the temperature of sonoluminescence," Suslick says.

But the extremely brief time during which a collapsed bubble emits light sets strict limits on how much heating and mixing can occur during the process. If Putterman and his co-workers manage to refine their measurements further and find that light emission actually occurs in just 10 picoseconds or less, then conventional explanations of how this energy transfer occurs may need to be drastically revised. — *I. Peterson*

New clues to origins of Down's syndrome

Older mothers are known to face a greater risk than younger women of giving birth to a baby with Down's syndrome, a genetic disorder characterized by mental retardation. But researchers have not been able to explain why. A new study of 158 families with children affected by Down's now supports one contending theory — that older women are more likely to carry a Down's baby to term.

Human geneticist Stylianos E. Antonarakis of Johns Hopkins University in Baltimore headed an international team of 18 other researchers that determined the extra chromosome responsible for Down's is incorporated more often during the first of the human egg's two stages of meiotic development. Both younger and older women were equally likely to have a chromosome error in the first stage, regardless of their age, the researchers reported last week at a meeting of the American Pediatric Society and Society for Pediatric Research in New Orleans.

The team used DNA tags to trace the origin of the extra chromosome-21 in the Down's children. They found, as expected from their previous studies, that 95 percent of the extra chromosomes came from the mother and only 5 percent from the father. When they traced further, they found that three-fourths of all maternal chromosome errors resulted from the first stage of meiosis, the cell division process that halves the genetic content of eggs and sperm so that children don't get double the proper number of genes.

Although the results are difficult to interpret, Antonarakis says, "what was surprising was that we didn't see a difference in maternal age according to the stage of meiosis where the chromosome error occurs." If mothers of all ages have similar chromosome errors leading to Down's, he reasons, older mothers might have more Down's babies because their bodies fail to recognize an egg with an extra chromosome as abnormal. In other words, "It's possible that older mothers could carry a Down's baby to birth better," he told SCIENCE NEWS.

But Antonarakis cautions that his group did not study tissue from fetuses spontaneously aborted by the women, to see if younger mothers were more likely to miscarry a Down's child than older mothers. "It's possible that in aborted fetuses there is a stronger correlation between maternal age and the stage of meiosis leading to Down's," he says.

David H. Ledbetter, a geneticist from the Baylor College of Medicine in Houston, agrees that further studies will be needed to confirm that younger women are more likely to miscarry Down's babies. "The only way to directly test it would be to compare the ages of women who have children with Down's syndrome and those who spontaneously abort Down's syndrome fetuses," he says. — *C. Ezzell*