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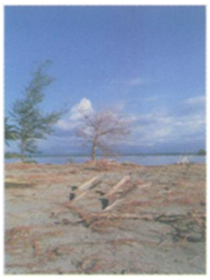
This Week

Articles

Research Notes

Departments



Cover: On July 17, one of the most deadly tsunamis of the century swept the north shore of Papua New Guinea, carrying away almost all traces of habitation from this beach. The four posts leaning in the foreground are all that remain of a house destroyed by the waves. In the background, a pail hangs in a tree, showing that water reached at least 7 meters above sea level. **Page 221** (Photo: Costas Synolakis)

Letters

Still more faces of entropy

"Another Face of Entropy" (SN: 8/15/98, p. 108) was the best explanation of entropy that I have ever read. I have always wondered if the compressed matter in a black hole is at a very low state of entropy. If so, could the creation and growth of very large numbers of black holes overcome the laws of thermodynamics?

Donald C. Wilfong
San Ramon, Calif.

Black holes actually contain the most entropy possible in a given space, theorists say. Jacob Bekenstein and Steven Hawking concluded in the mid-1970s that the entropy of a black hole is proportional to the area of a disk surrounding it from within which matter or energy cannot escape. According to physicist Lee Smolin, in his book The Life of the Cosmos *(1997, Oxford University Press), a consequence of that finding is that the maximum entropy of a given region of space is the entropy of the largest black hole that can fit into it.*

—P. Weiss

In some entropic self-assembly experiments, virus particles were used; however, it is not stated that such particles carry electric charge. Thus, the result is not a pure entropy effect associated with the geometry and kinetics of the particles involved.

Frank Meno
Pittsburgh, Pa.

To minimize the influence of electrostatic forces among the viruses and other colloidal particles, experimenters add salts to their suspensions. Salt ions form clouds around each colloidal particle that cause the particles to appear neutrally charged within a limited range of distance from each other.

—P. Weiss

Have any of the "entropy force" researchers considered the implications of their work for cosmology? The "uniform" soup that cosmologists assume for the first instants of the universe is obviously a low-entropy, highly unstable situation. As soon as the first phase transition—the separation of photons and solid matter—occurs, entropy takes over. Photons, being smaller than the resultant helium atoms, will start shoving the atoms around until they coalesce and expand into the soap bubble structures we see in the universe today.

Tim LeGore
West Richland, Wash.

Would this view of entropy explain the self-organization of the early universe? It occurs to me that in the time between the inflation of the universe and the phase change when the energy density dropped to the point of transparency, the environment was perfect for the kind of "organization by entropy" that this article discusses. If the principles and behavior apply at the appropriate scale, then this phenomenon could provide the impetus to define the structure that we now see in the universe.

Letters continued on p. 217

CORRECTIONS

Due to a typesetting error, pages 180 to 183 of the September 19 issue were mislabeled September 12.

In "The Color of Honey" (SN: 9/12/98, p. 170), a milligram, not milliliter, of buckwheat honey contains 4.32×10^{-3} microequivalents of antioxidant activity.

Letters continued from p. 211

In fact, the timescale is sufficient for the creation of massive gravity wells. It may well be that entropy is responsible for organizing the structures, up to and including galaxies and galactic clusters, even before the "phase change" to a "transparent" universe. If this were the case, then there would be no need for any more esoteric mechanism to explain it.

William Lightner
Rogers, Ark.

Entropic forces similar to those that organize particles in colloidal suspensions most likely played little, if any, role in the organization of the early universe, physicists contend. The density of primordial particles was far too low to allow the constant jostling among particles that leads to entropy-driven order. Cosmologists also see no parallel between galaxy-galaxy collisions, in which galaxies typically mingle and deform, and the hard body versus hard body, purely repulsive encounters of entropy-ruled systems. At that galactic scale, they say gravity appears to be the dominant force.

—P. Weiss

How about entropy playing a role in the deposition of plaque in blood vessels? Could depletion forces contribute to this phenomenon?

Bob McClintock
Miami, Fla.

It occurred to me that the entropy experiments might provide another computational verification of the problem raised in "Cracking Kepler's sphere-packing problem" (SN: 8/15/98, p. 103). A large number of big balls and a larger number of small balls would be placed in a container. After allowing time for interaction, the packing of clusters of the big balls far from the container walls would simply be observed.

Several prerequisite questions would need to be answered to prove the approach viable. Does maximizing the restricted regions of overlap of the big balls equate to maximum entropy? Does maximizing those restricted regions equate to tightest packing of the big balls? And what experimental conditions allow the system to reach a global entropy maximum without getting stuck in some local maximum? I suspect that choosing ball sizes that guarantee no overlap of nearby restricted regions can help in answering yes to the first two questions.

Wendell Bishop
Somerville, Mass.

Chickadee choices

In "Chickadees sneak up the social ladder" (SN: 7/11/98, p. 27), self-selection and a desire to improve the breed may not be the controlling factors as the wayward female chickadee sneaks up the social ladder. She probably has no alternative. Males ranking below her spouse would be quite unwilling to mate and risk his wrath.

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Computers

Chaotic route to computation

Irregular fluctuations in light intensity have long plagued the operation of a wide variety of lasers. During the past decade, researchers have learned how to avoid, control, or exploit such chaotic outbursts by adjusting laser parameters, such as power input (SN: 2/22/92, p. 119). In effect, they can turn a dial to tune a laser's signal so that it flutters randomly, falls into a regular pattern, or remains steady.

Now, researchers have demonstrated in a simulation how a network of chaotic lasers could operate as a computer, adding or multiplying numbers and processing information. William L. Ditto of the Georgia Institute of Technology in Atlanta and Sudeshna Sinha of the Institute of Mathematical Sciences in Madras, India, describe their scheme in the Sept. 7 PHYSICAL REVIEW LETTERS.

The researchers use certain patterns of laser signals to encode different decimal digits, one digit per laser in the network. To perform an operation such as addition, they allow some of the fluctuating light to leak from one laser to another, setting off an avalanche of activity as the linked lasers react to multiple inputs from their neighbors. Ditto and Sinha show that after the system has settled down, the numerical answer is encoded in the network's final behavior pattern.

"There are lots of different ways to do the encoding," Ditto says. For example, "we can change the network connectivity or the chaotic system parameters."

Moreover, the chaotic elements don't have to be lasers. Any network of systems showing chaotic behavior—including electric circuits or nerve cells—will have comparable computational capabilities. "It's an entirely new computing paradigm," Ditto contends. Instead of precisely specifying every tiny step, a programmer simply sets the initial conditions and lets the system work out an answer in its own way.

Ditto and his coworkers plan to test their idea using chaotic ammonia lasers and, ultimately, a network of nerve cells attached to silicon. "This is a glimpse of how we can make common dynamic systems work for us in a way that's more like how we think the brain does computation," says Ditto. —*I.P.*

Factoring reaches new heights

A powerful computer takes just a few seconds to prove that a number consisting of 73 decimal digits is a prime, evenly divisible only by itself and one. In contrast, the same computer typically requires a much longer time to factor a 73-digit composite number into its prime-number components. Indeed, factoring numbers beyond about 130 digits has been impractical. This fortuitous circumstance underlies the widely used RSA method of encrypting digital information (SN: 5/7/94, p. 292).

Now, Herman te Riele and his coworkers at the National Research Institute for Mathematics and Computer Science (CWI) in Amsterdam report that they have factored a 186-digit number—the largest yet cracked—using a technique called the special number field sieve (SN: 5/31/97, p. 340). The number, $(2^{15}-135)^{41}-1$, turns out to have several factors, including a 73-digit prime and a 71-digit prime. The factorization required 88 computers running for 42 days.

The researchers soon expect to tackle the much tougher task of factoring a number consisting of a string of 512 ones and zeros. If they succeed, they would be able to decode secret messages created using one version of the RSA method. —*I.P.*