Physics

Ivars Peterson reports from Anaheim, Calif., at an American Physical Society meeting

Chaotic systems that stay in step

A chaotic system has such a high degree of unpredictability that it's hard to imagine how two identical but independent systems could ever be synchronized. For example, the wildly fluctuating voltages characteristic of chaotic electronic circuits could never stay in step. Even if both circuits started off under virtually the same conditions, the tiniest difference would quickly lead to voltage readings that don't match at all. But it may be possible to synchronize parts of certain chaotic systems, say Louis M. Pecora and Thomas L. Carroll of the Naval Research Laboratory in Washington, D.C. The trick is to link the two systems by passing a common signal between them in just the right way.

Pecora and Carroll start with a known chaotic system, in the form of either a set of mathematical equations or an electronic circuit. They divide the given system arbitrarily into two subsystems and make a duplicate of one of the subsystems. A signal from the original system replaces the missing section and drives the duplicated fragment.

Computer simulations show that under some conditions, the values of certain parameters evaluated for the truncated, duplicate system converge to the same values as evaluated for the other, even when they have different starting points. Experiments with electronic circuits produce similar results: The voltages fluctuate rapidly in both circuits but stay in step.

Pecora and Carroll have now identified specific criteria necessary for achieving synchronization, but many questions remain open. "There's lots to explore," Pecora says. "You can come up with many different possibilities."

The ability to design synchronized but chaotic systems could eventually lead to new schemes for encrypting messages to keep them secret. Already it is possible to conceive of having two remote systems that behave chaotically yet remain synchronized by way of a single linking signal. Pecora also suggests that the synchronization process may be a useful metaphor for some types of brain responses.

Bacteria, templates and gold islands

Sometimes it's handy to get nature to do some of the work for you, especially when the work involves the delicate task of creating regularly spaced, nanometer-sized holes in a thin metal film. The protein molecules that make up the outer wall of the bacterium *Sulfolobus acidocaldarius* assemble themselves into a two-dimensional layer with an array of holes that allow materials to pass in and out. When deposited on a smooth, graphite surface, such a protein layer (essentially a two-dimensional, crystalline array) can serve as a template. By coating the protein layer with a thin metal film, then using a technique known as ion milling, researchers can selectively remove the metal from spots corresponding to the holes in the protein layer.

It's a simple, inexpensive means of patterning surfaces periodically on a nanometer scale, say Kenneth Douglas and Noel A. Clark of the University of Colorado in Boulder and Kenneth J. Rothschild of Boston University, who developed the technique. The resulting metal screen, with holes about 14 nanometers in diameter arranged in a triangular lattice, measures just a few nanometers thick.

The group is now studying the possibility of fabricating unique composite materials by letting the holes in such a metal grid selectively capture biological molecules such as the protein ferritin, which fit snugly into the holes and bind to the underlying graphite surface. It may also be possible to create arrays of gold islands by letting tiny gold particles settle into the holes. These structures offer exciting possibilities for making novel chemical, electronic or optically active devices such as sensors, the researchers say.

Space Sciences

Jonathan Eberhart reports from Houston at the annual Lunar and Planetary Science Conference

Meteorites from the moon's lava plains

Scientists have collected thousands of meteorites in Antarctica, where low temperatures keep the rocks from eroding away, a geological oddity concentrates some of them in certain places, and the often snowy and icy terrain makes them easy to spot. Researchers have identified about 10 of these meteorites as coming from the moon. All of the lunar meteorites found heretofore appear to have originated in the heavily cratered highlands that seem to constitute most of the moon's crust. But researchers now report finding three that may have arrived from the lunar lava plains, or maria.

One of these, weighing about 30.7 grams (a little more than an ounce), was gathered in an Antarctic region called the Elephant Moraine, say Jeremy S. Delaney of Rutgers University in New Brunswick, N.J., and Paul H. Warren of the University of California, Los Angeles. Designated MAC88105, this meteorite is a breccia – a rock composed of numerous basaltic fragments and smaller grains held in a glassy matrix. Its basalt is a type with very low levels of titanium. Although remotely measured spectra have led some researchers to believe titanium is common on the moon, it is rare in basaltic moonrocks returned to Earth by space missions.

According to Delaney and Warren, researchers initially listed the Elephant Moraine as a eucrite – a piece of an asteroid. Later, however, studies of its composition revealed details (such as the ratio of different oxygen isotopes) that strongly suggest the meteorite came from a lunar mare.

The largest of the three apparent mare samples, weighing 442 grams, is one of the largest lunar meteorites ever identified. Researchers have temporarily named it Asuka 31, after Japan's newest Antarctic research station. This one, too, resembles a eucrite, but its ratio of iron to manganese resembles that of other lunar rock types, notes Keizo Yanai of the Institute of Polar Research in Tokyo.

The third meteorite, collected in Antarctica's Yamato Mountains and designated Y793169, weighs only 6.09 grams. Like the other two, it is composed of basalt with very little titanium, suggesting a consistent compositional difference between the moon's maria and its highlands.

Triton's geysers: Solar-powered scenario

A likely candidate for Voyager 2's most dramatic finding when the spacecraft flew past Neptune's big moon Triton last year was the discovery in a few photos of dark streaks rising straight up from Triton's surface – apparently geysers of nitrogen. At the time, Laurence A. Soderblom of the U.S. Geological Survey (USGS) in Flagstaff, Ariz., suggested the plumes might be driven by dark surface material absorbing heat from the sun (SN: 9/2/89, p.148). Scientists have since sought to understand the details of such a mechanism.

If the sun indeed provides the heat, says Randolph L. Kirk of the USGS in Flagstaff, the geysers "must have a very efficient means of transporting energy from a large collector region to a much smaller geyser source area." One possibility, he says, may be that nitrogen gas flows through a porous layer beneath darkened areas on the surface. Kirk notes that such a layer may not be very permeable, but he suggests the process could be enhanced by cracks due to temperature changes as Triton's orbit takes it nearer and farther from the sun.

In addition, Kirk says, "despite the efficiency of the gas in transporting heat away, a reservoir at the required temperature can be established under a collector of modest size (a few kilometers in radius), provided the permeable layer is relatively thin." Some such mechanism seems likely, he says, since a deposit of solid nitrogen probably cannot get energy fast enough from nitrogen in a gaseous state to drive geysers as powerful as those in the Voyager photos.