within NO dimers are extremely complex. To simplify these motions nearly to the point of removing them entirely, Casassa and his co-workers used a special molecular jet that cooled the molecules to near absolute zero, the point at which all internal motions come to a halt.

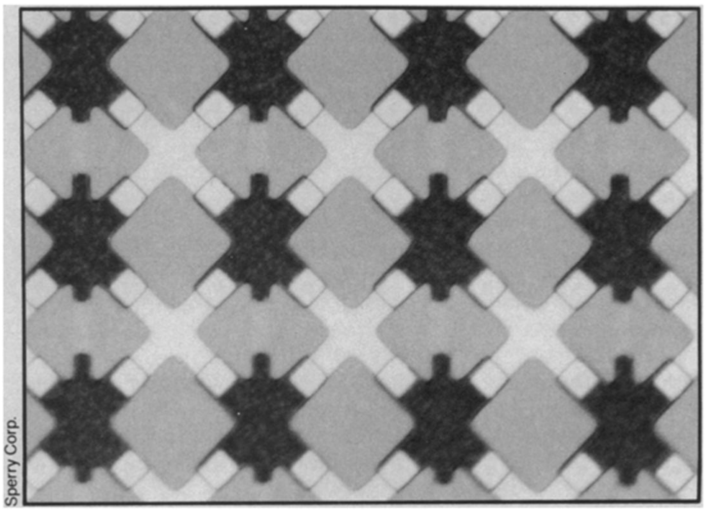
Then, by using trillionth-of-a-second laser pulses that were tuned to inject precise amounts of energy into the NO dimers, the scientists were able to choreograph from scratch a simple molecular dance. They directed the molecules to vibrate in one of two modes: symmetric vibrations, in which the back and forth oscillations of both nitrogen-oxygen pairs are synchronized; or asymmetric vibrations, in which the atoms of one NO molecule approach each other while the atoms of the other recede from one another.

After setting the dimers vibrating in one of the two vibrational modes, the scientists used another ultrafast laser to see how the dance was going. This laser could in effect take snapshots of the dances at different times after movement began. The researchers observed that the dissociation of the NO pairs took 890 picoseconds (1 picosecond = 1 trillionth of a second), or 40 times longer, to finalize when the scientists made them vibrate in the higher-energy asymmetric mode than when they made the dimers vibrate in the lower-energy, symmetric mode.

Intuition suggests that higher-energy vibrations should break apart weakly bound dimers more easily than can lower-energy vibrations. And a leading theory on how molecules break apart formalizes this intuition. But Casassa's experiments clash with both intuition and theory. Casassa suggests one possible explanation that he has not yet tested. He says that some of the energy from the asymmetric vibrations might be shunted into electronic motions in a way impossible for the lower-energy vibrations, which might vent their energies more readily by causing the dimer to dissociate. Hence, the longer dissociation times for the high-energy vibrations.

Whatever the explanation, the paradoxical molecular behavior that Casassa and his colleagues observed has turned a few heads in the scientific community. Physical chemist Richard Zare of Stanford University calls Casassa's work "very exciting" and praises the experiments as "elegant and beautiful." The next step, say Casassa and other laser chemists, is to critique more molecular choreographies to see if the behavior observed in NO dimers is a general phenomenon of molecules bound by weak van der Waals forces. *— I. Amato*

Checking out a theoretical superconducting transition



Sperry Corp.

In this segment of a million-element, Josephson junction array, niobium electrodes show up as dark and light crosses. The different shades indicate that the electrodes are at two different levels. The little squares, only 8 microns wide, where the electrode arms overlap show the junction locations.

In the strange world of superfluids and superconductors, currents can flow forever. In order to study and understand this surprising behavior, physicists often turn to sophisticated technology. One approach is to construct a physical system — say a microelectronic device — that corresponds to a particular theoretical model. Researchers can then run experiments on the system to learn more about the theory.

Recently, scientists at the University of Minnesota in Minneapolis used a custom-made array consisting of a million Josephson junctions (SN: 10/27/84, p.265) to investigate something called the two-dimensional X-Y model. This theoretical model is useful for understanding currents in liquid-helium films and thin superconducting layers, such as those in Josephson junctions. It may also apply to processes like two-dimensional melting. Of particular interest is a special kind of temperature-dependent transition, known as the Kosterlitz-Thouless transition, found in the X-Y model's behavior.

Using the Josephson junction array, which was fabricated by Manjul Bhushan and her colleagues at the Sperry Corp. in St. Paul, Minn., the researchers found clear evidence for that transition. "I was amazed how sharp everything was," says Minnesota's Alan M. Goldman. Other researchers had seen the transition before but never this clearly.

The sharpness of the new results shows that this array is "an extraordinarily accurate realization" of the two-dimensional X-Y model, says Goldman. That makes the array a useful test bed for all sorts of ideas associated with the model.

The Sperry device, a 1-inch square, consists of two layers of niobium separated by a thin, insulating silicon film. This set of layers is carefully etched to create a pattern of niobium electrodes.

In a typical experiment, the device is cooled to temperatures below 6° K. For a given temperature, a current is applied across the whole array and the voltage measured. This provides an estimate of the array's electrical resistance at various temperatures. The Kosterlitz-Thouless transition shows up as an abrupt resistance shift at a critical temperature.

Says Goldman, "This is a striking example of being able to make structures that are model systems of important statistical mechanical problems." Goldman and his group presented their results at last month's Applied Superconductivity Conference in Baltimore.

"It's a very competitive field," says Harvard's Michael Tinkham, who has done similar experiments using a somewhat different type of array. "There are lots of groups in it." One goal of this research is to find out what effect an externally applied magnetic field has on the Kosterlitz-Thouless transition. The question is controversial because different theoretical models make different predictions. Goldman and others are now using their devices to study this special, "frustrated" case of the X-Y model.

Researchers are also doing computer simulations to explore this model. However, computers are generally too slow or have too little memory to handle arrays that consist of as many as a million elements. A computer simulation with fewer elements, says Tinkham, isn't realistic enough.

Moreover, says Goldman, "it's always nice to have a real, physical system on which to make measurements. By doing this, you can often learn things about nature that get lost in a computer simulation." *— I. Peterson*

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