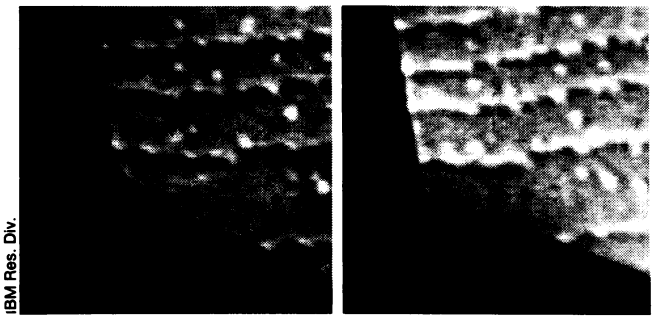
Shape oscillations mark crystal growth

Salt crystals grown by slow evaporation of water from concentrated brine generally develop a characteristic cubic shape with sharp corners and flat faces. In contrast, crystals produced by vapor deposition — in effect, one atom at a time — can actually oscillate in shape between a sharp-cornered and a round-cornered form as they grow.

This novel, cyclic phenomenon, first observed by researchers at the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y., is most apparent when the growing crystal is small—only 1 micron or so in size. As the crystal gets larger, the physical conditions responsible for the shape oscillations exert less influence, and the crystal reverts to its sharp-cornered form.

Under certain growth conditions, "small crystals differ from large ones in a fascinating and unanticipated way," Jerry D. Tersoff, A.W. Denier van der Gon, and Rudolf M. Tromp report in the Feb. 22 PHYSICAL REVIEW LETTERS. Their theoretical analysis reveals that shape oscillations are a "fundamental feature of the equilibrium shape of small crystals."



IBM Res. Div.

Sharpening of a corner occurs during growth of a silver crystal on a silicon substrate. Horizontal lines represent steps at the silver-silicon interface.

Tromp and van der Gon first noticed these surprising oscillations while studying the growth of silver crystals by depositing silver atoms onto a silicon surface. At first, the researchers assumed that the shape oscillations they unexpectedly observed were an artifact of their technique. But further analysis by Tersoff suggested thermodynamic reasons why such cyclic shape changes could occur naturally under the given conditions.

Made up of ragged steps, a crystal's rounded corners are actually quite rough on an atomic scale. Thus, a small, rounded crystal has rough corners and smooth, flat faces.

Because atoms require less energy to settle in a rough region than to start the formation of a new layer on a smooth face, they first go exclusively to the corners. Eventually the corners fill in, and deposited atoms have no other choice but to start forming an "island" on a smooth face.

Once established, this island acts as a reservoir, absorbing extra atoms from the corners, which become rounded again. After the island grows into a complete layer on one face, additional atoms have nowhere to go but the rounded corners, and the cycle begins again. *—I. Peterson*

No-'stick' tips for heart-healthy diets

With the addition of hydrogen, unsaturated oils undergo a transformation that straightens out a kink in their natural form. These stiffer "trans" fats permit stick margarine and shortening to remain solid at room temperature, as saturated fats do. But new research with human volunteers now confirms earlier reports that such fats also increase cholesterol concentrations in the blood.

Three years ago, a Dutch team came to the same conclusion (SN: 8/25/90, p.126). But that group fed a laboratory-concocted margarine-like product to young, healthy volunteers eating a traditional, high-fat diet.

"We took that a step further," says Alice H. Lichtenstein of the U.S. Department of Agriculture (USDA) Human Nutrition Research Center on Aging at Tufts University in Boston. Americans typically derive 35 percent of their calories from fat; she cut fat in her trials to 30 percent of calories, a level the American Heart Association recommends.

Her team then recruited 14 men and women age 44 to 78 with "borderline high" cholesterol (238 milligrams of cholesterol per deciliter of blood) and charted changes as they switched between a typical U.S. diet and two 32-day diets, all with the same number of calories. The first alternative derived two-thirds of its fat from corn oil, the second from a commercial corn-oil margarine. Both corn-oil-based diets contained proportionately about half the saturated fat of the baseline diet.

Many lipids in the blood fell in both the lower-fat and less-saturated-fat diets, Lichtenstein's team writes in the February ARTERIOSCLEROSIS AND THROMBOSIS. But compared to margarine, liquid corn oil fostered larger drops: 12.7 versus 7.4 percent in total blood cholesterol and 17.4 versus 10.4 percent in "bad," or low-density-lipoprotein, cholesterol.

These results "are very definitive" in pointing out the advantages of reducing overall fat and switching to products that contain unsaturated fats, says Lichtenstein. An even longer, more involved study by USDA scientists in Beltsville, Md., finds much the same thing, says Joseph T. Judd, who led the still-unpublished trial involving 29 men and an equal number of women.

The USDA group's paper "adds one more block to the argument that trans fatty acids should be reduced in the American diet," says Scott M. Grundy of the Center for Human Nutrition at the University of Texas Southwestern Medical Center in Dallas. However, he says, stick margarine "is still better [for the heart] than butter — by far." And soft margarine — with less trans fat — is better than hard, he adds.

David Kritchevsky of Philadelphia's Wistar Institute also notes as interesting the Boston group's finding that margarine did not raise concentrations of the cholesterol carrier Lp(a) in the blood; it had in the Dutch study. This might prove important, he argues, since high Lp(a) can slow the natural breakdown of blood clots — a leading cause of strokes and heart attacks. *—J. Raloff*

Probing the ancestry of supernova 1987A

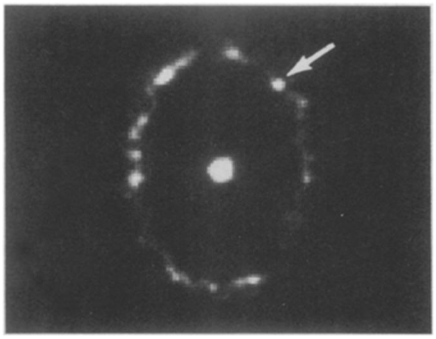
Six years have passed since astronomers witnessed the dazzling debut of supernova 1987A, glowing with the luminosity of 100 million suns. While the brightness of this exploded star has waned, the intense interest in it remains. Astronomers are still puzzling, for example, over the character of the star that gave birth to this nearby supernova.

A new model supports speculation that the parent star did not live its life as a loner. Rather, it may have had an orbiting companion that significantly influenced its history.

The new study attempts to explain a ring of fluorescent gas surrounding supernova 1987A that formed from material ejected by the supernova's parent star more than 20,000 years before the explosion occurred. During that era, the compact parent evolved into a bloated star known as a red giant, which blows a low-speed, high-density wind of material into space. Later, just a few thousand years before the supernova explosion, the red giant apparently lost some of its girth, forming a blue giant, which emits a faster, lower density wind. In time, this wind caught up with the wind from the red giant. The resulting collision compressed the gas in the red giant wind, sculpting it into a shape that became visible when radiation from the supernova explosion heated it.

Had the winds blown gas equally in all directions, the collision would probably have formed a shell rather than the ring revealed by the Hubble Space Telescope in 1990. Some researchers then proposed that the gravitational tug of an unseen companion star could have concentrated the red giant wind along an equatorial ring, away from the parent star's polar regions. However, the variation in wind density along different directions seemed too small to require a companion.

In a more detailed analysis, John M. Blondin of North Carolina State University in Raleigh and Peter Lundqvist of the Stockholm Observatory in Sweden now come to a different conclusion. They find that in order for an asymmetry in the red giant wind to account for the ring as well as a pair of lobe-shaped emissions above and below the ring, the wind must have blown 20 times as much gas out along the equator of the parent star as at its poles. Such a scenario requires a companion, the astronomers report in the March 1 ASTROPHYSICAL JOURNAL.


F. Duccio Macchetto, Nino Panagia/ESA; Plait

Hubble image shows gas ring around supernova 1987A. In enhancing images by computer, Chevalier and Philip Plait of the University of Virginia identified a star (arrow) thought to lie in the supernova's home galaxy. That lines up with the ring as seen from Earth.

"If you follow this model, then the only explanation I can see . . . is a nearby companion," asserts Blondin. Nevertheless, he has begun work on a model in which the spin of a solitary parent star might generate a blue giant wind that preferentially blows along the equator. Roger Chevalier of the University of Virginia in Charlottesville notes that a magnetic field embedded in the blue giant wind might confine gas to a ring.

If 1987A's predecessor had a partner that survived the explosion, astronomers may spot it as the supernova continues to fade. In a Jan. 15 circular of the International Astronomical Union, Arlin P.S. Crotts of Columbia University and William E. Kunkel of the Carnegie Institution of Washington's Las Campanas Observatory in La Serena, Chile, reported that if the partner's core is still burning hydrogen, the star has less than 2.5 times the mass of the sun. *—R. Cowen*

First helium dimer: A truly supercool giant

All of the approximately 100 chemical elements in nature form pure molecules made up of one type of atom — except for the inert gas helium. Helium has the reputation of a loner, a lightweight atom that never settles down to bond with others of its own kind. Scientists have speculated that helium atoms do pair up to form diatomic molecules, but only at extremely low temperatures.

Try one-thousandth of a kelvin, a smidgen above absolute zero.

Using a new apparatus that can attain such frigidity, W. Ronald Gentry and his colleagues at the University of Minnesota in Minneapolis have detected helium dimers for the first time. Their observation proves the existence of such molecules — ending a 65-year debate — and validates recent calculations predicting that the extreme low temperature was necessary to coax the atoms to cozy up to one another.

While no longer an oddball among the elements, helium nevertheless forms an unusual molecule. The dimer is held together by the weakest chemical bond ever measured. "Helium doesn't form ordinary bonds," says Gentry. "The only thing that holds the molecule together is the long-range force caused by the electrons being unevenly distributed around the nucleus."

Oddly, the second smallest atom also forms the world's largest diatomic molecule, rivaling biological macromolecules in size, he notes. Between the dimer's two atoms lies a gulf of 55 angstroms instead of the usual two to three.

James B. Anderson of Pennsylvania State University in University Park comments that Gentry's group beautifully demonstrated that they had indeed detected the fragile molecule and not some experimental artifact. "While the theory has been solid for a few years," Anderson says, "it wasn't clear that a helium dimer would actually be seen this century."

In the Feb. 15 JOURNAL OF CHEMICAL PHYSICS, Gentry and his co-workers describe how they cooled the helium by squirting a pulsed beam of high-pressure helium gas into a vacuum chamber. There, the helium expanded as its pressure plummeted by 12 orders of magnitude. A mass spectrometer detected the dimers.

The team will now use the apparatus to further study the new helium molecule. Says Gentry, "These very-low-temperature beams are so interesting because they allow us to probe the extreme quantum mechanical behavior of matter." *—K.F. Schmidt*

Atlantic winds transport ozone eastward

Satellites have mapped the concentrations of ground-level ozone hovering over some of the most populous regions of North America, Europe, and Asia. Replenished by the photochemical conversion of polluting gases, this low-lying ozone can trigger asthma attacks, cause crop damage, and possibly contribute to global warming. However, the total amount of ground-level ozone and how much of it drifts across the Earth remain poorly understood.

A new study indicates that winds flowing across the northern Atlantic Ocean "export" North American ozone to Europe. The researchers say this may prove part of a global flow of ozone in the latitudes between 30°N and 60°N.

Using measurements of ozone and carbon monoxide taken at three sites on Canada's Atlantic coast, the scientists also offer the first estimate of how much ozone Europeans may actually receive from across the ocean, a U.S.-Canadian research team reports in the March 5 SCIENCE.

They estimate that about 16 percent of the ozone cooked up in the lower atmosphere over the eastern United States and Canada wafts across the Atlantic in the summer, far exceeding the amount of natural stratospheric ozone likely to bleed down into the lower atmosphere over the North Atlantic in the same period. The other 84 percent of the ozone produced in the United States remains behind, eventually breaking down into simpler gases or being deposited on trees and other vegetation.

Scientists aren't sure yet what environmental mischief this ozone may cause. "But it's clear that we're making a major perturbation of the [lower atmosphere's] chemistry," says David D. Parrish of the National Oceanic and Atmospheric Administration in Boulder, Colo. "Our experience in the stratosphere with fluorocarbons tells us we should at least understand these perturbations and look in some intelligent way at what the impacts could be."

Studies of ozone export fit into a larger effort to measure ground-level ozone precisely and simulate its behavior with computers, says atmospheric chemist Jennifer A. Logan of Harvard University. Such mathematical models could specify the amount of ozone that stems from human activity, detail its global circulation, and help scientists predict the possible effects of ground-level ozone on climate and agriculture, Logan notes. *—D. Pendick*