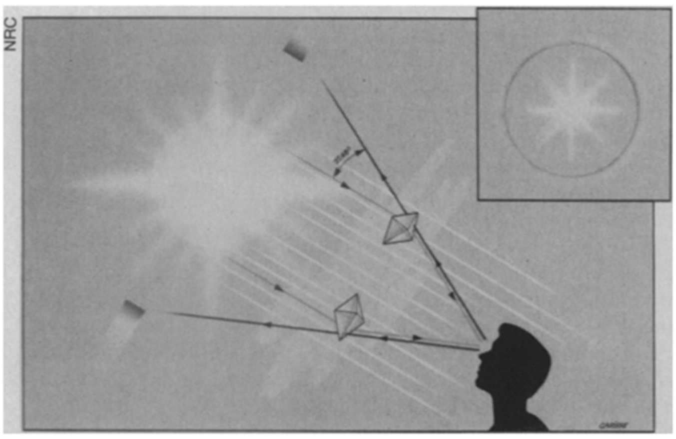
Physical Sciences

An icy, cubic ring around the sun

The pale, misty halo that sometimes rings the sun or the moon is the result of reflection and refraction of light by tiny ice crystals high in the air. Most of the time, the angle between the halo, an earth-bound observer and the sun is 22°. But one type of halo, reported only seven times in the last 350 years, glistens at about 28° from the sun. The origin of this rare halo, named Scheiner's halo, has been a mystery for centuries. Its geometry doesn't match that of ice that crystallizes into the familiar hexagonal form produced in large quantities on earth. Calculations show that hexagonal ice crystals produce the 22° halo and other related sky arcs, but no hexagonal crystal orientation produces one at 28°. Edward Whalley of the National Research Council in Ottawa now suggests that Scheiner's halo may be evidence for the existence of "cubic ice" in nature, a different crystalline form of ice that has been known so far only in the laboratory.



Cubic ice was first made and recognized as a new kind of ice in 1905. Unlike the hexagonal form of ice, which consists of neatly stacked layers of puckered hexagons of water molecules, cubic ice has a diamond structure and forms octahedral crystals in which successive hexagonal layers are systematically displaced along a diameter of a hexagon.

Whalley's interest in cubic ice began about 25 years ago when his group discovered an efficient way of making cubic ice on a large scale. "We've always had a kind of paternal interest in cubic ice and wondered where it could occur in nature," says Whalley. After hearing about Scheiner's halo, Whalley calculated that refraction between two octahedral faces that meet at an apex of an octahedron gives rise to a halo at about 28°.

One puzzle remains. In the laboratory, cubic ice forms at temperatures below −100°C. The formation of Scheiner's halo, if Whalley's idea is right, seems to require the freezing of droplets of liquid water into octahedral ice crystals at temperatures as high as −20°C. This may be possible, Whalley says, because sometimes conditions in the upper atmosphere favor the appearance of a few seed crystals of cubic ice in preference to hexagonal ice. Very rarely, these crystals may grow large enough to cause a noticeable halo. When they do, the crystals seem to disappear quickly, because Scheiner's halo has never persisted for more than a few minutes.

Twinned snowflakes may also suggest the presence of cubic ice in nature. Japanese researchers have noted that joined pairs of snowflakes often have their axes at about 70° to each other. Whalley says, "They propose that cubic ice nuclei frequently form, but nearly all of the time they convert themselves into twinned crystals of hexagonal ice by growing on two adjacent octahedral faces. This sounds very plausible, but I know of no direct evidence that at the center of one of these snowflakes is an octahedral nucleus." Nevertheless, Whalley concludes, "There seems little doubt that cubic ice often forms in the upper atmosphere."

Agriculture

Breezy solution to hard-boiled problem

Anyone who eats hard-boiled eggs has undoubtedly run across one that refuses to be shelled neatly. While no crisis for the average consumer, whether part of an egg adheres like glue to its shell has become an issue of paramount concern to the burgeoning commercial hard-cooked egg industry — purveyor of eggs to restaurants, salad bars and institutional sandwich makers. Now scientists at the University of Georgia in Athens have hit upon a solution that's literally a breeze.

The easiest solution to neatly peeled eggs is to let them age, because the older an egg is, the easier it will peel when hard cooked. However, while eggs maintain their taste for four to six weeks — sometimes even longer — the diffusion of carbon dioxide (CO_2) out through the shell leads to chemical changes in an aged egg that encourage its yolk to move off center. And eggs with off-centered yolks are hard to slice without splitting the white — a bane to those who thrive on a food's appearance.

"So our challenge," explains Walter Britton, "was to find something to very rapidly change the pH just enough to make a fresh egg peel easily, but not enough to let the white [ultimately] deteriorate." Since CO_2 diffusion through the shell seemed the key to the pH change between a fresh and aged egg, Britton and colleague Daniel Fletcher decided to encourage CO_2 diffusion in fresh eggs — initially by storing them in a sodium-hydroxide bath. "Within 24 hours," Britton notes, "we could cook these eggs and peel them with no trouble." But then they found an even more commercially attractive alternative — placing fresh eggs in the presence of a "gentle breeze" — such as a fan might generate — for 24 hours. Right now the team is working on finding the optimal air flow to minimize CO_2 diffusion time. One can't just blow up a storm or evaporation would occur. And since eggs are sold by weight, processors want to avoid that.

Home cooks are cautioned that this technique might not work so well for them. Eggs in groceries are usually treated with mineral oil to retard CO_2 loss — and hence aging.

Ozone — a measure of its cost in crops

Ozone (O_3) is a major industrial air pollutant. A hazard to human health, there have been indications that it might jeopardize crop production too. Now agricultural scientists from four universities and three federal laboratories have quantified — in both physical and economic terms — ozone's threat to some of the nation's most important crops. Estimates of how crop production might change under ozone concentrations in ambient air ranging from 0.04 parts per million (ppm) to 0.08 ppm, were based on field data involving soybeans, corn, wheat, cotton, peanuts, lettuce, turnips, spinach and kidney beans. Ambient ozone levels for much of the agricultural United States are believed to range from 0.04 to 0.07 ppm. (Except for California, ozone levels tend to be highest east of the Mississippi.)

Field data were developed by the National Crop Loss Assessment Network (NCLAN), which has field stations in six states. Explains Walter Heck, chairman of NCLAN's research-management committee, "When we got into the NCLAN program years ago, I would have guessed that even with some of the more sensitive crops, you wouldn't be losing more than three to five percent [from ozone], and for the more resistant crops like corn that we wouldn't be losing anything. But as a matter of fact," he told Science News, "the data that we have has convinced me that ozone losses for some of our more sensitive crops can in some years be as high as 10 or 15 percent."

A report of the ozone assessment in the December Environmental Science and Technology estimated ambient levels of 0.08 ppm ozone throughout the "corn belt" could reduce annual corn production 10 million tons per year, soybeans 3.7 million tons and wheat 330,000 tons relative to actual production recorded in regions where ozone was only 0.045 to 0.057 ppm.