Atomic evaporation in liquid helium

For the first time, a British research team has demonstrated that an individual heat pulse can eject a single atom from the surface of a liquid. This quantum evaporation process is the thermal equivalent of the photoelectric effect in which light, behaving like a stream of particles (photons), can knock electrons out of materials. In the newly observed "phonokinetic" effect, high-energy phonons (particle-like packets of waves that carry heat) eject atoms from a liquid surface.

In the July 28 NATURE, M. J. Baird and his colleagues at the University of Exeter in England report, "The interaction between the phonons and surface atoms is a one-to-one quantum process as has been conjectured by several authors but has not hitherto been demonstrated. ... Liquid [helium], therefore, is the first liquid in which we can understand evaporation at the atomic level."

The researchers used a bath of superfluid helium at 0.1 kelvin, a temperature low enough to ensure that the space above the liquid is an excellent vacuum. Thus, any liberated atom would move in a straight line with a negligible chance of being deflected before it is detected. An immersed heater produced a burst of phonons that traveled upward toward the liquid's surface. These phonons either reflected from the surface or knocked out atoms that could be detected by a sensitive instrument in the space above the liquid. The phonons and ejected atoms traveled along the same straight line.

The heater was always at a fixed distance below the detector, but the whole system could be raised or lowered, keeping the total path length constant. Baird's group was able to deduce the time taken for the phonons to go from the heater to the surface and for the ejected atoms to travel from the surface to the detector. They found that the phonon energy equaled the sum of the binding energy (the energy an escaping atom requires to overcome the forces that hold it to a liquid's surface) and the kinetic energy of the ejected atom.

John F. Allen of the University of St. Andrews in Great Britain, in the same issue of NATURE, comments, "What has been lacking has been the ability to produce an identifiable high-energy phonon to knock an identifiable atom from the liquid." This experiment clearly establishes "that we can speak of a phonokinetic effect which is the analogue of the photoelectric effect," he concludes. *—I. Peterson*

Vapor method yields elusive metallic glass

Iron and silver are like oil and water; they don't mix. In the past this presented difficulties for metallurgists wanting to produce an alloy from these elements. In separate but concurrent studies, researchers in both the United States and Japan have now found a way to fabricate an iron-silver (Fe-Ag) blend with a technique that should prove promising in the manufacture of other previously inaccessible alloys.

Since metallurgists usually rely on mixing in the liquid state to provide uniformity in alloys, a new method was needed to form blends such as Fe-Ag in which the elements are insoluble in the molten form. The "vapor-quench" technique has reportedly done the trick, according to physicists Chia-Ling Chien and Karl M. Unruh of Johns Hopkins University in Baltimore, Md. They report in the Aug. 1 PHYSICAL REVIEW that they were able to achieve a 50:50 Fe-Ag mix by vaporizing individual atoms off the surface of an Fe-Ag pressed-powder cake. A thin film of the blend was then deposited onto supercold metallic or polymer plates.

David J. Sellmyer, physics chairman at the University of Nebraska in Lincoln, predicts that the success of this technique will prompt other researchers to make additional artificial alloys. "It often happens that in making these materials you discover interesting new properties that haven't been seen before," he says.

Some material scientists are reserving judgment. David Turnbull, an applied physicist at Harvard University in Cambridge, Mass., feels that Chien and Unruh's result, if confirmed, would be highly significant but is concerned about the homogeneity of the new Fe-Ag alloy. "It may be homogeneous," he says, "but I would not be convinced without further tests showing that it is well-mixed with 50:50 compositions at the atomic level." Chien, however, remains confident that his sample is uniform to within 2 percent.

Chemical compounds, such as table salt, are mixtures of elements locked into a strict crystalline structure that specifies the exact ratio of one elemental concentration to the others. The components of alloys, however, are usually so atomically similar to one another that atoms of one element can substitute for another in a crystalline network, as they do in steel. As a result, alloys can be formed with a variety of compositions.

An amorphous solid, such as the new Fe-Ag glass and common glass, is an alloy that lacks the usual crystalline structure. The random arrangement of the atoms in amorphous metals results in physical properties quite different from those of crystalline alloys. These metallic glasses, as they are called, are often tougher, more corrosion resistant and more easily magnetized than their crystalline counterparts, giving them a variety of industrial applications (SN: 12/12/81, p. 380).

Chien and Unruh's work is the first report of a concentrated metallic glass produced from a system of elements with no known compounds or crystalline alloys. The Fe-Ag glass is a "metastable" state, however, and if pushed to temperatures above about 250°C it will begin to separate and crystallize.

If iron and silver have such an aversion to each other, what binds the atoms together in the new metallic glass? Chien suspects that strong cohesive forces in iron may be responsible and that the silver atoms may simply be trapped between them. He remarks that this Fe-Ag alloy "puts on the defensive" the so-called micro-crystalline theories of amorphous solids, which imply that the presence of a metallic glass is linked to the existence of a crystalline counterpart. *—P.D. Sackett*

'Major milestone' in laser weapons tests

In the first successful tests of its kind, an airborne laser recently "defeated" missiles launched at it from another aircraft. The U.S. Air Force tests, announced July 25, marked completion of a series of experiments involving the Airborne Laser Laboratory. This flying test station, which the Air Force stresses is highly experimental and not a prototype weapon system, disabled five AIM-9 Sidewinder air-to-air heat-seeking missiles, causing them to veer off target and eventually crash-land.

The challenge was to target and track an incoming missile precisely so that the infrared (carbon dioxide gas) laser could continuously illuminate one point on the missile's exterior long enough to burn through and destroy its sensitive guidance components inside. Initial trials two years ago ended in failure. Even this time, the Airborne Laser Laboratory's first eight attempts were unsuccessful. Explains Major Sam Giammo of the Air Force Systems Command, "We'd fire one [Sidewinder], fine tune the equipment a little bit, then fire another." This was over a period of two weeks at the end of May. "But once we got the equipment calibrated," he said, "we were five for five."

The Air Force is calling the achievement "a major milestone" in its high-energy laser program. It is one of the most visible advances in research by the Department of Defense (DOD) on directed-energy weaponry. Although this particular effort began long before DOD outlined its Space Laser Program Plan last year, Giammo acknowledged the technology demonstrated in these tests would apply to other DOD laser programs.

Over the past year, DOD has expressed growing interest in laser weapons — particularly for defensive purposes; for use against incoming enemy missiles and for protection of important data-gathering