Fine points of melting in plasma crystals

The melting of a solid is such a commonplace occurrence that it may seem surprising that scientists do not yet completely understand the behavior of atoms and molecules during this transition.

The process is so complicated that computer simulations fail to capture its subtleties. Moreover, because relatively few particles make the transition at any given time, it's difficult to detect their movements amid those of all the other particles present in the coexisting liquid and solid states.

Now, researchers can view on a microscopic scale how melting takes place. Instead of looking at water molecules in ice or atoms in solid copper, they peer at tiny plastic spheres immersed in a plasma of ionized gas.

Under suitable conditions, these spheres spontaneously arrange themselves into orderly patterns resembling arrays of atoms in a crystal (SN: 8/6/94, p. 84). Lowering the gas pressure of the plasma causes this orderliness to disappear, just as raising the temperature causes an ordinary solid to melt.

Such plasma crystals "are ideally suited for investigating the processes underlying the solid-to-liquid phase transition," Hubertus M. Thomas and Gregor E. Morfill of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, report in the Feb. 29 NATURE.

The researchers use a high voltage to strip electrons from krypton atoms and create a weakly ionized plasma similar to that in a fluorescent light. Micrometer-size plastic spheres sprinkled into the plasma collide with electrons and ions, quickly picking up a negative electric charge. Repelling each other, the spheres space themselves out uniformly across a dozen or more layers. These layers stack up to form a thin, disk-shaped cloud only a few millimeters in diameter.

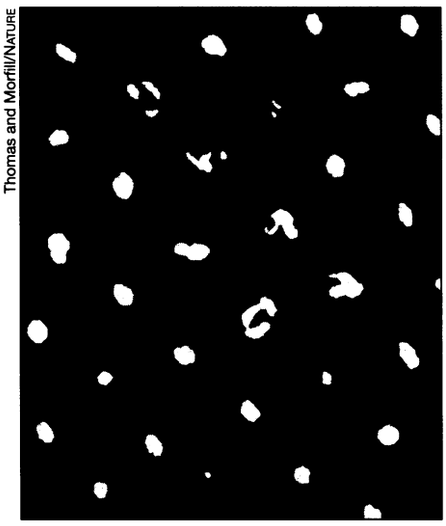
Using a sheet of laser light to illuminate a layer in the plasma crystal, the researchers can observe what happens to the particles as the gas pressure is lowered. These observations suggest that melting passes through two intermediate stages between the crystalline solid and the liquid state.

As melting begins, the array breaks up into islands of crystalline order (somewhat like ice cubes in water) around which flow streams of particles. These small crystalline regions then disintegrate, but the particles settle into a new orderly pattern. The particles also vibrate noticeably about their equilibrium positions (see image).

What isn't clear at this stage is whether this unusual vibrational state is peculiar to plasma crystals or whether it could be a sign of a hitherto unknown intermediate stage of melting in a wide range of materials.

"You're drawing an analogy between spheres in a plasma crystal and atoms in a simple solid," comments David G. Grier of the University of Chicago. "A lot more needs to be known about the interaction between these spheres and the electric field [in the plasma]." —*I. Peterson*

Thomas and Morfill/NATURE



Video image of tiny plastic spheres, each 6.9 micrometers in diameter, suspended in a plasma. These particles vibrate about their equilibrium positions as the plasma crystal nears the end of its melting transition.

The worm turns—into a source of new drugs

Hookworms, the internal vampires that infect an estimated 1 billion people worldwide, may someday aid the very species whose blood they so blithely feed upon. To keep their free meals flowing, hookworms synthesize proteins that prevent blood from coagulating, report researchers at Yale University School of Medicine and Corvas International, a biotech firm in San Diego.

These proteins, three of which are described in detail in the March 5 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, offer the potential of safer or more potent drugs to prevent thrombosis, the dangerous clotting of blood within veins and arteries that can lead to strokes or heart attacks.

"It looks as though the hookworm proteins inhibit coagulation at two different points in the [clotting] process," says Michael Cappello of Yale.

That hookworms make such proteins is not surprising, since the survival of these parasites depends upon their ability to latch onto a mammal's small intestine and drain blood for nourishment. Knowledge of the worms' anticlotting skill dates to the turn of the century, notes Cappello. Scientists of that era found that if they dried adult hookworms, ground them up, and added that powder to plasma, the blood would not clot.

Those early investigators didn't have the research tools needed to isolate the responsible molecules, however. That achievement awaited Yale's Peter J. Hotez, who suggests that internal parasites offer a source of drugs comparable to the oceans' waters and soil samples from rain forests.

"These endoparasites have done something that the seas and the tropical rain forests haven't done. . . . They've done millions of years' of [research and development] for you in the form of evolution. They've been coevolving with their hosts. By living inside hosts, they've fine-tuned molecules which I think are ideal solutions for a lot of medical problems," says Hotez.

Hotez's interest in hookworms stems largely from his desire to find a vaccine against them. Uncommon in the United States, hookworm infections in developing countries often cause severe anemia, retarded physical and mental development, and even death, especially among children. One recent survey found that 17 percent of people in China are infected. "It's one of [China's] biggest problems," says Hotez.

The search for proteins that might stimulate hookworm immunity led Hotez and Cappello to isolate and purify an anticlotting protein from *Ancylostoma caninum*, a species of worms that infects both dogs and people. With George P. Vlasuk and his coworkers at Corvas, the Yale group has now characterized the function of that protein and two others from the same worm species.

Clotting occurs when injured blood vessels expose surface molecules to a bloodborne enzyme called factor VIIa. The combination of these molecules activates another enzyme, factor Xa, which converts a molecule called prothrombin into thrombin. Thrombin speeds coagulation by creating clots of the protein fibrin and inducing the aggregation of blood cells called platelets.

Two of the new proteins thwart clotting by binding to and inactivating factor Xa; the third protein stymies factor VIIa and "inhibits the initiation of the entire coagulation cascade," says Vlasuk.

In animal studies not yet published, the factor VIIa inhibitor appears to be an even more effective anticoagulant than known antithrombotic agents such as heparin, says Vlasuk. Corvas plans clinical trials of the compound next year.

Cappello also hopes to develop a novel vaccine using the proteins. Such a vaccine would be intended not to raise a direct immune attack on the hookworms but to generate antibodies that neutralize the anticlotting proteins and cut off the worms' food supply. —*J. Travis*