But he and other scientists worry that the commands may have become distorted or erased from the craft's on-board computer. If so, Mars Observer could not have fired its engines as planned and thus will not go into a low orbit around the planet. The craft simply may have sailed past Mars, ending a two-year mission before it ever began.

If communications should resume by the end of August, engineers could still instruct a wayward Mars Observer to orbit the planet. But calculations show the craft would take 40 days in a highly elliptical path to orbit Mars instead of the 118-minute circular path desired for a detailed study of the planet.

Trouble began about 9 p.m. Eastern Daylight Time on Aug. 21. Technicians had commanded the craft to pressurize its fuel tanks, a procedure that requires the craft to detonate a valve so that helium gas can flow into the tanks. Because the explosion might shock the craft's transmitters, technicians had deliberately switched them off minutes before, silencing the craft's only link with Earth. Five minutes later, with pressurization completed, engineers commanded the transmitters to turn on again. The craft remained mute.

Cunningham says there's "less than a 0.1 percent chance" that the valve detonation – a routine procedure with no more power than a firecracker – might have destroyed the craft. But a NASA contractor who wished to remain anonymous was less confident: "They [JPL officials] are calling it a 'loss of downlink.' But you might just as well call it a 'loss of spacecraft.'" He added that if a leak occurred in the tanks as pressure increased, it could have spun the craft wildly, hurling its solar arrays and other vital parts into space.

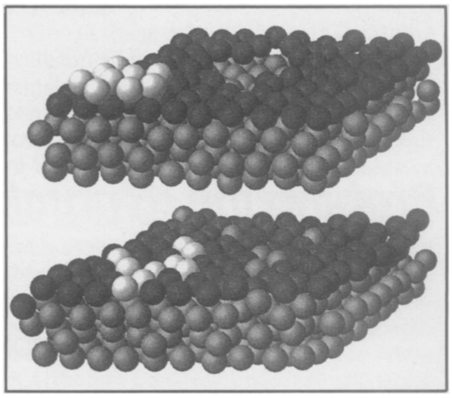
Scientists familiar with the Venus-orbiting Magellan spacecraft said that its transmitters – built by a different company than those on the Mars Observer – were not turned off before valve detonations. "That's just the time [during detonation] when you'd like to have as much communication with the craft as possible," notes Frank McKinney, project manager for spacecraft mission operations at Martin Marietta Astronautics in Denver.

Cunningham says that if the transmitters had remained on during pressurization, engineers might have gathered more hints about the cause of the communications failure. But he adds that the manufacturer had recommended that NASA turn off the transmitters during such procedures, advice followed previously without problems.

NASA expressed even greater pessimism about the fate of NOAA-13, a new weather satellite intended to replace an aging, but identical model that monitors Earth from a polar orbit. Researchers attribute the loss to a bad battery and don't expect to recover a signal.

– R. Cowen

Superheating and repairing a metal surface



Landman

Before irradiation by a short laser pulse, an island of copper atoms (light gray spheres) sits atop a copper (111) surface (dark gray spheres) near a hole in this upper layer of atoms (top). Computer simulations show that superheating causes the island to sink into the surface layer, while other atoms shift their positions to fill in the hole (bottom).

A crystalline solid typically melts at a characteristic temperature. But short, intense pulses of laser light can cause certain surfaces of metal crystals to melt at temperatures below the solid's normal melting point. In contrast, other types of crystalline surfaces – made up of more closely packed atoms – resist melting.

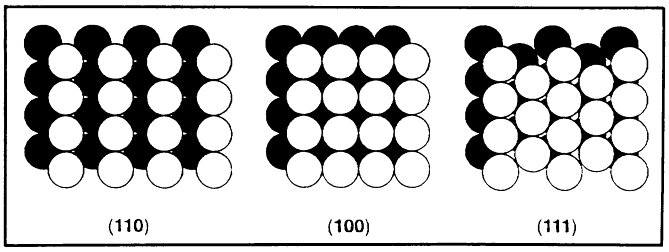
Last year, researchers demonstrated that a lead crystal's surface can be heated as much as 120 kelvins above the metal's melting point of 327.5°C (600.7 kelvins). Now, computer simulations of the behavior of copper (which has the same crystal structure as lead) confirm that laser pulses can "superheat" a surface made up of tightly packed atoms – even when the surface has defects.

"This was surprising," says Uzi Landman of the Georgia Institute of Technology in Atlanta. "Defects are normally suspected to be the cause of melting." However, under the influence of a superheating laser pulse, an initially flawed copper surface resists melting and actually mends itself.

Landman and Hannu Häkkinen report their findings in the Aug. 16 PHYSICAL REVIEW LETTERS.

Slicing through a crystal of lead or copper in different directions exposes surfaces having different atomic arrangements (see diagrams below). The metal atoms are most closely packed on the type of surface labeled (111) and least closely packed on the (110) surface.

Researchers had previously observed that the lead (110) surface can start melting well before the crystal reaches a temperature of 600.7 kelvins. Last year, Hani E. Elsayed-Ali, now at Old Dominion University in Norfolk, Va., and John W. Herman of the University of Rochester (N.Y.) showed that the lead (111) surface can be substantially superheated (SN: 9/12/92, p.164).



Elsayed-Ali

Arrangement of atoms on different types of crystal surfaces.

This result inspired Landman and Häkkinen to simulate the response of a metal (111) surface to intense laser pulses. To get a better sense of what happens on an atomic scale, they chose to model a copper crystal, made up of orderly rows and layers of copper ions immersed in a sea of free electrons.

To obtain a more realistic picture of this interaction, they modeled how the laser light excites the electrons, which in turn influence the motion of the ions in the lattice. "We tried to capture the whole sequence of events that occur in a laboratory experiment," Landman says. "This had not been done before."

The researchers first simulated the response of a perfect crystal surface to a laser pulse and obtained clear evidence of superheating. Then they introduced a number of vacancies into the surface and found that superheating still occurred. Even when they placed an island of atoms atop the copper (111) surface and gouged out a large hole nearby, the surface didn't melt.

"We gave it every opportunity to melt, but to our surprise, it still wouldn't melt," Landman says. In fact, the surface repaired itself, filling in the hole (see diagrams above).

"This was of great interest to us," Herman says. "Because you would naturally think that defects would act as nucleation sites for disorder and melting, we had been wondering why you could superheat a surface that has defects." Real metal surfaces always have some defects.

Superheating can also occur in solids whose crystal structures differ from those of lead and copper. In the Aug. 15 PHYSICAL REVIEW B, Herman, Elsayed-Ali, and Elizabeth A. Murphy at Rochester report that a bismuth surface remains orderly at temperatures as high as 90 kelvins above bismuth's melting point.

"This shows how general this phenomenon is," Elsayed-Ali says.

– I. Peterson