Space Sciences

Envisioning the waters of Phobos

Does water lie frozen inside the tiny Martian moon Phobos? Scientists have many reasons to think there used to be a substantial amount of it, say Fraser P. Fanale and James R. Salvail of the University of Hawaii in Honolulu, who now suggest that perhaps some of the water remains.

Spectrally, Phobos resembles the class (C) of asteroids that appear similar to a group of meteorites called carbonaceous chondrites. Their compositions include varying amounts of water, and some show signs of having undergone "intensive alteration by liquids," the scientists note in the April GEOPHYSICAL RESEARCH LETTERS. Using estimates of how much water Phobos had when it formed and how much heating the satellite might have experienced during its history, Fanale and Salvail calculated how much water might remain in it and attempted to determine how far below the surface and how widely spread the water lies, probably in the form of ice.

Allowing for a wide variation in the number and sizes of the pores in Phobos' rock, the researchers conclude that the depth of the ice layer's top probably ranges from "a few tens to a few hundreds of meters" over much of the satellite. For example, halfway from the equator to each of the satellite's poles – a latitude of 45° north and south – the temperature at the top of the permanently frozen layer is about 225 kelvins. In the equatorial zone, the top of the ice would probably lie no lower than about 1 kilometer. And near the equator, no water may remain – unless water originally made up about one-fifth of the satellite's mass – because heat from various sources would have driven it off.

Fanale was one of several U.S. scientists invited to take part in the Soviet Phobos project, which was to carry out electromagnetic sounding of the satellite's depths from orbit, among other tasks. The Soviets lost communications with the Phobos 2 craft before its landers could be deployed. But they may soon announce results obtained before the craft fell silent – perhaps including spectra gathered from orbit that might reveal the presence of water.

Unexpected asteroid: A close call from space

It passed about twice the distance to Earth's moon, but an asteroid that missed the planet by some 500,000 miles on March 23 was only the second such object ever cataloged that came so close. The first, called Hermes, was discovered in 1937 but never located again. Others are known only because they left craters where they struck Earth's surface.

Henry E. Holt (a retired geologist with the U.S. Geological Survey in Flagstaff, Ariz.) and Norman G. Thomas (a retired astronomer from Lowell Observatory in Flagstaff) discovered the newcomer on April 6 in photos taken earlier with the 18-inch Schmidt telescope on Palomar Mountain in California. No astronomers saw the asteroid as it approached, because it came in through the daytime sky. Holt estimates the big boulder probably measured several hundred yards across, assuming that its albedo or reflectivity represents a surface like that of Earth's moon and some meteorites.

The object's orbit tilts about 5° from those of most planets in the solar system. So, although it is not in the orbital planes of Venus and Mars when it is at those planets' distances from the sun, the asteroid is approximately in plane when it crosses Earth's orbit, Holt says. Unless the asteroid's present orbit is perturbed by Earth or another object, its closest approaches to Earth should occur about every 25 to 30 years, since its year is only 14 to 15 days longer than Earth's. Next April, says Holt, it will probably pass "several million miles" away. More precise estimates of when and at what distance it will pass again will require extended observations to establish a more accurate orbit, since the object was seen only from March 31 to April 9.

Technology

Ivars Peterson reports from Baltimore at the Conference on Lasers and Electro-Optics

Giving the etch to superior optics

Most high-quality lenses are still made the way Isaac Newton made his – by grinding and polishing glass against glass. But even when automated, the process takes time, and when the lenses must have a specific geometric form for a particular application, the number of steps required to produce them increases dramatically.

For the last decade, researchers at the MIT Lincoln Laboratory in Lexington, Mass., have explored an alternative technology for making high-quality lenses and other optical elements. Using etching techniques borrowed from the integrated-circuit electronics industry, they can modify the surfaces of lenses to improve their optical properties. "Our aim is to make lenses better, cheaper and lighter," says MIT's Wilfrid B. Veldkamp. The new optical etching process is now developed enough that several companies are starting to use it for the commercial production of lenses.

The technique involves etching a lens surface to create a staircase pattern of notches that scatter light in just the right way. A diffraction grating, in which an array of parallel lines ruled on a glass or plastic surface spreads white light into a rainbow of colors, applies the same principle. By carefully controlling the depth, width and shape of such notches, the researchers can scatter light so it travels only in specific directions. Although the notion that a diffraction pattern can change the direction in which light travels goes back many years, the MIT researchers' achievement lies in learning to make the scattering process efficient. Their carefully computed designs ensure that all the scattering takes place in the appropriate directions so that no light is lost.

The etching process can turn a cheap lens into a high-performance optical element. A spherical lens – the kind of glass lens easiest to grind and polish – has the disadvantage that it doesn't focus light rays to a single point. The resulting image is somewhat distorted and fuzzy. But etching a carefully computed pattern of rings on the lens' surface corrects the problem. Similar etched patterns also remove the colored fringes often seen around images made by inexpensive lenses. "You can turn a $10 lens into a higher-quality one just by putting a diffraction-grating pattern on one side," Veldkamp says. Moreover, replacing a bulky, heavy, complex assembly of corrective lenses with a single etched lens capable of producing a clear image greatly simplifies the optical systems in telescopes and other instruments.

The MIT researchers have demonstrated their techniques on a variety of lenses suitable for infrared, visible and ultraviolet light. The trick is to match the lens material, which bends the light, with the appropriate etched pattern.

Because this etching process can be done on a microscopic scale, one of its most promising applications is in microoptics, for creating large arrays consisting of thousands of tiny lenses, each as small as a micron in diameter. Such arrays, which look like frosted glass, can be used for steering laser beams. They also act like a fly's eye to give a wide field of view. Incorporated into sensors consisting of layered structures that combine optics and electronics, they show promise as integrated, automated vision systems that both "see" and evaluate what is seen. Equipping a telescope with such a scanner would enable it to identify promising spots and zoom in on them without having to scan the whole scene to the same level of detail.

"We're right in the middle of an optics revolution," Veldkamp says. "We're using lithography and etching to replace a very labor-intensive fabrication process." He adds: "The ability to mass-produce diffractive relief elements by embossing, forging or molding from a single master element is what gives this technology great potential. This potential is still largely untapped."