York University Medical School) and Henry Slayter at Harvard Medical School applied them to ribosome crystals. In positive staining, contrast is provided by heavy metal ions bound to the specimen, rather than coating its surface. With a modified version of the Fourier technique of DeRosier and Klug, Lake determined an electron density map of the ribosome at a resolution of 100 angstroms from the 17 different views present in a micrograph of a sectioned helical array of ribosomes.

Although Fourier transform methods seem to many researchers to be the natural way to go about image reconstruction, there are other possible approaches. For example, in 1970, Richard Gordon (now at the National Institute for Arthritis, Metabolism, and Digestive Diseases, Bethesda, Maryland), Robert Bender, and Gabor Herman of the State University of New York at Buffalo proposed a method called the algebraic reconstruction technique (ART) that did not use Fourier transforms. Instead, ART is an iterative technique that searches for the minimum discrepancy between actual projections (micrographs) and computed projections of an estimated image. Although ART and its variants are of much interest to researchers in other disciplines, most electron microscopists are sticking with the Fourier technique.

Also at the MRC laboratory, Klug and Tony Crowther have developed criteria for obtaining maximum information from a set of projections while, at the same time, preventing the introduction of artifacts in the image. Although their analysis was carried out in terms of Fourier space, the investigators' results are valid for other reconstruction methods. And Harold Erickson and Klug demonstrated how to recover the maximum contrast in an object by defocusing the electron microscope and using a computer to compensate for the distortion in the resulting image. This procedure was an essential ingredient of Unwin and Henderson's success.

Despite its potential efficacy in imaging biological molecules, three-dimensional image reconstruction has not yet become a widely practiced technique. In the United States, for example, Lake and his associates at the New York University Medical School, who have been studying ribosomes, and David Eisenberg, Frederick Eiserling, and their colleagues at the University of California, Los Angeles, who have been combining

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The Coldest Planet: Methane Ice Found on Pluto

Pluto is 39 times farther away from the sun than the earth is, and at that distance it appears fainter than many stars. The sun's radiation is so weak at Pluto that temperatures close to absolute zero have long been expected.

The difficulties in observing such a faint object are great, and so it was with much excitement that planetary astronomers received the recent news that the surface composition of Pluto had been measured for the first time, and found to be frozen methane. The finding means that the surface must be colder than 50°K, the temperature at which pure methane condenses at very low pressure. It also lends credence to certain theories of the origin of the solar system, and suggests that perhaps Pluto is the only planet that has survived in a pristine state, preserving a memory of the conditions at which it was formed 4.6 billion years ago.

Using the 4-meter telescope at the Kitt Peak National Observatory, three astronomers from the University of Hawaii showed by reflectance spectroscopy that the surface of the outermost planet is at least partially covered with methane ice. Dale Cruikshank, David Morrison, and Carl Pilcher observed the infrared reflections of Pluto through two very narrow band filters—one selected to admit bright reflections from water ice and the other to admit reflections from methane ice. "On Pluto, the response of the filters was exactly as expected for methane ice," says Cruikshank. The filters were also used to observe several moons of Saturn, already known to have the spectral signature of water ice, and the opposite response was found. Only Pluto exhibited the band ratio expected for methane ice.

Although methane was known in the atmospheres of Jupiter, Saturn, Uranus, and Neptune, and had also been identified as an obvious component of the atmosphere of Titan, a moon of Saturn, the recent measurements were the first detection of methane in solid form. The data were obtained during five nights in mid-March, using one of the world's largest telescopes, an instrument that is normally used for stellar and extragalactic astronomy.

Of course, the measurement alone can only be a hint at the complete description of Pluto, but it suggests that Pluto is small and icy, with low density—more like the satellites of the outer planets than the outer planets themselves.

Previously, Pluto was thought to be about 6000 kilometers in diameter, but refinements based on the methane discovery will tend to lower that estimate, according to the Hawaii astronomers, perhaps to the size of the moon (3500 kilometers). Such small planetary bodies are the ones most likely to radiate away their internal heat without undergoing chemical change. The measurement of Pluto's methane coat, says Morrison, is an insight into the "surface composition of objects small enough to retain some memory of the conditions at which they formed."

If solid methane composes more than the surface of Pluto, the planet should have a very low density. But its density is virtually unknown. The diameter is in question and some astronomers think no limits at all can be put on the mass with the data available. Thus its bulk composition is also unknown, but the general considerations of the chemistry of the outer planets give some clues.

Chemical models of the outer solar system predict that it should be rich in water, ammonia, and methane—as well as their combinations—because they would be the last substances to condense out of the early solar nebula. Laboratory chemistry, with the help of computer calculations, shows that among these icy materials, pure methane should be the last to condense. Thus it is something of a confirmation to find it on the outermost planet, which was presumably formed at the lowest temperature. But Pluto could also have a more complex structure. It could have a core of water ice, formed first, followed by layers of methane clathrate, ammonia clathrate, and finally pure methane ice.

Referring to Pluto's genesis from the solar nebula, David Morrison says, "We have at last found one point where it was cold enough to produce solid methane."—W.D.M.