Two estimates conflict on Charon's density

Locked in a gravitational embrace 5.9 billion kilometers from the sun, Pluto and its moon, Charon, rank among the least explored bodies in the solar system. This week, astronomers reported two new estimates of the density of Charon.

Though the estimates differ — one group calculates that Charon has about the same density as Pluto, while the other estimates it has significantly less — the findings may ultimately shed light on the origin and composition of these distant denizens of our solar system.

George W. Null and his colleagues at NASA's Jet Propulsion Laboratory in Pasadena, Calif., base their findings on observations taken by the Hubble Space Telescope during four days in August 1991. Hubble resolved each member of the closely orbiting Pluto-Charon pair. Using the single star in their images as a reference point, the researchers tracked the center of mass of the Pluto-Charon system and calculated each body's mass and density.

Null's team, which includes William M. Owen Jr. and Stephen P. Synnott, puts Charon's density at 1.30 grams per cubic centimeter (gm/cm^3), with an uncertainty of 0.23 gm/cm^3. That number is about 60 percent of the density of Pluto. The astronomers presented their findings this week in Flagstaff, Ariz., at a conference on Pluto and Charon. They also detail their study in the June ASTRONOMICAL JOURNAL.

Another team, headed by Leslie A. Young of the Massachusetts Institute of Technology, calculates that Charon has a density similar to that of Pluto. The scientists observed the planet and its moon for six nights in early 1992, using the University of Hawaii's 2.2-meter telescope atop Mauna Kea. At the Flagstaff conference, Young and her colleagues reported that Charon has a density of 2.35 gm/cm^3, with an uncertainty of 0.02 gm/cm^3.

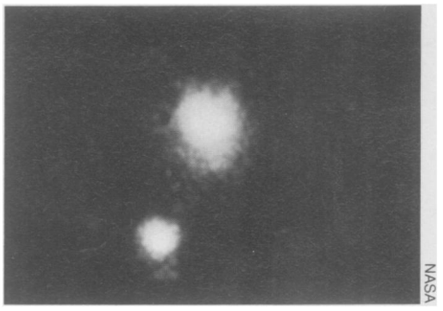
Young notes that, unlike Hubble, their telescope could not separate the Pluto-Charon pair into its individual partners. However, she adds, the Hawaii telescope's larger field of view encompassed 10 stars, compared with Hubble's single reference star. Null says his team calculates that additional reference stars should make little difference in the accuracy of its density determination.

If Charon has a density similar to Pluto's — halfway between that of rock and ice — it would indicate that Charon is a mixture of the two kinds of materials, Young says. In contrast, she adds, Null's estimate suggests that Charon is mostly ice.

S. Alan Stern of the Southwest Research Institute in San Antonio, Texas, notes that if Charon is less dense than Pluto, it would support the theory that the satellite was created by a projectile that slammed into Pluto after the planet's denser material had sunk toward its core. The projectile would have gouged a Charon-size chunk from Pluto's low-density mantle, akin to the way astronomers believe our moon was gouged from Earth. He notes that if Pluto and Charon have the same density, a collision could still have created Charon, but it must have happened before the planet's denser material separated out.

Null and Young agree that more observations should settle the density debate. They won't have to wait long. This August, Null and his colleagues will again use Hubble to observe Pluto and Charon.

— *R. Cowen*

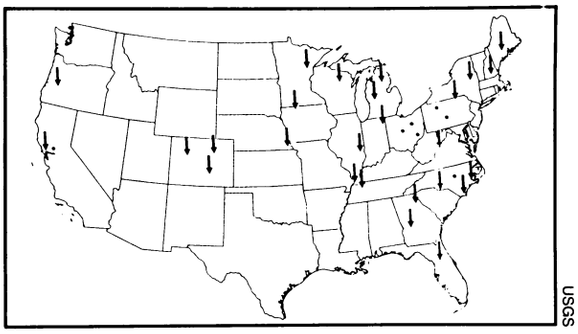


Hubble Space Telescope's 1991 view of Pluto and Charon.

Acid precipitation drops in United States

Measurements of rainwater at selected locations across the United States reveal a significant decline in the pollution that causes acid rain, according to a report issued last week by the U.S. Geological Survey.

The study shows that between 1980 and 1991, the concentration of sulfate ions — a key component of acid precipitation — dropped at a statistically significant rate at 26 out of 33 rainwater collection sites.



Arrows show stations where concentrations of sulfate in rainwater declined between 1980 and 1991. Dots show stations lacking a significant trend for sulfate.

"The decreases are fairly substantial and they are widespread," says Timothy A. Cohn, who coauthored the report with William G. Baier, both at the USGS in Reston, Va. Although the national network of rain collection sites has some 200 stations, the two researchers focused on sites with the most extensive precipitation records.

The USGS study also found that the acidity of rainwater decreased over the same period at most of the sites. The pH of precipitation rose significantly at nine of the 33 stations, signaling decreasing acidity. An additional 16 stations showed an increase, but in these cases the changes were not large enough to be statistically significant.

Such trends represent the payoff from air pollution standards put in place in the 1970s during implementation of the Clean Air Act of 1970 and its 1977 amendments. Although not fashioned to address acid rain, the laws sought to improve air quality by reducing emissions of sulfur dioxide gas, which turns into sulfate in the atmosphere. These emissions come chiefly from power plants that burn fossil fuels, especially sulfur-rich coal.

Since 1970, U.S. emissions of sulfur dioxide have dropped by 30 percent, with most of the decline coming in the 1970s and early 1980s, says Derek Winstanley, director of the National Acid Precipitation Assessment Program in Washington, D.C. The 1990 amendments to the Clean Air Act require the nation to reduce its sulfur dioxide output some 40 percent from the 1980 level.

The act also calls for a 10 percent reduction in emissions of nitrogen oxides, which convert in the atmosphere into nitrate, another component of acid rain. Nitrogen oxides are found in power plant emissions and car exhaust.

The USGS study shows that nitrate concentrations in the rainwater dropped at most stations, but only three sites displayed statistically significant declines. Jack Pickering of the USGS says the absence of major nitrate reductions conforms to expectations, because releases of nitrogen dioxides have not declined as much as sulfur dioxide emissions.

While other studies have shown decreasing concentrations of sulfate in rainwater, the USGS is the first to show the increases in pH that researchers have expected to see as sulfur emissions fall. "If we didn't start to see an increase in pH as we reduce sulfur dioxide emissions, we'd begin to wonder if we had an effective program in place here. This gives us confidence that things are working in the direction that one would hope," says Winstanley.

— *R. Monastersky*