Almost Planet X

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Optical and infrared observations of a bright object in the outer Solar System reveal it to be surprisingly large — almost as big as Pluto's moon. It could be the first of many such discoveries.

When Neptune, the eighth planet in the Solar System, was discovered in 1846, astronomers began looking for a ninth. Inspired by irregularities in Neptune's orbit, Percival Lowell began searching in 1905 for what he called Planet X. But it wasn't until 1930, 14 years after Lowell's death, that Clyde Tombaugh of the Lowell Observatory in Flagstaff, Arizona, discovered Pluto. The search for Planet X was over. Or was it? Pluto turned out to be much smaller than expected, and some astronomers, including Tombaugh, continued to search for a tenth planet, beyond Pluto.

No one has found a tenth planet, but during the past decade astronomers have discovered that Pluto is not alone. It seems that Pluto and its moon Charon are the largest known members of an ancient ring or belt of icy bodies, known as the Kuiper belt[1,2]. The primitive nature of the material in this belt might hold important clues about the formation and evolution of the Solar System. Unfortunately, apart from Pluto and Charon, these objects are so faint that studying their most basic properties requires a herculean effort. On page 446 of this issue, Jewitt, Aussel and Evans[3] present the best measurements yet of the size and reflectivity of another body in the belt. Their work raises the possibility that Pluto is not the only Planet X, but perhaps one of several.

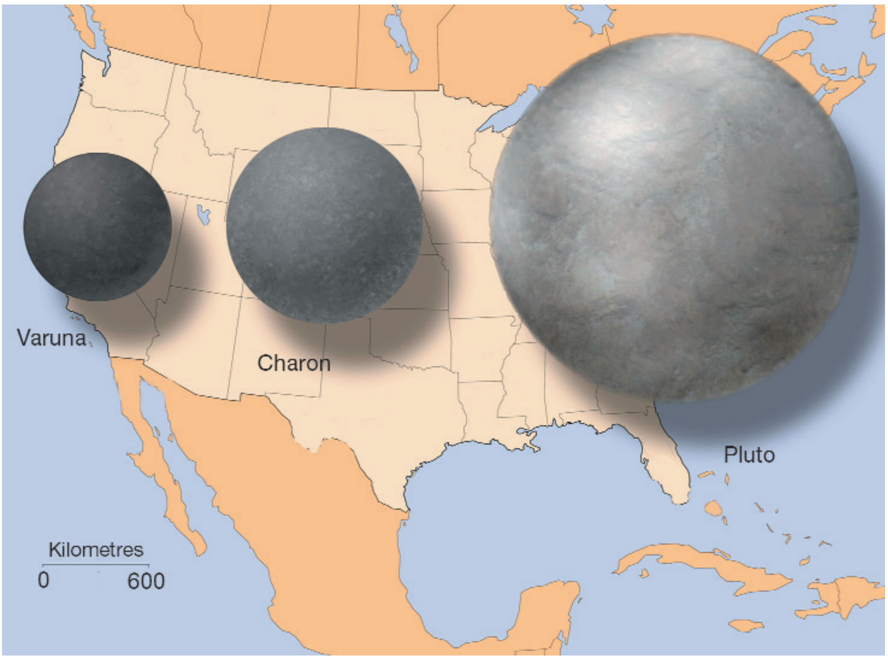

Figure 1 **The size and surface darkness of the ninth planet Pluto, its moon Charon, and the newly discovered object Varuna, the three largest known members of an ancient belt of icy objects that surround the eight planets closest to the Sun. Varuna was discovered by the Spacewatch team at the University of Arizona[4], who regularly scan the skies for asteroids and comets. Infrared and optical measurements by Jewitt and colleagues[3] suggest that Varuna is by far the largest body so far discovered in the belt, apart from Pluto and Charon. This work implies that Pluto and Charon are not unusually large, and that there may be other, as yet undiscovered objects in the outer reaches of the Solar System, perhaps including 'planets' even larger than Pluto.**

The body studied by Jewitt and colleagues, now called Varuna[4] (Fig. 1), was detected last November by the Spacewatch telescope in Arizona. It is the third brightest object in the belt, after Pluto and Charon. The optical and infrared measurements made by Jewitt *et al.* show that Varuna is slightly smaller than Charon, making it the third largest known object in the belt, but with a much darker surface than Charon. The results suggest that Pluto and Charon are not uniquely large objects, and that a continuum of sizes may exist. We can now imagine that bodies even larger and more distant than Pluto will be found. Such objects have so far escaped detection because of their extreme faintness, which is due in part to the feeble illumination from the Sun, and in part to their very dark surfaces.

The idea of a belt of icy bodies surrounding the outer planets goes back to 1930, soon after the discovery of Pluto. Leonard[5] was the first to publish the idea, which was later expanded upon by Kuiper[6] and Edgeworth[7]. For 60 years, Pluto and its moon Charon were the only known objects in the Kuiper belt. The third was found in 1992 (ref. 1), following advances in telescope and detector technology. There are now nearly 400 known objects in the belt, although there may be hundreds of thousands of 100-km-sized bodies and possibly billions of 10-km-sized objects that have yet to be discovered[8]. Although there are so many Kuiper belt objects (KBOs), the total mass of the belt is probably only about a tenth the mass of the Earth[8]. All the evidence to date suggested that Pluto was a uniquely large object within the Kuiper belt.

Presently, the best way to estimate the diameter of a KBO is to measure the amount of sunlight it reflects, using an optical telescope. At a given distance, the brighter the object, the larger the surface area facing the Earth. But there is a caveat. The brightness of an object depends not only on the area of the reflecting surface, but also on the albedo, the percentage of sunlight the surface reflects. Material as black as charcoal has an albedo of about 4%, whereas material as reflective as frost has an albedo of about 40%. So optical brightness measurements alone cannot distinguish between a large, dark object and a small, highly reflective one. Determining independent values for the diameter and albedo requires measuring both the sunlight reflected and the thermal infrared light emitted by the body.

This technique has been successfully used to determine the diameter and albedo of asteroids in the inner Solar System. But KBOs are much harder to detect in the infrared because they emit radiation at wavelengths that can be easily absorbed by the Earth's atmosphere. Some objects, known as Centaurs, are thought to have escaped from the Kuiper belt and can be found throughout the outer Solar System, sometimes passing even closer to the Sun, not far from Earth[8]. As the Sun warms them, some of the icy material evaporates in a cloud of dust and gas, which is occasionally visible as the tail of a comet. Until now, astronomers have assumed that KBOs have an albedo similar to the closer Centaur objects and comets[8], whose albedo is typically 4%. Such an assumption is fraught with danger because the Sun's warmth may trigger chemical and physical changes in Centaurs that alter their surface reflectivity.

Varuna is so bright that Jewitt and colleagues have been able to measure simultaneously its optical reflectivity and infrared emission; they found that it has a diameter of 900 km and an albedo of 7%. Its surface is darker than that of Pluto and Charon, but its albedo is slightly higher than the value previously assumed for KBOs. Only Pluto and its satellite Charon have larger diameters than Varuna (2,400 km and 1,200 km, respectively). So Varuna closes the gap between the largest previously known KBO, which was around 600 km in diameter (assuming an albedo equal to that of Varuna), and the smallest planet in the Solar System, Pluto.

Varuna and the handful of Centaurs whose albedos have been measured all have dark surfaces, which tells us there is little surface frost or ice. We already know that Pluto and Charon have very bright surfaces[9]. Because of its size, Pluto is a very different beast to the other KBOs — it is large enough to retain a tenuous atmosphere, resulting in a global surface frost. Charon, on the other hand, has a similar diameter to Varuna, but its albedo (40%) is about six times that of Varuna. Why do Varuna and Charon have such different albedos? It could be because the surface of Charon is covered in frozen water[10], perhaps a result of whatever process caused it to become a moon of Pluto.

More measurements of thermal emission are needed to determine whether dark surfaces are ubiquitous in the Kuiper belt, as well as to obtain reliable diameters. Thermal infrared observations of these faint objects are extraordinarily difficult from the ground, but much easier in space. The Space Infrared Telescope Facility (SIRTF) satellite is expected to measure the diameters and albedos of dozens of KBOs after its launch in 2002. Such observations are our best chance of finding more planets beyond Pluto. ■

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