The Kuiper belt, a region of small, icy bodies thought to be left over from the formation of the solar system, extends from the orbit of Neptune to more than 5 trillion miles from the Sun. It contains numerous bodies called Kuiper belt objects (KBOs), the most famous being Pluto and its moons. Due to their small size, only the larger KBOs can be detected with direct imaging. Smaller objects, however, can be detected indirectly when they pass in front of a background star and partially obscure the stellar light. These events, called occultations, should last only several tenths of a second for such small and distant KBOs; therefore this method of detection requires a dedicated observing plan that carefully monitors many stars. Hilke Schlichting, of the Canadian Institute for Theoretical Astrophysics in Toronto, and her collaborators devised an unconventional way to detect these tiny KBOs: by extracting their signatures from previously collected Hubble engineering data.

Hubble has three optical instruments called Fine Guidance Sensors (FGSs) that provide high-precision navigational information to the space observatory’s attitude control system. They do this by exploiting the wave nature of light to make extremely precise measurements of stellar positions. Schlichting and her team determined that the FGS instruments are also sufficiently sensitive to detect the faint signal of a KBO passing in front of a star. Such an event would cause a brief occultation and a diffraction signature in the FGS data as the light from the background guide star is bent around the intervening foreground KBO.

The researchers selected 4.5 years of FGS observations for analysis. During this period Hubble’s FGSs spent a total of 12,000 hours observing along a strip of sky within 20 degrees of the solar system’s ecliptic plane. This is where scientists expect to find the majority of KBOs. Schlichting and her team analyzed the FGS observations of 50,000 guide stars in total. Scouring the huge database, they found a single 0.3-second-long occultation event. Detection was only possible because the FGS instruments sample changes in starlight 40 times a second. The researchers found the KBO at an inclination of 14 degrees to the ecliptic, and assumed the KBO was in a circular orbit. The KBO’s distance was then estimated from the duration of the occultation, and the amount of dimming was used to calculate the size of the object.

The tiny body appears to be just over a half mile—or approximately 1 kilometer—across and is located 4.2 billion miles away. The object is so small and distant that it is 100 times dimmer in reflected sunlight than what Hubble can see directly. In fact, the smallest KBO previously seen in reflected light by any telescope is roughly 30 miles across, or 60 times larger.

This small KBO represents a missing link between micron-sized dust particles and larger KBOs in the Pluto-size class of 1,000 km. Researchers have long suspected that these bodies exist, but previously lacked proof for objects of this size. They are believed to be the result of collisions among the members of the original Kuiper belt population.

The detection of only one event actually reveals a deficit of sub-kilometer-sized objects compared with the population extrapolated to exist from the known number of large Kuiper belt objects. This implies that sub-kilometer-sized objects are undergoing collisional erosion. These small bodies are likely the source material
Dr. Hilke Schlichting is a Hubble postdoctoral fellow at the University of California, Los Angeles. Her work focuses on planet formation, particularly the dynamical and physical properties of the Kuiper belt and Oort cloud populations, and the information they reveal about the formation of the solar system. Her past research has included the origins of planetary spins and the velocity distribution of planetesimals and protoplanets during various stages of their formation. Schlichting received her B.A. and M.S. in physics from the University of Cambridge and her Ph.D. in astrophysics from the California Institute of Technology. She was born in Bad Soden, Germany, and has lived in Germany, Japan, England, Canada, and the United States.

A brief occultation and diffraction signature was seen in the Hubble Fine Guidance Sensor data as the light from a background star was bent around the intervening foreground KBO. (Artist’s conception).

for comets, and additional observations may shed light on whether comets are solid, like pieces of rock, or more closely resemble collections of rubble held together by gravity.

In an effort to uncover more small KBOs, the team plans to analyze the remaining FGS data for nearly the full duration of Hubble operations since its launch in 1990. The discovery of additional objects could provide direct evidence for the theorized population of approximately 10,000 bodies thought to supply the number of observed Jupiter-family comets—those with periods of less than 20 years. Such research is a powerful illustration of the capability of archived Hubble data to enable new and important discoveries.

Further Reading

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