RESEARCH ARTICLE SUMMARY

PLANETARY SCIENCE

The small satellites of Pluto as observed by New Horizons

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INTRODUCTION: The Pluto system is surprisingly complex, comprising six objects that orbit their common center of mass in approximately a single plane and in nearly circular orbits. When the New Horizons mission was selected for flight by NASA in 2001, only the two largest objects were known: the binary dwarf planets Pluto and Charon. Two much smaller moons, Nix and Hydra, were discovered in May 2005, just 8 months before the launch of the New Horizons spacecraft, and two even smaller moons, Kerberos and Styx, were discovered in 2011 and 2012, respectively. The entire Pluto system was likely produced in the aftermath of a giant impact between two Pluto-sized bodies approximately 4 to 4.5 billion years ago, with the small moons forming within the resulting debris disk. But many details remain unconfirmed, and the New Horizons results on Pluto's small moons help to elucidate the conditions under which the Pluto system formed and evolved.

RATIONALE: Pluto's small moons are difficult to observe from Earth-based facilities, with only the most basic visible and near-infrared photometric measurements possible to date. The New Horizons flyby enabled a whole new category of measurements of Pluto's small moons. The Long Range Reconnaissance Imager (LORRI) provided high–spatial resolution panchromatic imaging, with thousands of pixels across the surfaces of Nix and Hydra and the first resolved images of Kerberos and Styx. In addition, LORRI was used to conduct systematic monitoring of the brightness of all four small moons over several months, from which the detailed rotational properties could be deduced. The Multispectral Visible Imaging Camera (MVIC) provided resolved color measurements of the surfaces of Nix and Hydra. The Linear Etalon Imaging Spectral Array (LEISA) captured near-infrared spectra (in the wavelength range 1.25 to 2.5 μm) of all the small moons for compositional studies, but those data have not yet been sent to Earth.

RESULTS: All four of Pluto's small moons are highly elongated objects with surprisingly high surface reflectances (albedos) suggestive of a water-ice surface composition. Kerberos appears to have a double-lobed shape, possibly formed by the merger of two smaller bodies. Crater counts for Nix and Hydra imply surface ages of at least 4 billion years. Nix and Hydra have mostly neutral (i.e., gray) colors, but an apparent crater on Nix's surface is redder than the rest of the surface; this finding suggests either that the impacting body had a different composition or that material with a different composition was excavated from below Nix's surface. All four small moons have rotational periods much shorter than their orbital periods, and their rotational poles are clustered nearly orthogonal to the direction of the common rotational poles of Pluto and Charon.

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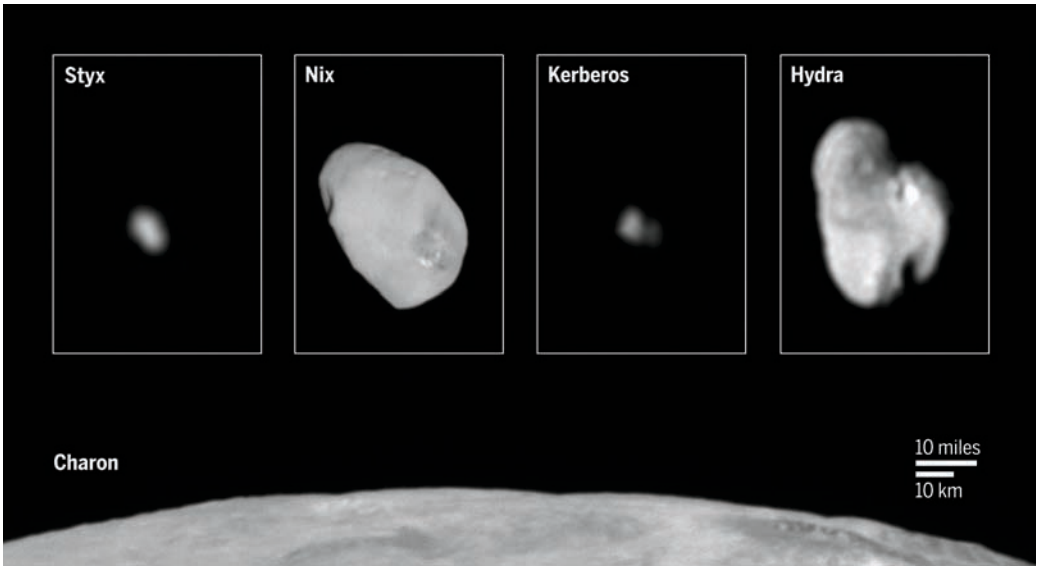

Pluto's family of satellites. NASA's New Horizons mission has resolved Pluto's four small moons, shown in order of their orbital distance from Pluto (from left to right). Nix and Hydra have comparable sizes (with equivalent spherical diameters of ~40 km) and are much larger than Styx and Kerberos (both of which have equivalent spherical diameters of ~10 km). All four of these moons are highly elongated and are dwarfed in size by Charon, which is nearly spherical with a diameter of 1210 km. The scale bars apply to all images.

CONCLUSION: Pluto's small moons exhibit rapid rotation and large rotational obliquities, indicating that tidal despinning has not played the dominant role in their rotational evolution. Collisional processes are implicated in determining the shapes of the small moons, but collisional evolution was probably limited to the first several hundred million years after the system's formation. The bright surfaces of Pluto's small moons suggest that if the Pluto-Charon binary was produced during a giant collision, the two precursor bodies were at least partially differentiated with icy surface layers. ■

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