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Rotation States of Pluto's Small Moons and the Search for Spin-Orbit Resonances

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Abstract

During the New Horizons flyby of Pluto, it was observed that the four small moons, Styx, Nix, Kerberos and Hydra, have very unusual spin states. Whereas we might have expected the moons to be tidally locked, they are in fact all spinning at rates markedly faster than their mean motions. Also, all of the moons' rotation poles are misaligned with their orbital poles; several moons have obliquities near 90°. It has been speculated that these states may be the result of spin-orbit resonances driven by the large, regular perturbations from the central "binary planet" comprising Pluto and Charon. However, to date, no such resonances have been associated with the moons' rotations.

We are currently in the second year of a Hubble Space Telescope observing program focused on the photometry and dynamics of the Pluto system. The most recent data set, combined with earlier HST images obtained during 2010–2015, provides a very long baseline for determining the rotation state of each small moon. The analysis, however, is complicated by the presence of marked year-by-year variations in the amplitudes of the light curves. These are the result of polar precession, which causes each moon's orientation toward the Earth to vary on time scales of a few years.

We will present the initial results of new data analysis and 3-D modeling that enable us to recover the polar precession rate and orientation of each moon. Preliminary results show that these rates are compatible with New Horizons data, but much more precise. We note that the model of high-obliquity moons that are both spinning and precessing explains the photometry better than the earlier hypothesis by Showalter and Hamilton[1] that these moons are in chaotic rotation.

With the new results in hand, we will revisit the question of whether any spin-orbit resonances are active. Because of the large obliquities and polar precession, the standard formulas do not apply. Instead, each resonance is defined by three periods: the rotation period, the polar precession period, and the synodic orbital period with Charon. The resonant spin rates derived from this new formulation are very different what one would expect if polar precession is ignored, as it has been in previous searches for resonances. As a result, the question of whether the unusual rotation states are defined by spin-orbit resonances remains open.

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References

[1] Showalter, M. R., and Hamilton, D. P. (2015) *Nature,* **522**, 45–49, doi:10.1038/nature14469.