PUTTING (486958) ARROKOTH IN CONTEXT: NEW HORIZONS PHOTOMETRY OF OTHER SMALL COLD CLASSICAL KUIPER BELT OBJECTS. A. J. Verbiscer[1], S. B. Porter[2], J. J. Kavelaars[3], P. Helfenstein[4], S. D. Benecchi[5], H. A. Weaver[6], J. R. Spencer[2], K. N. Singer[2], S. A. Stern[2], J. W. Parker[2] and the New Horizons Science Team, [1]University of Virginia, P.O. Box 400325, Charlottesville, VA 22904-4325 (av4n@virginia.edu), [2]Southwest Research Institute, [3]National Research Council of Canada, [4]Cornell University, [5]Planetary Science Institute, [6]The Johns Hopkins University Applied Physics Laboratory.

Introduction: In addition to its 3500-km flyby of Kuiper belt object (KBO) (486958) Arrokoth, NASA's New Horizons spacecraft has observed more than 30 other KBOs and dwarf planets at viewing geometries unattainable from Earth. Several of these KBOs, like Arrokoth, are members of the dynamically cold classical (CC) population; therefore, the New Horizons observations of these objects at high solar phase angles provide important context to place Arrokoth among other small CC KBOs (H_V = 8-11) in terms of their rotation rates, rotation pole orientations, shapes, and surface scattering properties.

Observations: New Horizons observed CC KBOs 2014 PN_{70}, 2014 OS_{393}, 2011 HF_{103}, 2011 HZ_{102}, 2011 JY_{31}, and 2011 JX_{31} from distances as small as 0.09 au at multiple solar phase angles between 19° and 122°.

Results: Rotation periods range from 12.05 hours for 2014 PN_{70}, near Arrokoth's 15.92-hour period [1] to more than 35 hours for 2014 OS_{393} and 2011 JY_{31}. The amplitudes of most CC KBO rotation curves increase with increasing solar phase angles (Fig. 1), likely due to their irregular shapes, in the same manner as the amplitudes of irregular saturnian satellite [2] and asteroid [3] rotation curves increase with phase angle. Binary CC KBO 2011 JY_{31} [4-5], however, has a low-amplitude (0.2 magnitudes) rotation curve that does not increase in amplitude with increasing phase angle [6]. All CC KBOs observed by New Horizons, including Arrokoth, have steep solar phase curves and small phase integrals, much like those of other small, dark asteroids, comet nuclei, and satellites, and unlike the shallower phase curves exhibited by larger KBOs with more surface volatiles (Fig. 2) [7].

Acknowledgments: This work was supported by the New Horizons Project under contract NASW-02008 to NASA.

References: [1] Stern S. A. et al. (2019) *Science, 364,* aaw9771. [2] Denk T. and Mottola S. (2019) *Icarus, 128,* 49. [3] Gehrels T. (1956) *ApJ, 123,* 331. [4] Porter S. B. et al. (2020) *BAAS, 52,* Abstract #307.03. [5] Weaver H. A. et al. (2022) *PSJ*, submitted. [6] Verbiscer A. J. et al. (2019) *AJ*, *158*, 123. [7] Verbiscer A. J. et al. (2022), *PSJ*, submitted.

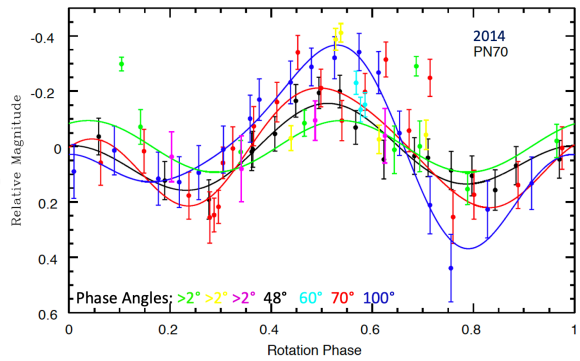

Figure 1: Rotation curves for CC KBO 2014 PN_{70}, once a potential close flyby target for New Horizons, which came within 0.1 au of this KBO in March 2019. 2014 PN_{70} has a rotation period of 12 hours with double-peaked rotation curves that increase in amplitude with increasing phase angle. Amplitudes are 0.2 magnitude at phase angles <2° (green, yellow, and magenta), 0.3 magnitude at phase angle 48° (black), 0.4 magnitude at phase angle 70° (red), and 0.8 magnitude at phase angle 100° (blue).

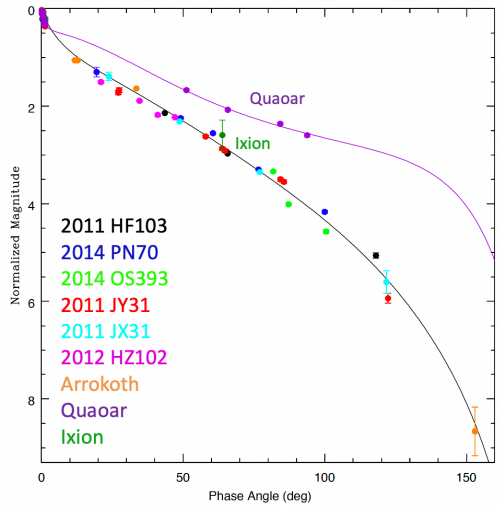

Figure 2: Solar phase curves of all CC KBOs observed by New Horizons and large KBOs Ixion and Quaoar. Quaoar has more surface volatiles than Ixion and the CC KBOs and therefore has a shallower solar phase curve [7].