Rotational Periods of Kuiper belt Objects and Centaurs with K2

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Kuiper belt objects (KBOs) are the small icy remnants of planet formation orbiting beyond Neptune. Centaurs are the recent escapees from the Kuiper belt on unstable giant planet crossing orbits in the middle solar system. Starting with campaigns 2 and 3, we plan on proposing to observe all KBOs and Centaurs brighter than 21.6 V mag with K2 (in total ~10-15 objects depending on final Field 4-8 centers selected) to obtain an unbiased sample of rotational periods. The distribution of rotation rates and shapes of these bodies allow us to probe both the angular momentum distribution and collisional evolution of the early planetesimal disk that today's Kuiper belt originated from. Unable to be resolved beyond a point source by most ground- or space-based telescopes, the rotational light curve is one of our only means of probing the shape, density, and surface properties for nearly all KBOs and Centaurs. Elongated planetesimals have brightness variations > 0.15 mag, and spherical bodies have light curve amplitude variations < 0.15 mag caused by varying albedo spots on their surfaces.

To achieve a few percent photometric precision necessary to measure the rotations of 20-22nd magnitude KBOs and Centaur requires 2-4-m class ground-based telescopes and a large number of nights with good weather, a significant investment of dedicated time on these facilities. Even then, in many cases a unique period cannot be identified. For example, Benecchi et al (2013) had 39 nights on a 2.5-m telescope observing 32 KBOs, but only successfully identified periods for 15. Only ~100 of the nearly 1000 known KBOs and Centaurs with secure orbits have rotational periods measured or constrained, but numerous observable biases are contained in this sample. Their observed rotational periods are typically a few hours to several days with the vast majority having periods around 7-9 hrs. Due to ground-based observing at a single site (usually only for a few nights), they have detected light curves are skewed towards higher amplitudes and rotations faster than a single night.

The K2 mission offers a rare chance to study the Kuiper belt. For a 20-21.5 V magnitude object, a single 30-minute exposure with K2 with fine guiding is estimated to achieve a few percent photometric accuracy (according to the Guest Observer Office). K2 light curves of KBOs and Centaurs will have the greatest number of data points ever obtained on distant Solar System objects. With this photometric precision and the nearly continuous observation, K2 will measure the rotational periods and shapes for KBOs and Centaurs where previous attempts were unsuccessful either because they have too low amplitudes or periods too long to detect effectively with ground-based resources. K2 will be able to break the degeneracy between single peaked and double peaked light curves for KBOs where periods have been identified but aliases exist due the limited number of observations on ground-based telescopes (typically a few observations per night scattered over a semester). Observing even a few objects with K2 would be a significant addition to the known sample and help better understand the biases in the current sample of rotations measured from the ground.

Using the JPL Horizons ephemeris program, we identified all the KBOs with V > 21.6 mag that fall within Campaigns 2 and 3's fields-of-view (FOV) and spend several days to the full campaign on silicon (see the Table below). The objects only move a few arcseconds per hour with star-like PRFs in a single K2 observation. To monitor these objects, which move a few arcminutes per night, would require a target pixel mask over their path on the FOV. Table 1 has the break down per object of positional uncertainty and total days on silicon. 2013 PH44 and 2002 KW14 have higher positional uncertainties, but they are observable throughout the summer and we are applying for LCOGT Director's Discretionary time for astrometric follow-up observations on the 2-meter Faulkes telescopes to secure the positional uncertainty to well below a Kepler pixel (4'').

Name	V Magnitude	3-sigma RA Uncertainty (arcseconds)	3-sigma Dec Uncertainty (arcseconds)	Campaign	Approximate Days on Silicon
2002 KW14	21.38	9.239	3.385	2	88
2002 KX14	20.53	1.481	0.697	2	87
2007 JH43	20.98	1.128	0.687	2	88
2007 JJ43	20.25	2.455	0.499	2	73
2013 PH44	20.84	11.638	2.642	3	44

References: Benecchi, S. & Sheppard, S. 2013, AJ, 145, 124