Rotation Period of the Mars Flyby Comet C/2013 A1 (Siding Spring)

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The dynamically new (DN, first time in the inner solar system) comet C/2013 A1 (Siding Spring) will pass Mars on 2014 Oct 19 at a distance of only 135,000 km. Mars-orbiting spacecraft will use this unprecedented opportunity (estimated to occur every $\sim 10^5$ yr; Ye & Hui 2014, ApJ in press) to study the comet's innermost coma and potentially resolve the nucleus to scales as small as 150 m. Outside of radar imaging, such high-resolutions normally require spacecraft flybys. However, we have not visited a DN comet due to their high relative velocities and stochastic perihelion passages. Further highlighting the importance of this event, NASA has organized a campaign (cometcampaign.org) to encourage and facilitate observations of the comet. Shortly after the Mars encounter, from Oct 20–26, the comet crosses the K2 Campaign 2 field. We propose K2 apertures to measure the comet's lightcurve during this period, especially to put the Mars-orbiter and Earth-based data into a broader context. K2's 30-min cadence, photometric stability, high-observing efficiency, and the comet's 77-hr duration on silicon (most rotation periods are <20 hr) are ideal for these tasks.

Dynamically new and short-period comets behave differently, and understanding the thermal, structural, and compositional origins of this difference is crucial to connecting the composition of comets to the early solar system. Comet Siding Spring's Mars encounter is a rare opportunity that will yield a rich data set, including comprehensive gas and dust production rates as a function of time. These production rates will enable detailed nucleus thermal modeling, which can be used to address the differences between comet classes. The nucleus rotation period is a critical parameter for those models, since it controls, in part, heat propagation into the nucleus subsurface. As the nucleus rotates, the mass-loss rate varies as active areas move in and out of sunlight, which causes the total coma brightness to vary. Thus, a high-precision K2 lightcurve of the coma can be used to derive the comet's rotation period, to search for spontaneous outburst activity, and to enable temporal comparisons between data sets obtained from Mars- and Earth-based observatories.

Why Kepler? Comet rotation periods are challenging to measure with ground-based observatories due to constraints that restrict observability and lead to period aliases (e.g., horizon, solar elongation). However, K2 will have 77 hr of a near-constant perspective (distance varies $\pm 10\%$, phase angle ± 1 deg), interrupted only by one non-functioning CCD module. K2's 3000-km/pix resolution and typical dust coma expansion speeds (~ 100 m/s) suggest the 30-min cadence is appropriate. The spatial resolution is not too large; Farnham et al. (in prep.) revealed the 10-hr period and few percent amplitude of comet Garradd's lightcurve using *Deep Impact* under similar conditions. Finally, lightcurve variations are expected based on HST/WFC3 images that reveal coma features (Li et al. in prep.) indicating there are at least 2 high-activity areas on the surface.

We propose observations of four custom long-cadence apertures covering the comet's ephemeris, one for each active CCD crossed, for a combined length of 2540 pix. Our target list is the comet's path in the Campaign 2 field. An aperture width of 16 pix (6 pix for photometry, 7 pix for the comet's 3-σ ephemeris uncertainty, 3 pix for K2 pointing uncertainties) yields our total request of 41,000 pix, the equivalent of 520 5-pix radius point source apertures. The core of the coma will be $\sim$12th mag, allowing for $\sim$100 PPM per cadence precision. The comet's proper motion ($\sim 100''$/hr) will be $\sim$12 pix per cadence, affecting the precision by less than a factor of 2. However, the brightness along the trail will reveal the comet's lightcurve on $\sim$10-min timescales. Aperture segments, when the comet is absent, will be used to create background maps that can be subtracted from the comet observations to remove faint background stars (critical for a high-precision lightcurve).