DISCRIMINATING THE DYNAMICAL HISTORY OF OORT CLOUD COMETS USING BRIGHTNESS BEHAVIOR.

C. E. Holt[1], M. M. Knight[2,1], T. Lister[3], M. S. P. Kelley[1], Q. Ye[1,4], C. Snodgrass[4], C. Opitom[5], R. Kokotanekova[6], S. Protopapa[7], M. Micheli[8], M. Schwamb[9], M. M. Dobson[9], and the LCO Outbursting Objects Key (LOOK) Project Collaboration, [1]University of Maryland (cholt1@umd.edu), [2]United States Naval Academy, [3]Las Cumbres Observatory, [4]Boston University, [5]University of Edinburgh, [6]Bulgarian Academy of Sciences, [7]Southwest Research Institute, [8]Queen's University Belfast, [9]ESA NEO Coordination Centre

Introduction: Comets spend most of their lifetime relatively unchanged in the outer Solar System as relics of planet formation. Dynamically new comets (DNCs) are comets with nearly parabolic orbits suggesting they are entering the inner Solar System for the first time. DNCs are valuable probes for linking observed cometary properties to conditions in the pre-solar nebula and subsequent evolution since they are believed to have experienced only minor solar heating before being discovered. Generally, dynamical models have been used to distinguish between new and returning long-period comets (LPCs) [1], but there is not a clear discerning threshold and recent studies have shown that such models are more difficult to accurately construct than previously suggested [2, 3]. Therefore, an observational diagnostic that can distinguish new from returning comets, separate from dynamical models, would be extremely valuable.

Thanks to powerful sky surveys, comets today are routinely discovered with heliocentric distances (r_h) greater than 5 au, and discoveries of comets with $r_h >$ 10 au are increasing. However, the drivers of distant activity are not fully understood. H_2O is the most abundant volatile and the main driver of cometary activity within ~3 au, but water-ice sublimation is inefficient beyond ~6 au. Distant activity is likely driven by more volatile ices like CO and CO_2. Characterizing the evolution of cometary activity beginning beyond 5 au is critical for connecting distant observations to near-Sun activity. Accurate predictions are especially critical to the selected European Space Agency (ESA) mission, Comet Interceptor [5], which will be the first mission to study the nucleus of either a dynamically new comet or interstellar object.

Observations: For more than two years, we have been studying the activity evolution of more than 30 newly discovered, distant LPCs through their inbound orbit using a range of optical telescopes and SDSS *g* and *r* filters. Since August 2020, our Las Cumbres Observatory (LCO) Outbursting Objects Key Project (LOOK) has utilized LCO's network of 1-m telescopes to consistently monitor brighter LPCs discovered inbound beyond 5 au from the Sun approximately every three days [6]. In addition to LCO, we use the 4.1-m SOAR telescope in queued AEON mode to observe the more distant targets that were discovered inbound beyond 10 au approximately monthly. We also employ the 4.3-m Lowell Discovery Telescope (LDT) to supplement SOAR observations in the northern hemisphere. The SDSS-*g* filter covers C_2 and C_3 emission bands, whereas the *r* filter is mostly free of gas emission lines, allowing us to use the $g - r$ color as a proxy for the dust-to-gas ratio.

Results: By characterizing the brightness evolution, colors, and coma morphology of distant comets over a range of heliocentric distances, we are working to (i) better understand the behavior of comets at distances beyond which water sublimation is expected to be the driver of activity, (ii) make better predictions of brightness behavior of future discoveries, and (iii) assess whether brightness behavior can be used as a discriminator of dynamical age. We will present the long-term time-series photometry of our sample, showcasing that the brightening rate most often changes throughout an orbit, but an overall steeper increase in activity is observed in returning comets. We will also show evidence of a relationship between the rate of activity increase and heliocentric distance. Finally, we will present instances of seasonal effects, disintegration, color changes, and outbursts, highlighting correlations with heliocentric distance and/or dynamical age.

Acknowledgments: C.E.H. acknowledges support from the Future Investigators in NASA Earth and Space Science and Technology (FINESST) program - grant 80NSSC22K1325 - and support from the NASA Solar System Observations (SSO) program - grant 80NSSC22K1714.

This work makes use of observations from the Las Cumbres Observatory global telescope network. Observations with the LCOGT 1-m were obtained as part of the LCO Outbursting Objects Key (LOOK) Project (KEY2020B-009).

References: [1] J. H. Oort and M. Schmidt. (1951) *BAIN*, 11:259–269. [2] Dybczyńsky, P. A. & Królikowska, M. (2015) *MNRAS,* 448, 588–600. [3] Dybczyńsky, P. A. & Królikowska, M. (2022) *A&A*, 660:A100. [5] Snodgrass, C. & Jones, G. (2019) *Nature Communications*, 10:5418. [6] Lister, T. et al. (2022) *PSJ*, 3:173.