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New Recurrently Active Main-belt Comet 2010 LH15

Colin Orion Chandler[1,2,3] William J. Oldroyd[3] Henry H. Hsieh[4,5] Chadwick A. Trujillo[3]
William A. Burris[6,3] Jay K. Kueny[7,8,3,*] Jarod A. DeSpain[3] Kennedy A. Farrell[3]
Michele T. Mazzucato[9,†] Milton K. D. Bosch[†] Tiffany Shaw-Diaz,[†] and Virgilio Gonano[†]

[1] Dept. of Astronomy & the DiRAC Institute, University of Washington, 3910 15th Ave NE, Seattle, WA 98195, USA
[2] LSST Interdisciplinary Network for Collaboration and Computing, 933 N. Cherry Avenue, Tucson, AZ 85721, USA
[3] Dept. of Astronomy & Planetary Science, Northern Arizona University, PO Box 6010, Flagstaff, AZ 86011, USA
[4] Planetary Science Institute, 1700 East Fort Lowell Rd., Suite 106, Tucson, AZ 85719, USA
[5] Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan
[6] Dept. of Physics, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182, USA
[7] University of Arizona Dept. of Astronomy and Steward Observatory, 933 North Cherry Avenue Rm. N204, Tucson, AZ 85721, USA
[8] Lowell Observatory, 1400 W Mars Hill Rd, Flagstaff, AZ 86001, USA
[9] Royal Astronomical Society, Burlington House, Piccadilly, London, W1J 0BQ, UK

ABSTRACT

We announce the discovery of a main-belt comet (MBC), 2010 LH_{15} (alternately designated 2010 TJ_{175}). MBCs are a rare type of main-belt asteroid that display comet-like activity, such as tails or comae, caused by sublimation. Consequently, MBCs help us map the location of solar system volatiles, providing insight into the origins of material prerequisite for life as we know it. However, MBCs have proven elusive, with fewer than 20 found among the 1.1 million known main-belt asteroids. This finding derives from Active Asteroids, a NASA Partner Citizen Science program we designed to identify more of these important objects. After volunteers classified an image of 2010 LH_{15} as showing activity, we carried out a follow-up investigation which revealed evidence of activity from two epochs spanning nearly a decade. This discovery is timely, with 2010 LH_{15} inbound towards its 2024 March perihelion passage, with potential activity onset as early as late 2023.

Keywords: Asteroid belt (70), Asteroids (72), Comae (271), Comet tails (274)

1. INTRODUCTION

Main-belt comets (MBCs) are rare, with fewer than 20 found among the 1.1 million known main-belt asteroids. MBCs represent a subpopulation of the active asteroids, which are small solar system bodies that exhibit comet-like activity (i.e., tails, comae) but have asteroidal orbits (Jewitt et al. 2015). The MBCs are active asteroids that are specifically found in the main asteroid belt, and whose activity is attributed to sublimation (Hsieh et al. 2015). Knowledge of these objects and their composition help us map the location of solar system volatiles, thereby improving understanding of the origins of the ingredients for life as we know it.

2. METHODS

To find more of these remarkable objects we created the Citizen Science program *Active Asteroids*[1], a NASA Partner. Participants classify images of known minor planets, which we extracted from the Dark Energy Camera (DECam) public archive (Chandler et al. 2018, 2019, 2020, 2021, 2022), as either active or inactive. We investigate activity candidates by conducting archival image searches and follow-up telescope observations, then report our confirmed discoveries (e.g., Oldroyd et al. 2023; Chandler et al. 2023a,b).

Corresponding author: Colin Orion Chandler
coc123@uw.edu

[*] National Science Foundation Graduate Research Fellow
[†] Active Asteroids Citizen Scientist
[1] http://activeasteroids.net

3. RESULTS

One DECam image (Figure 1) of 2010 LH_{15} ($a = 2.74$ au, eccentricity $e = 0.35$, inclination $i = 10.9°$, perihelion distance $q = 1.77$ au, aphelion distance $Q = 3.72$ au, Tisserand's parameter with respect to Jupiter $T_J = 3.23$, retrieved UT 2023 March 11 from JPL Horizons; Giorgini et al. 1996) originally acquired UT 2019 September 30, was unanimously classified as showing activity by *Active Asteroids* volunteers. Our archival investigation revealed additional images (examples provided in Figure 1) unambiguously showing activity from two separate orbital epochs: ∼10 images from UT 2010 September 27 – October 10; (true anomaly range of $20.5° < \nu < 27.6°$) and > 10 between UT 2019 August 10 – November 3 ($-14.2° < \nu < 26.5°$). All images of activity were taken when 2010 LH_{15} was approximately near perihelion passage ($\nu = 0°$). When considered with the recurrent activity, this indicates that sublimation is the probable underlying activity mechanism. Hence, given its main-belt orbit, 2010 LH_{15} is an MBC.

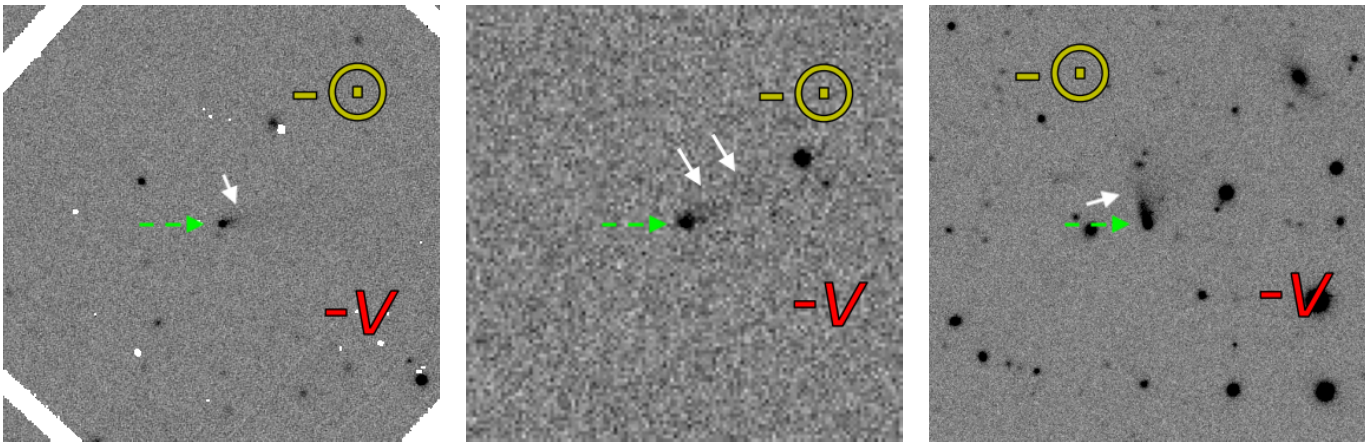

Figure 1. 2010 LH_{15} (green dashed arrows) with a tail (white arrows) oriented on sky roughly towards the anti-solar (yellow $-\odot$) direction, and counter-clockwise from the anti-motion (red $-v$) vector. The FOV of each image is $126'' \times 126''$. **Left:** UT 2020 September 27 45 s i-band GigaPixel1 exposure on the 1.8 m Pan-STARRS 1 (Haleakala). **Center:** UT 2019 August 31 Zwicky Transient Facility (ZTF) camera on the 48" Samuel Oschin telescope (Mt. Palomar) 30 s r band exposure. **Right:** UT 2019 September 30 90 s Dark Energy Camera (DECam) on the 4 m Blanco telescope (Cerro Tololo Inter-American Observatory, Chile); Prop. ID 2019B-1014, PI Olivares, observers F. Olivares, I. Sanchez. This was the image classified as active by *Active Asteroids* volunteers.

2010 LH_{15} is currently observable (as of 2023 March 15; $\nu \sim 240°$) and currently inbound to its 2024 March 26 perihelion passage, and may become active again as early as 2023 October when it reaches $\nu = 290°$, the earliest activity onset point observed to date for an MBC (Hsieh et al. 2023), just before its current observing window ends. It is also important to observe the target prior to its possible reactivation in order to measure properties of the nucleus (e.g., color, absolute magnitude, rotation rate) in the absence of activity, which will impede these measurements. After 2023 October, the object will next be observable from 2024 July to 2025 May ($45° \lesssim \nu \lesssim 130°$). Observations of the object during these available windows to characterize its expected activity are highly encouraged.

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Software & Services: World Coordinate System corrections facilitated by *Astrometry.net* (Lang et al. 2010). This research has made use of NASA's Astrophysics Data System, the NASA/IPAC Infrared Science Archive, the Institut de Mécanique Céleste et de Calcul des Éphémérides SkyBoT Virtual Observatory tool (Berthier et al. 2006), and data and/or services provided by the International Astronomical Union's Minor Planet Center, SAOImageDS9, developed by Smithsonian Astrophysical Observatory (Joye 2006).

Facilities & Instrumentation: This project used data obtained with the Dark Energy Camera (DECam), which was constructed by the Dark Energy Survey (DES) collaboration. This research uses services or data provided by the Astro Data Archive at NSF's NOIRLab. Based on observations at Cerro Tololo Inter-American Observatory, NSF's NOIRLab (NOIRLab Prop. ID 2019B-1014; PI: F. Olivares), the Pan-STARRS1 Surveys (PS1) and the PS1 public science archive (Chambers et al. 2016), the Zwicky Transient Facility (Bellm et al. 2019), and the CADC Solar System Object Information Search (Gwyn et al. 2012).

Facilities: CTIO:4m (DECam), IRSA[2], PO:1.2 m (PTF, ZTF), PS1

Software: astropy (Robitaille et al. 2013), `Matplotlib` (Hunter 2007), `NumPy` (Harris et al. 2020), `pandas` (Reback et al. 2022), `SAOImageDS9` (Joye 2006), `SciPy` (Virtanen et al. 2020)

[2] https://www.ipac.caltech.edu/doi/irsa/10.26131/IRSA539

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