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Activity in Centaur-like Jupiter-Family Comet 2023 RN_3

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ABSTRACT

We present multi-filter observations of Centaur-like Jupiter-family comet 2023 RN_3 conducted as part of the Las Cumbres Observatory (LCO) Outbursting Objects Key (LOOK) Project, as well as analysis of archival data in which 2023 RN_3 was expected to be present. We find clear evidence of comet-like mass loss in the form of an extended morphology on UT 2023 November 16 and 18, and an increase in intrinsic brightness of > 4 mag between 2022 September and 2023 November. We also report broadband colors for the coma of $g' - r' = 0.61 \pm 0.03$, $r' - i' = 0.30 \pm 0.03$, and $i' - z' = 0.04 \pm 0.08$, giving a $g'r'i'$ spectral slope of $S' = (12 \pm 2)$ %/100 nm.

Keywords: Comets (280), Centaur group (215), Comae (271), Sky surveys (1464)

1. INTRODUCTION

Centaurs are ice-rich solar system bodies on unstable orbits among the giant planets, connecting trans-Neptunian objects and Jupiter-family comets (JFCs) (Tiscareno & Malhotra 2003). Exact definitions vary, but they are typically characterized as having semimajor axes (a) and perihelia (q) between the orbits of Jupiter and Neptune (Jewitt & Kalas 1998).

2023 RN_3 has $q = 5.172$, an eccentricity of $e = 0.490$, an inclination of $i = 10.358°$, and a Tisserand parameter of $T_J = 2.907$, technically placing it on a JFC-like orbit (Tancredi 2014). However, its orbit is Centaur-like under some definitions (Emel'Yanenko 2005), while its distant activity (see below) makes it relevant to active Centaur studies (e.g., Jewitt 2009).

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2. OBSERVATIONS

We observed 2023 RN_3 as part of the Las Cumbres Observatory (LCO) Outbursting Objects Key (LOOK) Project (Program LTP2023B-001; Lister et al. 2022) on UT 2023 November 16 and 18 with the Teide Observatory LCO-A 1m telescope (TFN), and the 2.0m Faulkes Telescope North (FTN; Program FTPEPO2014A-004), following tentative activity detections on UT 2023 November 15 (N. Erasmus, private communication) by the ATLAS survey (Tonry et al. 2018a), and in October 2023 by P. VanWylen and L. Buzzi[1]. The object had a heliocentric distance of $r_h = 5.412$ au and true anomaly of $\nu = 30.1°$, and $r_h = 5.414$ au and $\nu = 30.2°$ (Giorgini et al. 1996) during TFN and FTN observations.

We obtained six g'- and r'-band exposures (3×245 s per filter) with TFN using a Sinistro camera, and two

[1] https://groups.io/g/mpml/topic/101896352

sets of simultaneous g'-, r'-, i'-, and z_s-band exposures (2×90 s per filter) with FTN using MuSCAT3 (Narita et al. 2020). All observations were processed using LCOGT pipeline software (McCully et al. 2018).

3. RESULTS

We measure average total magnitudes of $m_g = 18.74 \pm 0.01$ and $m_r = 18.14 \pm 0.02$ from TFN data, and $m_g = 18.69 \pm 0.02$, $m_r = 18.08 \pm 0.02$, $m_i = 17.78 \pm 0.02$, $m_z = 17.68 \pm 0.03$ from FTN data. Colors from FTN data are $g' - r' = 0.61 \pm 0.03$, $r' - i' = 0.30 \pm 0.03$, and $i' - z' = 0.04 \pm 0.08$, giving a $g'r'i'$ spectral slope of $S' = (12 \pm 2)$ %/100 nm.

Morphologically, 2023 RN_3 is clearly extended (Figure 1), with an elliptical coma with major and minor axis FWHMs of $3''.0$ and $2''.6$, compared to stellar FWHMs of $\sim 1''.8$ in TFN data.

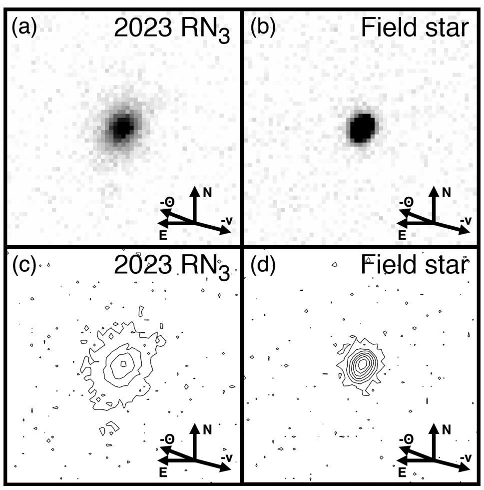

Figure 1. Single-exposure (90 s) r'-band images from FTN of 2023 RN_3 and a nearby field star with corresponding contour plots. Panels are $15'' \times 15''$.

4. ARCHIVAL DATA ANALYSIS

Using the Canadian Astronomy Data Center's SSOIS service[2] (Gwyn et al. 2012), we identified two images (50 s each in g'- and i'-band) obtained on UT 2022 September 14 with DECam (Flaugher et al. 2015) on the 4m Blanco Telescope for which 2023 RN_3 was expected in the field of view. We do not detect the object down to 3-σ limiting magnitudes of $m_{g,\rm lim} = 22.5$ and $m_{i,\rm lim} = 21.5$ (confirming non-detections reported by K. Ly[1]), corresponding to absolute magnitudes of $H_{g,\rm lim} > 15.3$ and $H_{i,\rm lim} > 14.3$ (assuming $G = 0.15$). Using these limits, 2023 RN_3 should have had $m_g > 22.9$ and $m_i > 21.90$ during our TFN and FTN observations, meaning that its intrinsic brightness increased by >4 mag, presumably from ejected dust, since 2022.

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This work uses observations from the Las Cumbres Observatory (LCO) global telescope network and using MuSCAT3, developed by the Astrobiology Center and supported by JSPS KAKENHI (JP18H05439) and JST-PRESTO (JPMJPR1775), at Faulkes Telescope North on Maui, HI, operated by LCO. Some observations were made via the Comet Chasers education project, part of the DeepSky2DeepImpact project funded by STFC(UK), which accesses LCO through the Faulkes Telescope Project (supported by the Dill Faulkes Educational Trust).

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This work used NASA's Astrophysics Data System.

Facilities: Blanco (DECam), FTN (MuSCAT3), LCOGT

Software: `astrometry.net` (Lang et al. 2010), `astropy` (Robitaille et al. 2013), BANZAI (McCully et al. 2018), `JPL Horizons`[3] (Giorgini et al. 1996), `PyRAF` (Greenfield & White 2000), `RefCat2` (Tonry et al. 2018b), `SAOImageDS9` (Joye & Mandel 2003), `sbpy` (Mommert et al. 2019), SSOIS (Gwyn et al. 2012), `uncertainties` (v3.0.2, E. O. Lebigot)

[2] https://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/ssois/

[3] https://ssd.jpl.nasa.gov/horizons/app.html

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