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Mars-Crossing Minor Planet 2018 VL10: a Jupiter-family Comet Discovery via Citizen Science

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Abstract

We announce the discovery of cometary activity emitting from minor planet 2018 VL_{10} in Dark Energy Camera images spanning from UT 2018 December 31 to UT 2019 March 3. The activity was identified by volunteers of our NASA Partner program *Active Asteroids*, a *Zooniverse*-hosted Citizen Science project designed to find previously unknown activity in known minor planets. Notably, 2018 VL_{10} crosses the orbits of Mars and Jupiter, and experiences close approaches of less than 0.5au with both Earth and Jupiter. We classify 2018 VL_{10} as a member of the Jupiter-family comets, a group of objects especially important to understand because they hold important clues about the solar system volatile distribution, past and present.

Previous article in issue

Next article in issue

1. Introduction

Minor planets on orbits typically associated with comets that have not been observed to be active are known as, for example, asteroids on cometary orbits (ACOs; Licandro et al. 2006). While discerning between asteroids and comets has become increasingly challenging (see Jewitt & Hsieh 2022), ACOs may have appeared inactive upon discovery because they were inactive, or observations did not probe faint enough to detect activity. It is unsurprising, then, that ACOs may later be discovered active. Depending on their dynamical characteristics, these bodies may then be classified as belonging to a different dynamical class, e.g., Jupiter Family Comets (JFCs). Active minor planets are important to find because they harbor evidence about, for example, the solar system volatile distribution, and astrophysical processes like the Yarkovsky–O'Keefe–Radzievskii–Paddack effect (Bottke et al. 2006). It is important, then, to both identify activity in

nominally asteroidal objects, as well as subsequently dynamically classifying the objects. Unlike active asteroids, JFCs are thought to originate in the Kuiper Belt and thus contain pristine primordial material that informs us about solar system formation (Levison & Duncan 1997).

2. Methods

With the goal of engaging the public in our search for active minor planets, we created the NASA Partner *Active Asteroids* [18] Citizen Science program (Chandler 2022; Chandler et al. 2022). We show volunteers images of known minor plants we extracted from publicly available Dark Energy Camera (DECam) data (Chandler et al. 2018) and ask if they see activity evidence (i.e., a tail or coma). Our science team examines activity candidates and searches astronomical image archives to locate more evidence of activity.

To distinguish between active asteroids and other populations we employ a metric describing Jupiter's relative influence over a body's orbit, the Tisserand parameter with respect to Jupiter, T_J (see Oldroyd et al. 2023). Objects with $T_J<3$ are dynamically cometary (Levison 1996), and JFCs have $3>T_J>2$ (Jewitt 2009).

3. Results

We identified five images of 2018 VL_{10} showing activity, spanning UT 2018 December 31 (heliocentric distance r_H =1.419au, true anomaly angle f=0°) to 2019 March 3 (r_H =1.598au, f= 43°). Two images each from UT 2018 December 31 and 2019 February 1 (Figure 1) show strong evidence of activity in the form of a diffuse tail. A UT 2019 March 3 image (not shown) shows weak, diffuse signal in the anti-motion direction.

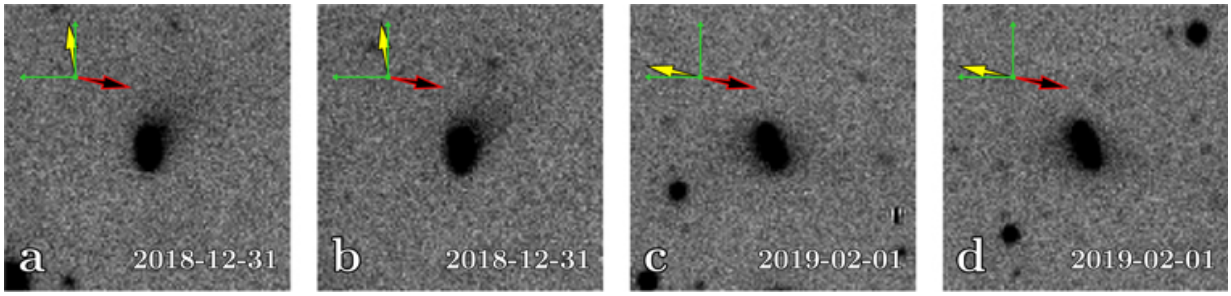

Figure 1. 2018 VL_{10} (at center) in these 32''× 32''DECam 150s *VR*-band exposures (Prop. ID 2018B-0122, PI Rest), with north up and east left. The anti-motion (red outlined black arrow) and anti-solar (yellow arrow) directions are indicated. (a) and (b): On UT 2018 December 31 (observer A. Zenteno) a diffuse tail spans between 12 and 2 o'clock. (c) and (d): On UT 2019 February 1 (observers A. Rest, A. Zenteno) diffuse comae and/or tail(s) are seen emanating roughly toward the anti-motion and anti-solar directions.

Notably, 2018 VL_{10} crosses the orbits of Mars and Jupiter and has a history of close approaches with Earth (most recently 0.479au on UT 2019 January 9) and Jupiter (most recently UT 1997 August 18 at 0.233au). (Close approach data retrieved UT 2023 September 24 from JPL). 2018 VL_{10} (semimajor axis a=4.586au, eccentricity e=0.692, inclination i=18.555, perihelion distance q =1.413au, aphelion distance Q=7.759 au) has a Tisserand parameter with respect to Jupiter of T_J =2.420, so we classify it as a JFC. Over the next thousand years 2018 VL_{10} undergoes deep close encounters with Jupiter that may significantly alter its orbit.

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Facility: CTIO:4m (DECam) - .

*Software:*astrometry.net (Lang et al. 2010), JPL Horizons (Giorgini et al. 1996), SkyBot (Berthier et al. 2006).

Footnotes

18 http://activeasteroids.net