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# New Active Jupiter Family Comet 2008 QZ44: a Discovery with Citizen Science

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## Abstract

We report our discovery of cometary activity in the form of a diffuse tail associated with minor planet 2008 QZ<sub>44</sub> during two previous orbits: 2008 and 2017. This finding was prompted in part by *Active Asteroids*, our Zooniverse-hosted NASA Partner Citizen Science program. Participants flagged two UT 2017 July 12 Dark Energy Camera images of 2008 QZ<sub>44</sub> as active. Independently, our team identified activity in nine Canada-France-Hawaii Telescope MegaPrime images from UT 2008 November 20. During both apparitions 2008 QZ<sub>44</sub> was near its perihelion passage. 2008 QZ<sub>44</sub> has a Tisserand parameter with respect to Jupiter of 2.821, placing it in the Jupiter-family comet (JFC) class, and our dynamical integrations confirm this classification. JFCs contain primordial material that informs us about solar system evolution, and help us map the present-day volatile distribution. We note that 2008 QZ<sub>44</sub> has previously been classified as a quasi-Hilda comet candidate.

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## 1. Introduction

Asteroids on Cometary Orbits (ACOs; Licandro et al. 2006) are objects that are dynamically similar to the Jupiter Family Comets (JFCs), yet they have not been observed to be active. As discussed in Section 2, our campaign is designed to find active asteroids (asteroids that show cometary activity), but we also discover activity associated with other minor planets, such as the ACOs, not previously known to be active. Broadly, active minor planets of all types (see Jewitt & Hsieh 2022) inform us about the solar system's volatile distribution, and teach us about astrophysical

processes at play in the solar system like the Yarkovsky–O'Keefe–Radzievskii–Paddack effect (Bottke et al. 2006). Originating in the Kuiper belt, the primordial composition of the JFCs helps us understand solar system formation and evolution (Levison & Duncan 1997).

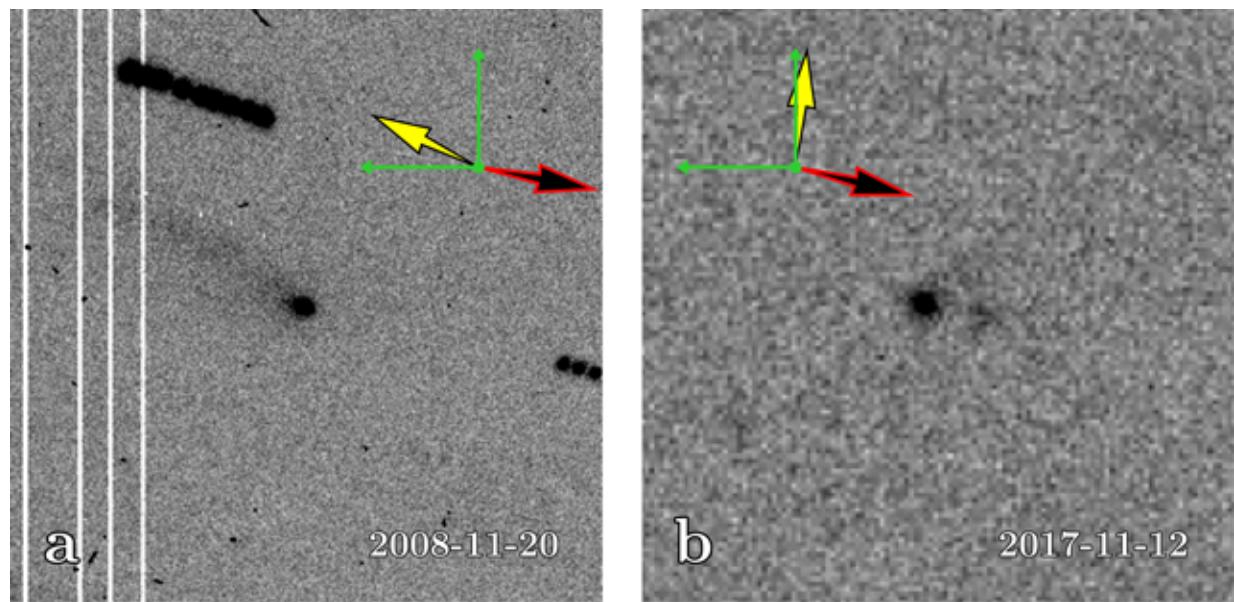
## 2. Methods

We created the NASA Partner Citizen Science project *Active Asteroids*<sup>19</sup> to get help from the public in searching Dark Energy Camera (DECam) data for previously unknown active minor planets (Chandler 2022). We do this by showing volunteers images we produce of known minor planets (Chandler et al. 2018), and asking whether or not they see activity in the image. Our team investigates objects volunteers flag as active, by searching through archival astronomical image data and, when possible, following up with telescopes (see Chandler et al. 2022).

We dynamically classify the objects by first assessing their orbital parameters then, if further disambiguation is required, we carry out dynamical modeling (see Oldroyd et al. 2023) with the REBOUND dynamical simulator (Rein & Liu 2012). The Tisserand parameter with respect to Jupiter,  $T_J$ , is a measure of Jupiter's influence over a body's orbit, and is often a useful tool for distinguishing between dynamical classes, though dynamical simulations (e.g., Chandler et al. 2022) are required to classify some bodies (e.g., Trojan asteroids).  $T_J < 3$  are canonically regarded as cometary (Levison 1996). JFCs span  $3 > T_J > 2$  (Jewitt 2009).

## 3. Results

We identified nine images of 2008 QZ<sub>44</sub> (Figure 1) showing activity from UT 2008 November 20, when the object was at a heliocentric distance  $r_H=2.43\text{au}$  and true anomaly angle  $f=29^\circ$ . Two images from UT 2017 November 12, and one image from UT 2017 November 13 ( $r_H=2.90\text{au}$ ,  $f=67^\circ$ ), also show faint activity evidence.



**Figure 1.** 2008 QZ<sub>44</sub> is at center, with North up and East left. The anti-solar (yellow arrow) and anti-motion (black outlined red arrow) directions are indicated. (a) UT 2008 November 20: 9 (3 *g*-band, 4 *r*-band) co-added 120s CFHT MegaPrime exposures (PI Hoekstra, observers "QSO Team"). A tail is seen oriented towards the anti-solar direction. The FOV is 126'' $\times$ 126''. (b) UT 2017 November 12: 71s *r*-band DECam exposure (prop. ID 2014B-0404, PI Schlegel, observers C. Stillman, J. Moustakas, M. Poemba). A faint tail is seen oriented towards the 2 o'clock position, between the anti-solar and anti-motion vectors. The FOV is 32'' $\times$ 32''.

2008 QZ<sub>44</sub> (semi-major axis  $a=4.195\text{au}$ , eccentricity  $e=0.441$ , inclination  $i=11^\circ 354$ , perihelion distance  $q=2.345\text{au}$ , aphelion distance  $Q=6.045\text{au}$ ; retrieved UT 2023 September 23 from JPL) has  $T_J=2.821$  and, as supported by our dynamical simulations (Section 2), is a member of the JFCs. We note 2008 QZ<sub>44</sub> has been reported as a quasi-Hilda comet (QHC) candidate (Correia-Otto et al. 2023), a class of bodies on orbits similar to Hilda asteroids, however, QHCs are not on stable interior 3:2 mean-motion-resonance with Jupiter.

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observations at the Canada-France-Hawaii Telescope were performed with care and respect from the summit of Maunakea which is a significant cultural and historic site. This work made use of the CADC Solar System Object Information Search (Gwyn et al. 2012).

*Facilities:* CFHT 3.58m (MegaCam) - , CTIO:4m (DECam). -

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

## Footnotes

19 <http://activeasteroids.net>

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