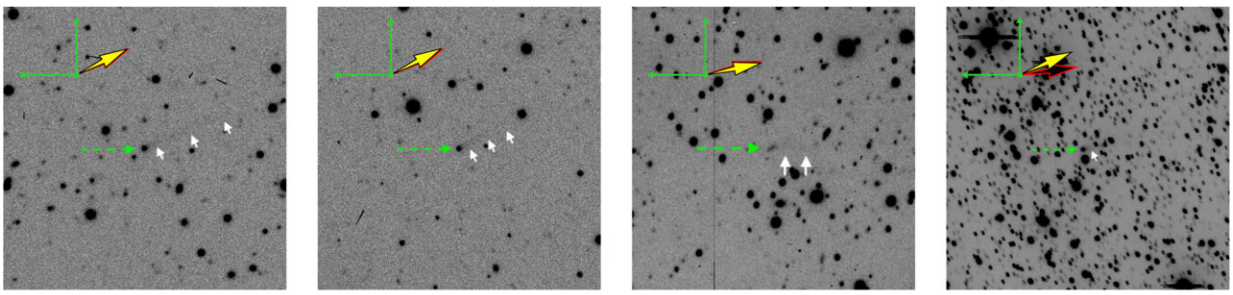
Testing of citizen scientist discovery suggests it is on the boundary between comet and asteroid

November 14 2023, by Bob Yirka



Images of 2009 DQ_{118} (green dashed arrows) displaying a cometary tail (white arrows). Frames (a) and (b) are from the first activity epoch and resulted from our Active Asteroids citizen scientist project and archival search. Frame (c) is an APO follow-up image showing faint signs of activity resulting in the tentative discovery of the second epoch of activity. In frames (a) through (c), the negative heliocentric velocity (black arrow outlined in red) and antisolar (yellow arrow) directions projected to the on-sky plane coincide with each other and the direction of the tail. Frame (d) is a stack of our Magellan follow-up observations confirming the discovery of the second activity epoch. In this frame, the tail is oriented between the antisolar (yellow arrow) and negative heliocentric velocity (black arrow outlined in red) directions projected to the on-sky plane. North is up, and east is left in each image (solid green arrows), and all directions are referenced to the ephemeris location of 2009 DQ_{118} (which is centered in each image) at the time of observation as given by JPL Horizons (Giorgini et al. 1996). (a) 300 s VR-band Dark Energy Camera (DECam) image taken with the 4 m Blanco Telescope at Cerro Tololo Inter-American Observatory (CTIO), Chile, on UT 2016 March 8 (Prop. ID 2016A-0189; PI: Rest; observers: A. Rest,

DJJ). (b) 200 s r-band DECam image, UT 2016 March 9 (Prop. ID 2015A-0121; PI: von der Linden; observer: A. von der Linden). (c) 300 s VR-band image taken with the Astrophysical Research Consortium Telescope Imaging Camera (ARCTIC) on the APO 3.5 m Astrophysical Research Consortium (ARC) Telescope, UT 2023 February 24 (Prop. ID 2Q2023-UW08; PI: Chandler; observer: C. Chandler). (d) A co-added stack of four 150 s WB4800-7800-band images taken with the Inamori-Magellan Areal Camera and Spectrograph (IMACS) on the 6.5 m Magellan Baade Telescope at Las Campanas Observatory, Chile, on UT 2023 April 22 (PI: S. Sheppard; observer: S. Sheppard). Credit: *The Astrophysical Journal Letters* (2023). DOI: 10.3847/2041-8213/acfcbc

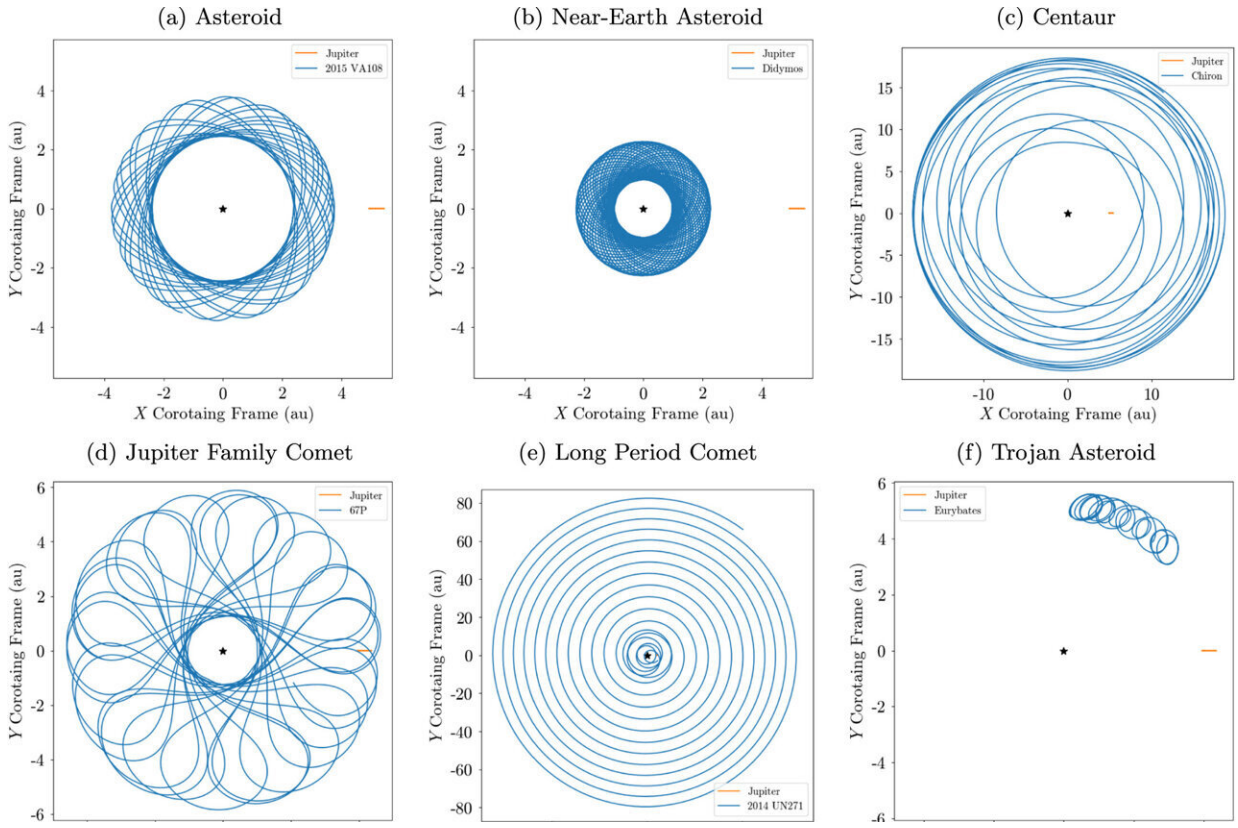
A team of space scientists, astronomers and astrophysicists affiliated with multiple institutions across the U.S., working with a colleague from Italy, has determined that a celestial object spotted by citizen scientists back in 2016 is neither a comet nor an asteroid, but an object that lies on the boundary between both. In their paper published in the journal *The Astrophysical Journal Letters,* the group describes the multiple tests they did to determine the nature of the object and what they learned about it as a result.

While much space science is conducted by professionals in the field, much is also done by so-called citizen scientists—people with an interest in space who participate by using amateur telescopes to peer at the night sky.

In this new effort, a group of such citizen scientists discovered an object in the night sky that had not been identified by the scientific community. They continued their work by searching through publicly available archival data and found images of the object, but no instances where it had been singled out. In so doing, they found what they described as clear signs of comet behavior. The group registered the object with the Active Asteroid project, where it came to the attention of the research

team.

The research team promptly named the object quasi-Hilda 2009 DQ_{118}. The Hildas are a band of comets and asteroids that exist between the Trojans and the main asteroid belt. The object found by the citizen scientists was not a true Hilda asteroid, however, hence its quasi title.



Orbits of representative bodies (blue curves) from eight dynamical classes in the corotating frame with Jupiter (orange line) illustrating the similarities between 2009 DQ_{118} and other quasi-Hildas. Each subplot shows 200 yr of orbital integration in this reference frame. (a) Active asteroid 2015 VA_{108} orbits in the main asteroid belt and is a candidate main-belt comet (Chandler et al. 2023). (b) Near-Earth binary asteroid (65803) Didymos-Dimorphos was the target of the NASA Double-Asteroid Redirection Test mission (DART). It is the first artificial active asteroid (Li et al. 2023). (c) Active Centaur (2060) Chiron (95P)

resides between the orbits of Jupiter and Uranus. (d) JFC 67P/Churyumov–Gerasimenko crosses the orbits of Jupiter and Mars. It was visited by the ESA Rosetta spacecraft. (e) Long-period comet C/2014 UN_{271} (Bernardinelli–Bernstein) is currently inbound from the Oort cloud and will reach its perihelion, near the orbit of Saturn, in 2031 January. Because this comet is highly inclined ($i \approx 95°$), it appears to be interior to the orbit of Jupiter in part of this X–Y projection. (f) Trojan asteroid (3548) Eurybates in a characteristic Trojan tadpole orbit indicative of a 1:1 mean-motion resonance with Jupiter. Eurybates is a target of the NASA Lucy spacecraft mission. (g) Asteroid (153) Hilda in its iconic 3:2 interior mean-motion resonance with Jupiter. Hilda asteroids are defined as being in this resonance and also display this trilobate pattern in this frame. (h) Active quasi-Hilda 282P/(323137) 2003 BM80 displays a typical asymmetric quasi-Hilda corotating pattern (Chandler et al. 2022). (i) 2009 DQ118 with a quasi-Hilda orbit similar to 282P. Credit: *The Astrophysical Journal Letters* (2023). DOI: 10.3847/2041-8213/acfcbc

After studying 20 images of the object found in the archives, the researchers gave it a look using both the Astrophysical Research Consortium Telescope and the Magellan Baade Telescope. In doing so, they found what they describe as a second epoch of activity associated with the object. They then carried out a photometric analysis of the tail and found that it was approximately the same length and brightness in all the images that had been taken. They also tracked its orbital history using dynamical simulations.

The work by the team showed that the object was indeed a quasi-Hilda and that it frequently came close to Jupiter as it orbited around the sun. The researchers found no evidence to suggest the object is a comet or an asteroid. It was neither mostly ice nor mostly rock, which puts it on the boundary between both.

More information: William J. Oldroyd et al, Recurring Activity

Discovered on Quasi-Hilda 2009 DQ_{118}, *The Astrophysical Journal Letters* (2023). DOI: 10.3847/2041-8213/acfcbc