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The Sporadic Activity of (6478) Gault: A YORP-driven event?

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Abstract

On 2019 January 5 a streamer associated with the 4–10 km main-belt asteroid (6478) Gault was detected by the ATLAS sky survey, a rare discovery of activity around a main-belt asteroid. Archival data from ATLAS and Pan-STARRS1 show the trail in early December 2018, but not between 2010 and January 2018. The feature has significantly changed over one month, perfectly matching predictions of pure dust dynamical evolution and changes in observing geometry for a short release of dust around 2018 October 28. Follow-up observations with HST show a second narrow trail corresponding to a brief release of dust on 2018 December 30. Both releases occurred with negligible velocity. We find the dust grains to be fairly large, with power-law size distributions in the 10^{-5}-10^{-3} m range and power-law indices of ~ −1.5. Three runs of ground-based data find a signature of ~2 hr rotation, close to the rotational limit, suggesting that the activity is the result of landslides or reconfigurations after YORP spin-up. We will present data from both the initial and later HST runs, along with ground based observations to examine the dust and its colors.

1. Introduction

"Active asteroids" are objects that have semi-major axes smaller than Jupiter's, are orbitally decoupled from Jupiter (with Tisserand parameter T_J > 3.0), exhibit comet-like mass loss, and are dynamically distinct from classical comets. Active asteroids offer insight into a range of solar-system phenomena (primordial volatiles from MBC sublimation, material composition from rotation and impacts), and it is crucial to study each specimen in detail to determine its mechanism of activity.

The Hawai`i ATLAS survey detected a tail on asteroid (6478) Gault in images obtained on 2019 January 5, when the object was at heliocentric distance r = 2.48 au (CBET 4594; [1]). The ATLAS archive shows that Gault was active on 2018 December 8, but not on earlier images during January 2018. The orbital elements (e = 0.194, a = 2.305 au, i = 22.8°, having T_J = 3.461) are consistent with it being an MBC, albeit with a small semi-major axis.

We undertook an extensive campaign to observe Gault using the Hubble Space Telescope (3 orbits), the CFHT 3.6m telescope on Maunakea, the ESA Optical Ground Station at the Teide Observatory, the Himalayan Chandra Telescope, and the 4.2m William Herschel Telescope on La Palma.

2. Discussion

The initial analysis of the data [1] showed that Gault experienced two dust releases occurring around 2018 October 28 and December 30, creating the observed streamers. The width of the October 28 streamer is best explained with a maximum emission velocity v_e ~ 0.7 m/s in the sky plane. These events were short, with upper duration limits of <15 days for the first, and <5 days for the second. The size distribution of the dust grains in the streamers follows a power law with an index ~ −1.65. The mass lost in the streamers is m ≈ 7×10^9 and 4×10^7 kg, respectively.

Dynamical simulations show that Gault is dynamically stable and unlikely to have been recently implanted from elsewhere, ruling out a cometary origin. The presence of a ~2 hour signature in three data sets identifies Gault as a superfast rotator that likely underwent a YORP-induced rotational disturbance.

In addition to this work, we will present some of our more recent observations.

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References

[1] Kleyna, J. T., Hainaut, O.R., Meech, K.J. et al.: The Sporadic Activity of (6478) Gault: A YORP-driven event?, ApJL, 874, L20, 2019.