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APO VISIBLE AND NEAR-INFRARED PHOTOMETRY/SPECTROSCOPY OF MULT-TAILED ACTIVE ASTEROID (6478) GAULT

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Abstract

The high-inclination, inner Main Belt asteroid (6478) Gault has been observed to be active having undergone two separate activity-producing events since October 2018, more than 1 year before reaching perihelion (e.g., [3,7]). We present optical and near-infrared (NIR) observations of (6478) taken with the ARC 3.5 m telescope at Apache Point Observatory between January 8, 2019, and April 26, 2019 UTC. We obtained broadband optical and near-infrared colors and optical spectroscopy that suggest (6478) belongs to the C-complex. In addition, the visual spectra show no features indicative of comet-like gas emissions. Constraining the albedo of (6478) with its optical colors, we determine that (6478) has a diameter of ~7 km. We obtained several lightcurves of (6478) each spanning hours between the months of January and April. Most of these lightcurves do not show any significant short timescale variations that which is possibly due to contamination by dust in the photometry measurements centered on the nucleus. Although, at least one lightcurve was obtained with exceptionally good image quality and shows an incomplete sinusoidal curve with a peak-to-peak amplitude of ~0.2 mag over a time scale of ~1.5 hours. Combining the ARC 3.5 m data with other publicly-available lightcurve data of (6478) reveals that it may have a double-peaked rotation period of >5 hours. In addition, we observe that underwent a possible third activity-producing event in the APO 3.5 m data and publicly available data of (6478) from the Hubble Space Telescope archive that occurred in mid to late February. Compared to other active asteroids whose activity is best explained by rotational disruption, such as (62412) [6], and the fact that (6478) is presently showing activity more than 1 year from perihelion (ν ~240°) than is typical for active comets, we conclude that a precise explanation for the activity of (6478) remains elusive, although possible explanations include the disruption of binary companion by tidal forces during pericenter passages [1].

1. Introduction

Main Belt comets (MBCs) or active asteroids (AAs) are objects that are located entirely withing the Main Belt and have dynamical characteristics distinctive from the members of the Jupiter and long period comet families, but display dust-producing activity similar in appearance to these comets [2]. The cause for the activity observed in MBCs/AAs can be broadly divided into two broad categories: those whose activity is caused by the sublimation of volatiles, i.e., the "real" Main Belt comets, and those whose activity is caused by other physical properties unrelated to the sublimation of volatiles such as disruptive collisions or rotational stresses, i.e., the active asteroids. MBCs can be considered a category of AAs, but here we use the latter term to mean exclusively those objects whose activity is not caused by volatiles. Here we discuss the occurrence and observation of the recently-discovered activity of (6478) Gault which has been observed to be undergoing multiple activity-producing events.

2. Observations and data reduction

We obtained optical and near-infrared observations of (6478) taken with the ARC 3.5 m telescope at Apache Point Observatory on multiple nights between January 8, 2019, and April 26, 2019 UTC. The ARCTIC optical imager, NICFPS NIR imager and DIS spectrograph were used. We took multiple sets of images and spectra on different nights spread over this range of dates. SDSS g,r,i and z filters were used for the optical images, MK J, H and Ks filters were used for the NIR image. A filter sequence of rgrirzig was used when taking optical imaging data and a JHKs sequence was used when taking NIR imaging data. A five point 25" dither pattern was used for both the optical and NIR observations. The

spectra were taken with the red camera mounted on DIS using a 300 spectral resolution grating sensitive between 0.52-0.98 microns. Image quality in all observations was between 0.8" and 2". Observations of solar analogue stars from the Pan-STARRS catalogue taken were used to calibrate the photometry and spectra. a 1080 s composite robust mean stack of 9 120 s image taken of (6478) on April 26, 2019 UTC with three tails of (6478) visible is presented in Fig. 1.

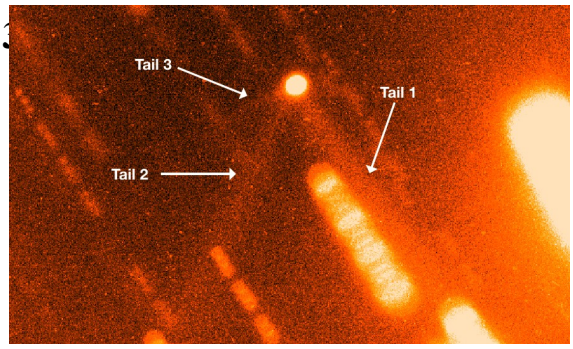

Figure 1: Composite image of (6478) on April 26, 2019 UTC made with a robust mean stack of 9 120 s images rejecting the lower and upper 16th percentile pixel values.

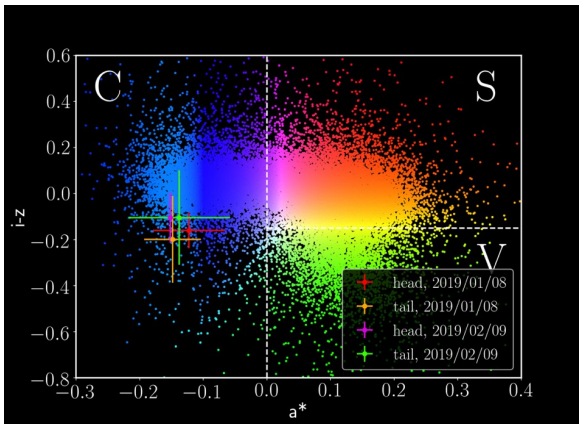

Figure 2: a vs. i-z colors of the nucleus and first tail of (6478) along with Main Belt asteroids observed by SDSS. The nucleus and tail colors are consistent with each other.*

The optical colors of (6478) calculated in a* vs i-z space resemble those of C-type asteroids when compared to the a* vs i-z colors of other Main Belt asteroids as seen in Figure 2 where a* is calculated as a function of g-r and r-i colors: a* = (0.89x(g -r)) + (0.45 x (r -i)) - 0.57. The C-type like colors are supported by the visible spectra which has a slightly blue slope and lacks any significant spectral features. In addition, the NIR J-H and H-K colors of (6478) resemble those of C-complex asteroids according to the classification of [5]. Lightcurve data taken on February 9, 2019 shown in Figure 3 shows possible ~0.2 magnitude brightness variations from the rotation of the nucleus. Gaussian processes analysis [4] of the lightcurve data available from the ARC 3.5 m observations and public archival data suggest that (6478) likely has a rotation period exceeding ~5 hours.

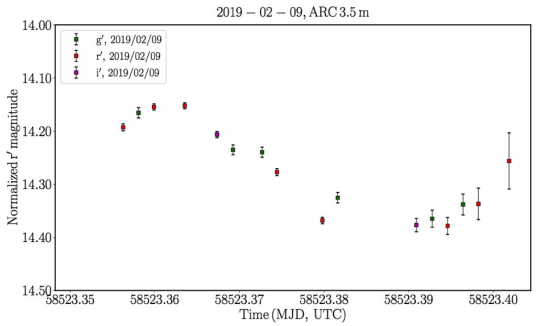

Figure 1: Lightcurve data obtained of (6478) taken on February 9, 2019 UTC. The image quality was 0.8" when the data were taken.

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